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BIOCHEMICAL AND ENZYMATIC ALTERATIONS IN THE SERUM OF *Synodontis clarias* And *Clarias agboyiensis* FROM EPE AND LEKKI LAGOONS

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ABSTRACT
In order to evaluate the impact of the environment on fish physiology, this study examined seasonal fluctuations in biochemical and enzymatic parameters in the serum of Synodontis clarias and Clarias agboyiensis taken from Lekki and Epe Lagoons, Nigeria. Aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), cholesterol (CHOL), triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), and glucose (GLU) were among the important biomarkers examined. Significant seasonal variations (p<0.05) were found in both lagoons. In general, the dry season had greater lipid profiles (TG, HDL, LDL) and enzyme activities (AST, ALT, ALP) than the wet season, suggesting increased metabolic activity and potential environmental stress during the dry season. On the other hand, glucose levels were consistently higher during the dry season, which may indicate a stress response or increased energy demands. There were also differences in biochemical and enzymatic parameters in the lagoons in both seasons; Epe Lagoon frequently had somewhat higher biochemical and enzymatic values, which may indicate different ecological conditions. While Clarias agboyiensis showed significant increases in AST and ALT during the rainy season, Synodontis clarias showed large decreases in ALP, HDL, and GLU. These results demonstrate how sensitive fish biochemical indices are to seasonal and habitat changes, highlighting their significance as biomarkers for tracking the health of aquatic ecosystems and promoting sustainable fisheries management.

Keywords: Enzymes, *S. clarias, C. agboyiensis,* Glucose, Lagoons

INTRODUCTION

In tropical climates, coastal and inland water bodies are essential for maintaining fisheries output and sustaining livelihoods (Adetoyinbo and Otter, 2020). Lagoon ecosystems like Lekki Lagoon and Epe Lagoon are some of Nigeria's most productive aquatic habitats, supporting a variety of fish species that are significant to the country's economy (Adewale, 2024). However, seasonal variations in environmental factors like temperature, salinity, dissolved oxygen, and nutrients load have an impact on these highly dynamic ecosystems. Fish physiology, health, and overall productivity can all be greatly impacted by these seasonal variations (Aderinola *et al.,* 2021). Fish are especially sensitive to environmental changes, and biochemical markers are useful tools for evaluating physiological reactions to these changes. Reliable markers of metabolic activity, stress response, and organ function are serum biochemical parameters, which include metabolites like glucose, cholesterol, and lipids as well as enzymes like aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP). Alterations in these parameters may reflect environmental stressors such as pollution, changes in water quality, or fluctuations in food availability (Akintola *et al.,* 2025).

Biochemical markers are excellent biosensors of aquatic pollutants and quantifiable reactions to an organism's exposure to xenobiotics. Aquatic pollution can easily be detected through biomarkers, as enzymes provide one of the most reliable means of assessing the degree of exposure of animals to pollutants. A number of particular enzymes, including alkaline (ALP) and acid phosphatases, as well as alanine and aspartate aminotransferases (ALT and AST) have been suggested for monitoring water pollution and are thought to be helpful biomarkers to ascertain pollution levels in aquatic systems (Audu *et al.,* 2015). Because of their ease of measurement and correlation with the quantities of contaminants that organisms are exposed to, biochemical biomarkers are now often used to monitor the health status of organisms (Otitoloju and Olagoke, 2011). By comparing relative cellular enzyme activity with exposure levels, they are frequently employed to track the effects of oxidative stress caused by contaminants. Typically, the activities of antioxidant stress enzymes are progressively acquiring relevance in aquatic environment monitoring. Enzymes are crucial factors which permit several biochemical reactions that represent life to proceed in the cells of the body and therefore any changes in enzyme concentration in tissue cells reflect the state of health. The first enzymes in diagnostic enzymology to show liver impairment are amino transaminases (AST and ALT), which are trustworthy organ marker enzymes. The measurement of phosphatase (ACP and ALP) activity is a useful indicator of liver function (Balakrishnan *et al.,* 2014). Additionally, total cholesterol levels are useful markers of fish health (Yoneyama *et al.*, 2009).

