



Research Article

Some Haemo-biochemical Changes Induced by
Gastrointestinal Parasites of Cultured and Wild African
Catfish in Zaria, Kaduna, Nigerian

¹Dauda, J., ²Abdulsalam, H., ³Bello, A. M., ³Audu, Y., ⁴Wakawa, A.M., ⁵Bolorunduro, P. I and ⁵Tijani A. A.

¹Department of Veterinary Public Health and Preventive Medicine, University of Maiduguri

²Department of Veterinary Pathology, University of Maiduguri

³Department of Veterinary Medicine, University of Maiduguri

⁴Department of Veterinary Medicine, Ahmadu Bello University, Zaria

⁵NAERLS, Ahmadu Bello University, Zaria

*Corresponding author: abdulsalamjnr@gmail.com, doi.org/10.55639/607.2838

ARTICLE INFO:

Keywords:

Haematological,
biochemical,
gastrointestinal
parasites,
Clarias gariepinus

ABSTRACT

The present study investigated the occurrence of gastrointestinal (GIT) parasites and their relationship with some haemato-biochemical parameters in wild and cultured catfish (*Clarias gariepinus*) in Zaria and its Environs, Nigeria. A total of two hundred and forty (240) African catfish (*Clarias gariepinus*) were sampled from cultured ponds and some water bodies around Zaria. About 2 ml of blood was collected from the caudal vein of each catfish and dispensed into EDTA and plain sample bottles for haematological and serum biochemical analysis, respectively. After blood sample collection, the catfish were dissected longitudinally to examine for parasites (GIT) grossly and using Simple flotation technique for parasite eggs and oocysts of Helminthes and protozoans. Modified Ziehl Neelson staining technique was further performed on oocysts suspected to be *Cryptosporidium*. Percentage distributions of the various parasites include: *Cryptosporidium* oocysts, *Eimeria* oocysts and nematodes were 86.2%, 48.4% and 40% in the wild; as against 13.8%, 51.6% and 60% in cultured *Clarias gariepinus*, respectively. The PCV, RBC, and Hb were significantly lower ($p < 0.05$) in the infected ($28.0 \pm 0.331\%$, $3.4 \pm 0.592 \times 10^{12}/L$, 8.3 ± 0.174 g/dl) compare with the uninfected *Clarias gariepinus* ($33.3 \pm 0.229\%$, $3.9 \pm 0.050 \times 10^{12}/L$, 10.5 ± 0.110 g/dl), respectively. However, the WBC was significantly higher ($p = 0.041$) in the infected ($4.5 \pm 0.047 \times 10^9/L$) when compared to the uninfected ($3.9 \pm 0.017 \times 10^9/L$) *Clarias gariepinus* species. Also, there were statistically significant increases ($p < 0.05$) in the mean values of AST, ALT, and ALP in the infected (82.2 ± 1.037 U/L, 95.8 ± 1.209 U/L, 68.8 ± 1.180 U/L) when compared with the uninfected (60.7 ± 0.741 U/L, 68.9 ± 0.844 U/L, 47.1 ± 0.759 U/L) *Clarias gariepinus*, respectively. The results of present study overserved that helminth parasites induce haematobiochemical changes.

Corresponding author: Abdulsalam H., Email: abdulsalamjnr@gmail.com
Department of Veterinary Pathology, University of Maiduguri

INTRODUCTION

Fish provides a comparatively cheap source of animal protein for man and his livestock and attention is now being focused on fish production, both from natural water and aquaculture (Komatsu and Kitanishi, 2015). Fish as smoked, dried, or fresh is highly priced in Nigeria. It contributes 22% of animal protein supply in sub-Sahara Africa and 40% of animal protein consumption in Nigeria (Omeji *et al.*, 2022). Fish as common important source of protein do contain lipids, minerals, oils, and vitamins. The most common fish available in Nigeria are the catfish species of *C. gariepinus* and *C. angularis* (Kawe *et al.*, 2016). The *Clarias gariepinus* from the family *Clariidae* is among the most important tropical catfish species for aquaculture in West Africa. The wide geographical spread, high growth rate and the resistance to handling and stress has made *C. gariepinus* well valued in a wide number of African countries (Enas *et al.*, 2013).