Fish are especially vulnerable to water pollution, and contaminants can disrupt a variety of physiological and biochemical processes if they are absorbed by fish tissue, among other things (Durmaz *et al.,* 2006). Because they are consumers at a relatively high level in the aquatic food chain, fish continue to be a very dependable part of an aquatic monitoring system. Due to their high sensitivity to changes in the aquatic environment, fish are becoming a more significant bioindicator species in the monitoring of water pollution (Mondon, 2000). Any stress that fish are exposed to causes a variety of changes in their organs, especially the liver, spleen, and gills. Inland waters of Nigeria are home to the species *Synodontis clarias* and *Clarias agboyiensis*, which are significant both ecologically and economically. It is an appropriate bio-indicator for evaluating ecosystem health because to its tolerance to a variety of environmental situations. Despite its significance, little is known about how seasonal variations affect its physiological and biochemical reactions in lagoon systems, especially in Lekki and Epe lagoons, which have different hydrological and ecological features (Agbeja, 2017). Detecting sub-lethal stress, assessing fish health, and directing sustainable fisheries and aquaculture management techniques all depend on an understanding of seasonal fluctuations in biochemical markers. Planning for conservation and environmental monitoring also depend on this information, particularly in areas where anthropogenic pressures are growing. In order to provide baseline data for evaluating fish health and promoting sustainable management of these significant aquatic ecosystems, this study sought to examine the seasonal variations in serum biochemical and enzymatic parameters of *Synodontis clarias* and *Clarias agboyiensis* from Lekki Lagoon and Epe Lagoon.

MATERIALS AND METHODS

Description of Study Area

The study was carried out in Lekki and Epe Lagoons, which was further sub-divided into 8 stations namely: Ibeju Town, Omu, Abejuoye, Okera-kekere, Ejirin, Oko-Orisan, Oju-alaro and Chief fish jetty. Epe lagoon is situated between latitudes 003°50'-004°10'N and longitudes 06°35' - 06°40'E. the lagoon lies within the rainforest belt of southern Nigeria. The Lekki lagoon is one of the largest lagoons in west Africa and it supports a major fishery. The lagoon is located between Lagos and Ogun states of Nigeria and lies between longitude 003°55' and 4° 15' E and between latitude 6°25' and 6°37'N. (Figure 1).

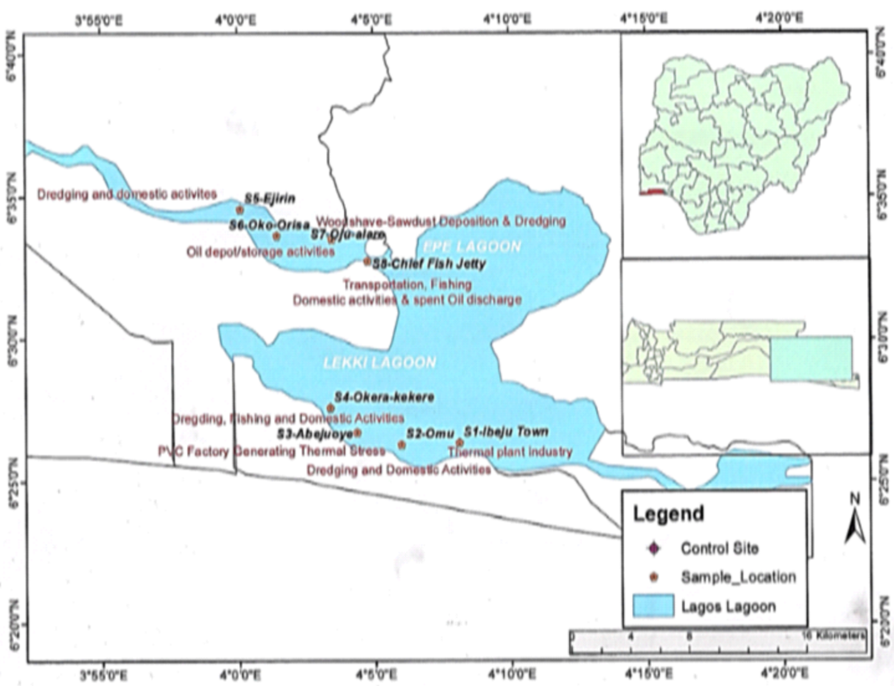

Figure 1: Map of Sampling Stations at Epe and Lekki Lagoons
Source: Field Survey, Department of Geography, University of Lagos

Collection and identification of Fish samples

The species *Clarias agboyiensis* (Plate 1) and *Synodontis clarias* (Plate 2) were identified with Field Guide to Nigerian Freshwater Fishes by Olaosebikan and Raji, (1998). The samples were selected based on their biological niche, availability, and susceptibility to pollution from hotspots. A trap net placed at the lagoon's bottom was used to capture the fish samples. *Synodontis clarias* of mean weight 33.52 ± 0.22g and mean length 28.40 ± 0.25 cm and *Clarias agboyiensis* of mean weight 210.06 ± 3.67 g and mean length 185.2 ± 2.54 cm were sampled and utilized in the laboratory. To reduce stress before sampling, fish were moved into aerated containers as soon as they were caught. During both seasons, a total of 40 healthy adult fish (20 of each species) with similar sizes and weight ranges were chosen at random from each lagoon. To maintain ambient conditions, fish were brought to the laboratory in insulated containers filled with lagoon water. Blood samples were collected within 60 minutes after sampling.

Blood Collection

To lessen handling stress, fish were put to sleep before blood was drawn. Using sterile disposable syringes, caudal vein punctures were used to collect blood samples. From each specimen, two to five millilitres of blood were drawn. After being collected, the blood samples were put into normal, non-heparinized tubes and left to coagulate at room temperature. After that, samples were centrifuged for 10 minutes at 3000 rpm to extract serum. Before biochemical analysis, the serum was properly decanted into labelled vials and kept at -20°C.

Biochemical Analysis

Following manufacturer directions, commercially accessible test kits and established clinical diagnostic techniques were used to assess serum biochemical parameters.According to Tietz (1990), the following parameters were examined.The colorimetric approach based on enzymatic activity was used to measure aspartate aminotransferase (AST) and alanine aminotransferase (ALT). Standard enzymatic kinetic techniques were used to quantify the activity of alkaline phosphatase (ALP). Enzymatic colorimetric assays were used to measure triglycerides (TG) and total cholesterol (CHOL). Low-density lipoprotein (LDL) cholesterol was determined using conventional calculating techniques, whereas high-density lipoprotein (HDL) cholesterol was tested following the precipitation of other lipoproteins. The glucose oxidase method was used to measure the concentration of glucose (GLU). Every analysis was performed in compliance with accepted practices in clinical biochemistry and fish physiology.

Quality Control

Instruments were calibrated before use, and all reagents were produced in accordance with manufacturer specifications. To guarantee accuracy and repeatability of the findings, samples were examined twice.

Statistical Analysis

Mean ± standard error (Mean ± S.E.) was used to express the collected data. SPSS (version 23.0) was used to conduct statistical analysis. Seasons and locations were tested for significant differences using one-way analysis of variance (ANOVA). Duncan's Multiple Range Test was used to separate means when substantial differences were found. At $p < 0.05$, differences were deemed statistically significant. Significant variations between means within rows were denoted by superscripts.

Ethical Considerations

Standard ethical rules for the use of animals in research were followed in all experimental methods involving fish handling and sampling, guaranteeing minimal stress and humane treatment throughout the investigation.

Plate 1 : *Clarias agboyiensis*

Plate 2 : *Synodontis clarias*

RESULTS

Tables 1 and 2 show seasonal differences in the serum biochemical characteristics of *Synodontis clarias* from the Lekki and Epe lagoons. Table 1 shows distinct seasonal patterns in both lagoons. In this study, there was decrease in AST from 91.60 ± 1.21 in dry season to 77.23 ± 2.01 U/L in wet season in Lekki lagoon, while AST decreased from 93.89 ± 1.52 in dry season to 83.56 ± 2.98 U/L in wet season in Epe Lagoon

. ALP showed a similar seasonal reduction, declining significantly in both lagoons during the rainy season. While there was a small decrease in Epe during the wet season, ALT exhibited less noticeable seasonal change. The values of the lipid profile showed regular seasonal trends. Triglycerides (TG) dramatically dropped from the dry to the wet season in both lagoons, whereas total cholesterol marginally increased during the wet season. In the two species, at both regions' levels of low-density lipoprotein (LDL) and high-density lipoprotein (HDL) significantly decreased during the rainy season.similarly , lower levels of glucose (GLU) were observed during the rainy season and higher values were recorded in during the dry season; in which Epe Lagoon had the lowest values (2.50 ± 0.11 mmol/L).

Different superscripts show that the majority of these differences were statistically significant ($p < 0.05$). A somewhat different seasonal pattern was seen in Table 2. In Lekki Lagoon, AST activity rose from 90.56 ± 2.10 to 119.86 ± 7.38 U/L during the rainy season, while in Epe Lagoon, it slightly increased. Both lagoons' ALT levels rose throughout the rainy season, with Epe having the highest value (33.52 ± 1.18 U/L). In contrast, both places' ALP somewhat decreased during the rainy season. In terms of lipid parameters, cholesterol levels in Lekki Lagoon were typically higher during the rainy season, while they marginally dropped in Epe Lagoon. In both lagoons, triglycerides showed a noticeable decrease from the dry to the rainy season. While LDL levels significantly decreased during the rainy season, especially in Lekki Lagoon, HDL levels decreased. In both lagoons, glucose concentrations showed a similar pattern, with much lower values during the wet season and much greater values during the dry season.The majority of metabolites and enzyme activity showed clear dry-wet season fluctuations, although the degree and direction of change differed across the Lekki and Epe lagoons. Overall, the data suggest considerable seasonal influences on biochemical parameters.