The demand for fish as a source of protein increases as the human population grows (Nnabuchi *et al.*, 2015). To increase fish supply as protein source, there has been tremendous increase in the development of fish farming (Skelton and Teugel, 1992). The growth rate in both fresh and saltwater fishing in Nigeria increased at an average rate of 7.4 percent in the 1960s (FAO, 2016) to 18% in 2020 (Odioko and Becer, 2022). However, Fish industry has been plagued by the problems which include overcrowding, poor environmental conditions and pollution which often results in reduced immunity of fish and higher susceptibility to parasites and diseases (Murray, 2005; Al-Murjan and Abdullahi, 2008).

Haemato-biochemical changes are used as indicators of organisms' responses to stressors and their health status under such conditions (Anyeni *et al.*, 2022). Generally, haematological tests are used to establish normal health status and to diagnose diseases caused by

various factors: viz heavy metals, environmental stress, parasitic infections, genotoxic effect of pollutants, nutrition, and pollution in human and veterinary science (Fedato *et al.*, 2010). Haematological parameters act as physiological indicators to changing external environments (Caruso *et al.*, 2005) because of their relationship with energetic (metabolic levels), respiratory (haemoglobin) and defense mechanisms (leukocyte levels) (Oriakpono *et al.*, 2012). They also provide an integrated measure of the health status of an organism, which over time manifests in changes in weight (Yaji *et al.*, 2007). Hence, the aim of this research was to study some of the haemato-biochemical changes induced by gastrointestinal parasites of *Clarias gariepinus* in both cultured and wild, which could be used in diseases diagnosis and in guiding the implementation of the treatment or preventive measures.

MATERIALS AND METHODS

Study Location

The research was conducted at the Department of Veterinary Medicine, Ahmadu Bello University Zaria, Kaduna State, Nigeria. Zaria is located within the Northern Guinea Savannah Zone of Northwestern Nigeria. It lies between latitude 7° to 11° N and longitude 7° 44 E. It has an average rainfall between 1,000 to 1,250 mm and an average temperature between 17 °C to 33 °C and vegetation made of predominantly trees and grasses, while the main economic activity is agriculture. It has a land area of 300² km and a human population of about 408,000 (Okolo and Makanjuola, 2021). It has a climate that is divided into two seasons, a rainy season between May to October and the dry season between Novembers to April, with a cold dry spell between Novembers to February (Harmatan).

Sample Size

The sample size was determined based on the formula by Thrusfield (2008). According to the work of Oniye *et al.*, (2004), a prevalence of

19.17% was obtained for helminth infection of Catfish in Zaria, and this prevalence was used for the calculation of sample size and 5%

$$n = \frac{Z^2 pq}{d^2}$$

n = sample size

p = prevalence (19.17%) (Oniye *et al.*, 2004)

d = desired absolute precision (0.05)

Z = Standard normal deviate for 95% confidence level (1.96)

$$q = 1 - p$$

$$\frac{1.96^2 \times 0.1917 \times (1 - 0.1917)}{0.05^2} = \frac{3.84 \times 0.1917 \times 0.8083}{0.0025} = \frac{0.5950}{0.0025} = 234$$

However, a total of 240 catfish (120 each of specifically *Clarias gariepinus* wild and cultured fish) were sampled to increased precision.

Sources of catfish

Two hundred and forty (240) live *Clarias gariepinus* were procured and used for this study. The 240 were sourced from local fishermen and commercial fish farms in Zaria (at n=120 for each, respectively). The fish were transported to the Helminthology Laboratory, Department of Veterinary Parasitology and Entomology, Ahmadu Bello University, Zaria in a 25-litre plastic container containing water.

Blood Sample Collection

About 2 ml of blood sample were obtained from the catfish via caudal vein as described by Kori-Siakpere *et al.* (2005). Blood samples collected were properly labelled as infected and non-infected based on the presence of parasites in dissected fish. From the 2 ml of the blood sample, 1 ml was dispensed into heparinized tubes while the remaining 1 ml was collected into non heparinized tubes for haematological and biochemical analyses, respectively. The non-heparinized blood samples were centrifuged at 3000 rpm for 10 minutes to extract serum.