Table 1: Seasonal variations in mean activities of biochemical parameters in the serum of *Synodontis clarias* from Lekki and Epe lagoons (Mean ± S.E)

	Lekki lagoons		Epe lagoons	
	Dry	Wet	Dry	Wet
AST u/l	91.60 ± 1.21^{c}	77.23 ± 2.01^{a}	93.89 ± 1.52^{c}	83.56 ± 2.98^{b}
ALT u/l	26.97 ± 1.72^{a}	27.03 ± 1.11^{a}	31.69 ± 1.10^{b}	26.72 ± 1.07^{a}
ALP u/l	24.03 ± 0.52^{c}	7.78 ± 0.54^{a}	27.83 ± 0.16^{c}	10.18 ± 0.72^{b}
CHOL mmol/l	5.19 ± 0.12^{b}	5.37 ± 0.17^{b}	4.18 ± 0.03^{a}	5.23 ± 0.16^{b}
TG mmol/l	9.46 ± 0.18^{b}	5.23 ± 0.17^{a}	9.07 ± 0.31^{b}	5.51 ± 0.14^{a}
HDL mmol/l	5.23 ± 0.20^{b}	2.18 ± 0.11^{a}	7.71 ± 0.23^{c}	2.33 ± 0.09^{a}
LDL mmol/l	5.32 ± 0.18^{c}	1.11 ± 0.09^{b}	5.01 ± 0.07^{c}	0.98 ± 0.07^{a}
GLU mmol/l	6.93 ± 0.16^{b}	3.55 ± 0.12^{a}	8.26 ± 0.12^{b}	2.50 ± 0.11^{a}

Means within the same row with different superscript are significantly different ($p<0.05$)

Table 2: Seasonal variations in mean activities of biochemical parameters in the serum of *Synodontis clarias* from Lekki and Epe lagoons (Mean ± S.E)

	Lekki lagoons		Epe lagoons	
	Dry	Wet	Dry	Wet
AST u/l	90.56 ± 2.10^{a}	119.86 ± 7.38^{c}	96.00 ± 4.17^{a}	100.15 ± 6.02^{b}
ALT u/l	18.86 ± 0.39^{a}	26.71 ± 0.78^{b}	16.47 ± 0.20^{a}	33.52 ± 1.18^{c}
ALP u/l	15.78 ± 0.28^{b}	12.05 ± 1.10^{a}	14.11 ± 0.16^{b}	11.98 ± 1.11^{a}
CHOL mmol/l	5.68 ± 0.11^{a}	6.09 ± 0.20^{a}	7.98 ± 0.23^{b}	6.29 ± 0.26^{a}
TG mmol/l	11.81 ± 0.16^{b}	5.96 ± 0.31^{a}	11.84 ± 0.16^{b}	6.55 ± 0.28^{a}
HDL mmol/l	5.13 ± 0.09^{b}	2.88 ± 0.10^{a}	4.38 ± 0.06^{b}	2.53 ± 0.08^{a}
LDL mmol/l	5.34 ± 0.24^{b}	1.21 ± 0.10^{a}	1.81 ± 0.13^{a}	1.10 ± 0.06^{a}
GLU mmol/l	6.86 ± 0.25^{b}	2.64 ± 0.09^{a}	9.05 ± 0.22^{c}	1.81 ± 0.10^{a}

Means within the same row with different superscript are significantly different ($p<0.05$)

DISCUSSION

Blood parameters variations have been linked to reactions that altered physiological and energetic demands (Adeogun, 2011) and could be an early indicator of stress before population losses are noticed. The fish *Synodontis clarias* and *Clarias agboyiensis* may have significant elevations in transaminase (ALT & AST) activity as a result of enzyme leakage via the damaged plasma membranes, which is peculiar to fish under stressful conditions (Akinrotimi *et al.,* 2025). Therefore, elevated serum ALT and AST levels indicate liver and cardiac disease. According to this study, elevated AST and ALT activity in fish are indicative of hepatic cellular injury that causes them to seep into the bloodstream. These results corroborated the theory that elevated serum transaminases (ALT and AST) could be a sign of liver toxicity, which causes the enzymes to be widely released into the bloodstream (Daabees *et al.,* 1992).Particularly when the degree of elevation is mild or severe, the amplitude and relative level of elevation of the ALT and AST are helpful in the differential diagnosis for the aetiology of the liver injury. The transfer of amino groups to produce the liver metabolites pyruvate and oxaloacetate, respectively, is catalysed by the abundant hepatic enzymes AST and ALT. While two AST isoenzymes are present in the cytosol and mitochondria, respectively, the ALT is situated in the liver's cytoplasm.