Dissection of Catfish for Parasites Examination

For easy handling prior to dissection, the fish were immobilized by cervical dislocation. A longitudinal slit on the ventral surface of the

abdomen from the anus to a point level with the pectoral fins was made using a surgical blade. The viscera were removed and separated into oesophagus, stomach, and intestine. Each of the sections were placed into separate Petri dishes containing 0.6% saline before examination for the presence of parasites under a dissecting microscope. Fish that shows microscopic presence of parasites (*Crytosporidium oocysts*, *Eimeria oocytes* and Nematodes) were considered infected.

Identification of Parasites

For the identification of the parasites, nematodes were cleared with lactophenol while the cestode and trematodes were stained overnight with a weak Ehrlich's haematoxylin solution and passed through graduated concentrations of alcohol (30, 50, 70, 90% and absolute) for 45 min to dehydrate, and cleared in methylsalicylate. The parasites were then covered and mounted on a slide in Canada balsam and viewed using Olympus Microscope under high power magnification (x40). The parasites were identified to species level using appropriate keys according to Pouder *et al.* (2011). All parasites recovered were recorded accordingly.

Simple flotation technique

From 2 g of intestinal contents in a centrifuge tube, 5 ml of flotation medium with specific gravity of 1.18-1.2 was added. The suspended

sample was sieved into a test tube using gauze. To obtain the desired amount of sediment (8 ml of sample formalin mixture), it was further sieved through 2 layers of gauze into a conical 15 ml centrifuge tube. Then 0.85% NaCl was added, and centrifuged for 10 mins at 500 x g. The supernatant was collected in a test-tube and suspended in 2 ml of Zinc sulfate. And then centrifuge for 2 mins at 500 xg, allowed to stop and settle on its own with the tube still in the centrifuge. This was followed by taking 2 drops using a pipette and placed on a clean glass slide and viewed under X10 objective. Oocysts seen were identified with the aid of an Atlas Encyclopedia of Parasitology Photographs and Manual of Parasitology (Levine, *et al.*, 1985).

Modified Ziehl Neelson staining technique

For confirmation of *Cryptosporidium* oocysts, positive oocysts were further subjected to modified Ziehl Neelsen stain as described by Lynne and Garcia (1999). 1 to 2 drops of intestinal content were lightly smeared on a glass slide and allowed to air-dry. The slide was placed on a heating block (70°C) for 5 minutes, and then transferred into a staining rack. This was followed by flooding it with carbol fuchsin, before over flaming using Bunsen burner which was stopped as soon as the stain began to steam. It was allowed to dry and stained again without heating, followed by rinsing with water. Decolorization was done with 5% sulphuric acid for 30 seconds, rinsed and drained with water. The slide was then flooded with methylene blue for 1 min, rinsed with water, stained and air dried and thereafter examined with the oil objective.

Evaluation of Haematological Parameters

Packed cell volume (PCV) was determined by the Microhaematocrit centrifugation technique as described by Brar *et al.* (2014). After gently mixing the blood sample in a vacutainer tube. The blood was drawn upto 75% of the Microhaematocrit capillary tube by capillary action and the opposite end of the tube carefully

sealed with plasticine. The capillary tubes were placed, with the closed end outwards, in a Microhaematocrit centrifuge (Hawksley and Sons Limited, England) and spun at 194.81 gpm for 5 min. Then the proportion of cells in total volume of blood was measured and recorded as a percentage using the Hawksley® Microhaematocrit Reader.

Haemoglobin concentration was measured spectrophotometrically by the cyanmethaemoglobin method as described by Brar *et al.* (2014). Five millilitre of haemoglobinocyanide (HICN) (Drabkin) solution were measured using a 5 ml syringe into plastic test tubes. Twenty microliter (20 µl) of blood was measured using a micropipette and added to the Drabkin solution in the test tube and properly mixed by gently shaking the test tube. It was centrifuged at 1,509 x g for 15 minutes to separate the empty RBC from interfering with the reading. The supernatant was separated into a sample bottle. The mixture was absorbed into the haemoglobin meter (XF-C, China). After the wiggling pump stops working, the value displayed on the screen was recorded in g/dl as the haemoglobin concentration.

Serum Biochemical Evaluation

Serum transaminases including: Aspartate aminotransferase (AST), Alanine aminotransferase (ALT) and Alkaline phosphatase (ALP) were determined using Randox reagent kits, according to manufacturer's instruction.

Statistical Analysis

All the data obtained were subjected to statistical analysis including the calculation of the means and standard error of the means. Data between groups were evaluated using student t-test and values of $P < 0.05$ were considered significant

RESULTS

Finding from this study showed that wild animals had higher percentage of infection (61.3%) than cultured (38.7%) *Clarias gariepinus*. Percentage distributions of the

various parasites include; *Cryptosporidium* oocysts, *Eimeria* oocysts and nematodes having 86.2%, 48.4% and 40% in the wild; while 13.8%, 51.6% and 60% in cultured *Clarias gariiepinus*, respectively (Table 1).

Based on infection, the PCV, RBC, and Hb were significantly ($p < 0.05$) lower in the infected *Clarias* species ($28.0 \pm 0.331\%$, $3.4 \pm 0.592 \times 10^{12}/L$, 8.3 ± 0.174 g/dl) when compare with the uninfected *Clarias* species ($33.3 \pm 0.229\%$, $3.9 \pm 0.050 \times 10^{12}/L$, 10.5 ± 0.110 g/dl), respectively.

However, the WBC was significantly higher ($p = 0.041$) in the infected *Clarias* species ($4.5 \pm 0.047 \times 10^9/L$) when compared to the uninfected ($3.9 \pm 0.017 \times 10^9/L$) (Table 2).

The infected *Clarias gariiepinus* had significantly ($p < 0.05$) higher mean serum AST, ALT and ALP (82.2 ± 1.037 U/L, 95.8 ± 1.209 U/L, 68.8 ± 1.180 U/L) when compared with the uninfected (60.7 ± 0.741 U/L, 68.9 ± 0.844 U/L, 47.1 ± 0.759 U/L respectively) (Table 3).

Table 1: Occurrence of Gastrointestinal parasites in *Clarias gariiepinus* Based on Types of Parasites

Source	Parasites			Total (%)
	<i>Cryptosporidium</i> oocysts (%)	<i>Eimeria</i> oocysts (%)	Nematodes (%)	
Wild	25 (86.2) ^a	15 (48.4)	6 (40)	46 (61.3) ^a
Cultured	4 (13.8) ^b	16 (51.6)	9 (60)	29 (38.7) ^b
Total	29 (100)	31 (100)	15 (100)	75 (100)

a vs b = 0.001 (significant)

Table 2: Haematological Parameters of *Clarias gariiepinus* Based on Health Status

Parameters	Health Status		P value
	Infected	Non-infected	
Packed Cell Volume (%)	28.0 ± 0.331	33.3 ± 0.229	0.021*
Red Blood Cell count ($\times 10^{12}/L$)	3.4 ± 0.592	3.9 ± 0.050	0.003*
White Blood Cell count ($\times 10^9/L$)	4.5 ± 0.047	3.9 ± 0.017	0.041*
Haemoglobin concentration (g/dl)	8.3 ± 0.174	10.5 ± 0.110	0.011*

* $p < 0.05$ (significant)

Table 3: Biochemical Parameters of *Clarias species* Based on Health Status

Parameters	Health Status		P value
	Infected	Non-infected	
Aspartate amino transferase (U/L)	82.2 ± 1.037	60.7 ± 0.741	0.015*
Alanine amino transferase (U/L)	95.8 ± 1.209	68.9 ± 0.844	0.001*
Alkaline phosphatase (U/L)	68.8 ± 1.180	47.1 ± 0.759	0.001*

* $p < 0.05$ (significant)

DISCUSSION

The helminth parasites identified in this study comprised of 2 groups: namely Nematoda (*Procamallanus laevionchus* and *Capillaria* spp) and protozoans (*Cryptosporidium* and *Eimeria* oocysts). The observed occurrence rate of 61.3% for gastrointestinal parasites in wild and 38.7% in cultured catfish in the study area was

considerably high when compared to the rate of 19% reported by Oniye *et al.* (2004) in Zaria, and Akinsanya and Otubanjo, (2006) in Lagos. The observed high levels of gastrointestinal parasites in the wild catfish than in cultured catfish may be attributed to the fact that the fish in the wild are allowed to feed for themselves during which the likelihood of them being

exposed to parasitism is higher when compared to cultured fish, where feed is provided under a controlled environment.

It is also important to note that blood is a good bio-indicator of the health of an organism. It also acts as a pathological reflector of the whole body. Hence, haematological parameters are important in diagnosing the functional status of fish. Thus, the reduction in RBC count, haemoglobin concentration and packed cell volume in infected fish in this study may be because of parasitic infection that often leads to anaemia (Martins *et al.*, 2004). Furthermore, the parasites simply might have acted as stressors and during the primary stages of stress; the PCV was altered due to the release of catecholamine (an enzyme) which mobilizes RBCs to swell because of fluid entry into the intracellular compartment (Chocchia *et al.*, 1982). Similar results were recorded by Hassen (2002) and Ismail (2003) in *Clarias gariepinus* naturally infected with *T.mukasai*. Lofty *et al.* (2003) and Omran and El-Kholony (2003) also reported that the severe anaemia that may be responsible to the reduction of RBC, PCV and Hb of the infected fish maybe because of chronic liver inflammation which causes depression of erythropoiesis. On the other hand, this study recorded significant elevation in WBC of the infected fish when compared to those of the uninfected fish. And this according to Lebola *et al.* (2001) and Hassen, (2002), the increase in WBCs count might have occurred as a pathological response since WBCs play a major role during infestation by stimulating the haemopoietic tissues and immune system to produce antibodies and chemical substances which work as defense agent against parasite infection. The finding also agrees with previous report by Pinky *et al.* (2012).

The observed significant higher activity of serum AST, ALT and ALP in the infected catfish than those in uninfected catfish agrees

with the earlier result of Younis, (1999) who reported that AST, ALT and Urea increased significantly in *O. niloticus* infected with external protozoa and monogenetic trematodes. Osman *et al.* (2009) also reported that serum AST and ALT enzyme activities, creatinine and Urea values were increased in *Trichodina* infected *Clarias gariepinus*. Mahmoud *et al.* (2011) more so reported that the serum AST, ALT, creatinine, and urea values were elevated in infected *O. niloticus* and *Clarias gariepinus*. The increase in the activity of AST and ALT in the serum of the infected fish revealed that the parasites might have had effects on the parenchymous tissues and/or skeletal musculature which probably may have altered the permeability and integrity of cell organelle (Egbu, 2011). Thus, allowing more of these enzymes to leak into the blood circulation.

Finding from our studies revealed that the presence of *Cryptosporidium oocysts*, *Eimeria oocysts* and *nematode* (infection) in both cultured and wild African catfish is associated with decreased in PCV, RBC and Hb ($28.0 \pm 0.331\%$, $3.4 \pm 0.592 \times 10^{12}/L$, 8.3 ± 0.174 g/dl) when compare with the uninfected *Clarias gariepinus* ($33.3 \pm 0.229\%$, $3.9 \pm 0.050 \times 10^{12}/L$, 10.5 ± 0.110 g/dl), respectively. However, the WBC was significantly higher ($p = 0.041$) in the infected *Clarias gariepinus* ($4.5 \pm 0.047 \times 10^9/L$) when compared to the uninfected ($3.9 \pm 0.017 \times 10^9/L$). The levels of transaminases (AST, ALT and ALP) were also were significantly higher ($p < 0.05$) in the infected *Clarias gariepinus* (82.2 ± 1.037 U/L, 95.8 ± 1.209 U/L, 68.8 ± 1.180 U/L) when compared with the uninfected (60.7 ± 0.741 U/L, 68.9 ± 0.844 U/L, 47.1 ± 0.759 U/L), respectively. It is therefore recommended that strict biosecurity measures and routine deworming should be ensured in the management of cultured African catfish for improve growth and health.

REFERENCES

- Akinsanya, B. and Otubanjo, O.A. (2006). Helminth parasites of *Clarias gariepinus* (*Clariidae*) in Lekki Lagoon, Lagos, Nigeria. *Revised Biology Tropica*, 54(1): 93-9.
- Anyeni, A.O., Adegbenro, M., Obadare, I.G., Oladayo, T.O. and Agbede, J.O. (2022). Haemato-biochemical indices, antioxidant and gut health status of broiler chicken fed composite leaf mix. *Animal Research International*, 19(1): 439 - 4402
- Al – Murjan, K. S. N. and Abdullahi, S. M. A. (2008). Some ectoparasites of the common carp (*Cyprinus carpio*) in Ainkawa fish hatchery, Erbil Province, Kurdistan Region, *Iran Journal for Duhov University* 12(1) (special issue), 102 – 107.
- Brar, R.S., Sandhu, H.S. and Singh, A. (2014). *Veterinary Clinical Diagnosis by Laboratory Methods*, 1 Ed. India: Kaylani Publishers, pp. 29-150.
- Caruso, G., Genovese, L., Maricchiolo, G. and Modica, A. (2005). Haematological, biochemical and immunological parameters as stress indicators in *Dicentrarchus labrax* and *Sparus aurata* farmed in off-shore cages. *Aquaculture International*, 13: 67-73 12.
- Chocchia, G. and Motais, R. (1989). Effect of catecholamines on deformability of red blood cells from trout: relative roles of cyclic AMP and cell volume. *Journal of Physiology*, 412:321-332.
- Egbu, F.M. (2011). Prevalence of Bovine Cysticercosis and Fascioliasis in Slaughtered Cattle in Nsukka Zone and the Haematological, Biochemical and Histopathological Changes in Response to Active Infection. M. Sc. Thesis. University of Nigeria, Nsukka, Nigeria.
- Enas, A., Abd, E., Doaa, M., Mokhtar, A., Sayed, A. and Hassan, A.H.S (2013). Comparative Histomorphological Studies on Oesophagus of Catfish and Grass Carp. *Journal of Histology*, doi:10.1155/2013/858674
- Fedato, R.P., Simonato, J.D., Martinez, C.B.R. and Sofiaa, S.H. (2010). Genetic damage in the bivalve mollusk *Corbiculafluminea* induced by the water-soluble fraction of gasoline. *Mutation Resources*, 700:80-85
- Food and Agriculture organization (FAO), (2016). The state of world fisheries and aquaculture
- Hassen, F.E.Z.M. (2002). Studies on Diseases Caused by Hennequya Infection. Ph.D. Thesis, Faculty of Veterinary Medicine Suez Canal University, Egypt.
- Ismail, G.A.E. (2003). Histopathological and Physiological Studies on Naturally Infected Catfish, *Clarias gariepinus* with Trypanosomes. M.Sc. Thesis, Faculty of Science Cairo University, Egypt.
- Kawe, S.M., God's power, R.O., Balarabe, M.R. and RI Akaniru, R.I. (2016). Prevalence of gastrointestinal helminth parasites of *Clarias gariepinus* in Abuja, Nigeria. *Sokoto Journal of Veterinary Sciences*, 14 (2): 24-26
- Komatsu, K. and Kitanishi, K. (2015). Household Protein Intake and Distribution of Protein Sources in the Markets of Southern Ghana: A Preliminary Report. *African Study Monographs*, 51(3): 157-173.
- Kori-Siakpere, O., Ake, J.E.G. and Idoge, E. (2005). Haematological characteristics of the African Snakehead, *Parachanna obscura*. *African Journal of Biotechnology*, 4(6):527-530.
- Lebola, S.L., Saunders, D.K. and Crawford, T.G. (2001). Observation on blood viscosity in striped bass, *Morone saxatilis* (Walbaum) associated with fish hatchery condition. *Kansas Academy of Science*, 104:183-184.
- Levine, N.D., Lee, R.R., Hunter, S.H. and Bovee, E.C (1985). *An Illustrated Guide to the Protozoa, Phylum II Apicomplexa*. Allen Press, Lawrence: 323-374.
- Lofty, H.S., Mahmoud, S.M. and Abdel-Gawad, M.A. (2003). Some studies on Fascioliasis in Mid-Egypt. *Agricultural Research*, 81(2):209-227.
- Lynne, S. and Garcia, M.S (1999). American Society for Microbiology. *Practical Guide to Diagnostic Parasitology*, 102-104.
- Mahmoud, A.E., Mona, S.Z., Abdel, R.Y., Dsouky, H.A., Osman, K.A.H., Ottiamm A.A.Z. (2011). Study on clinopathological and biochemical changes in some freshwater fish infected with external parasites and subjected to heavy metals pollution in Egypt. *Life Science Journal*, 8(3):401-405.
- Martins, M.L., Tavares-Dias, M., Fujimoto, R.Y., Onaka, E.M. and Nomura, D.T. (2004). Haematological alterations of *Lepomis macrocephalus* (Osteichthyes: Aniskidae) in

- fishpond. *Arq. Brasileiro Medical and Veterinary Zootenecnia*, 56:640-646.
- Murray, A. G. (2005). A framework for understanding the potential for emerging diseases in aquaculture. *Preventive Veerinary. Medicine*, 67:223 – 235
- Nnabuchi, O.O., Ejikeme, O.G., Didiugwu, N.C., Ncha, O.S., Onahs, S.P. and Amarachi, A.C (2015). Effect of parasites on the biochemical and haematological indices of some clariid (Siluriformes) catfish from Anambra River. *Nigeria International Journal of Fisheries and Aquatic Studies*, 3(2): 331-336.
- Odioko, E. and Becer, Z.A. (2022). The Economic Analysis of Nigerian Fisheries Sector; A Review. *Journal of Anatolian Environmental and Animal Sciences*, 79(2): 216-226.
- Okolo, E. and Makanjuola, A.T. (2021). Microbial Evaluation of Garri Sold Within Ahmadu Bello University Main Campus, Samaru, Zaria, Kaduna State. *Science World Journal*, 16(3): 259-265.
- Omeji, S., Yusufu, I. I. and Swem, M.A. (2022). Prevalence and Intensity of Gastrointestinal Helminths of *Clarias gariepinus* from selected Fish Farms in Makurdi, Benue State. *Arid Zone Journal of Basic and Applied Research*, 1(2): 104-115, ISSN: 2811-2881
- Omran, H.H. and El-Kholony, K.H. (2003). The influence of Nitroxylin on clinical, biochemical and haematological parameters in Egyptian buffaloes affected with liver flukes in Sharkia governorate. *Egyptian Journal of Agricultural Research*, 81(2):739-751 44.
- Oniye, S. J., Adebote, D. A. and Ayanda A. I. (2004). Helminth parasites of *Clarias gariepinus* (Teugels) in Zaria, Nigeria. *Journal of Aquatic Sciences*, 19(2): 17 – 75.
- Oriakpono, O., Hart, A. and Ekanem, W. (2012). Acute haematological response of a cichlid fish *Sarotherodon melanotheron* exposed to crude oil. *Journal of Toxicology and Environmental Health Sciences*, 4(9):151-155.
- Osman, H.A.M., Ismaiel, M.M., Abbas, T.W. and Ibrahim, T.B. (2009). An approach to the interaction between Trichodiniasis and pollution with Benzo-apyrene in catfish (*Clarias gariepinus*). *World Journal of Fish and Marine Sciences*, 1(4):283-289. 51.
- Pinky, K., Qureshi, T.A., Rekha, S., Susan, M. and Bilal, A. (2012). Histopathological and haematological investigations on *Nandus nandus* (Ham.) parasitized by metacercariae of *Clinostomum complanatum* (Rudolphi, 1819). *International Journal of Environmental Sciences*, 2(3):1324-1330.
- Pouder, D.B., Curtis, E.W. and Yanong, R.P.E (2011). Common freshwater fish parasites pictorial guide: Sessile ciliates. Retrieved April 12, 2011 from: <http://edis.ifas.ufl.edu/FA-107>
- Skelton, P.H. and Teugels, G.G. (1992). Neotype Designation for the African Catfish *Clarias gariepinus* (Pisces: Siluroidei: Clariidae). *Lchthyological Bulletin of the JLB Smith Institute of Ichthyology*, 56: 1-8.
- Thrusfield, M. (2008). *Veterinary Epidemiology*. 310 Third Edtn. Blackwell Science Ltd, a Blackwell Publishing company, UK, Pp 228-242.
- Yaji, A.J. and Auta, J. (2007). Sub-lethal effects of monocrotophos on some haematological indices of African catfish *Clarias gariepinus* (Teugels). *Journal of Fisheries International*, 2(1): 115-117.
- Younis, A.A.E. (1999). Effect of some ectoparasites on the blood and serum constituents of *Oreochromis niloticus* fish with referring to treatment. Beni Suif. *Veterinary Medical Journal*, 9(3):341-351.