Following hepatic injury or death, damaged hepatocytes release both ALT and AST into the blood. Fish species from the Epe and Lekki lagoons secrete liver damage into their blood, as evidenced by the elevated levels of AST and ALT in the serum of *C. agboyiensis* and *S. clarias*. As demonstrated in this work, AST and ALT transaminases play a significant role in the metabolism of proteins and amino acids and may release into the plasma in response to tissue damage and dysfunction. Unbalances in the physiology and architecture of the reservoir tissues are responsible for this rise in AST activity (Akinrotimi *et al.*, 2025). Blood cholesterol is carried by molecules known as lipoproteins. Low-density lipoprotein (LDL) and high-density lipoprotein (HDL) are two significant types of lipoproteins. Based on the HDL, LDL, and triglyceride levels, total cholesterol is a measurement of the overall quantity of cholesterol in your blood (NCDP, 2015). When compared to the levels of cholesterol in *Synodontis clarias* from Epe lagoons, the serum of *Clarias agboyiensis* from Epe lagoons was shown to have significantly higher amounts of cholesterol. Species-specific physiological and ecological variations may be the cause of the noticeably higher serum cholesterol level seen in *C. agboyiensis* compared to *S. clarias* from Epe Lagoon. In fish, cholesterol is essential for energy storage, steroid hormone synthesis, lipid metabolism, and cell membrane formation (Gabriel and Akinrotimi, 2011). Fish species' differences in eating patterns, nutritional status, metabolic activity, reproductive state, and environmental adaption are frequently associated with variations in serum cholesterol (Abu *et al.,* 2009). Because of its feeding ecology and metabolic traits, *C. agboyiensis* may have a higher ability for lipid assimilation and storage. According to Akinrotimi *et al*. (2011), fish species that consume diets high in animal protein and fats typically have higher serum cholesterol concentrations than species that eat less lipid-rich food sources. Additionally, since cholesterol is a precursor to steroid hormones needed for gonadal maturation, the observed variation may have been influenced by variations in the species' reproductive condition (Maita, 2007). The metabolism of cholesterol may also be influenced by environmental variables. Fish lipid metabolism and biochemical profiles can be changed by exposure to contaminants, changes in water quality, and stresses unique to their ecosystem (Gabriel *et al.,* 2011). Due to differences in physiological tolerance and adaptation mechanisms, species living in the same lagoon environment may react differently to such stresses. Therefore, species-specific metabolic responses, food preferences, reproductive activity, and environmental adaptability may all contribute to the higher cholesterol level found in *C. agboyiensis* (Zhou *et al,* 2009).

Most of the cholesterol in the body is low-density lipoprotein (LDL) cholesterol. Because excessive levels of LDL can cause plaque to accumulate in arteries and cause heart disease and stroke, LDL is also known as "bad" cholesterol (NCDP, 2015). Both *Synodontis clarias* from both lagoons and *Clarias agboyiensis* from Lekki lagoon were found to have elevated LDL levels during the dry season. The significantly elevated LDL concentrations observed in *Synodontis clarias* from both lagoons and *Chrysichthys agboyiensis* from Lekki Lagoon during the dry season may be associated with increased lipid metabolism, enhanced feeding activity, and greater accumulation of energy reserves under favourable environmental conditions. The reduced water volume characteristic of the dry season may also concentrate pollutants and other environmental stressors, thereby influencing hepatic lipid metabolism and promoting increased LDL production (Pradhan *et al.,* 2012). Conversely, the lower LDL values recorded during the rainy season could be attributed to dilution effects, improved water quality, altered feeding patterns, and increased utilization of lipid reserves for growth, osmoregulation, and reproductive processes. These findings suggest that seasonal environmental fluctuations play an important role in regulating lipid metabolism and lipoprotein dynamics in lagoon fish species (Zhou et al, 2009).

When *Synodontis clarias* is regularly consumed during the dry season, it can biomagnify and cause heart disease in humans. Cholesterol is absorbed by high-density lipoprotein (HDL) and returned to the liver, where it is eliminated from the body. Because high levels of HDL can lower the risk of heart disease and stroke, it is known as "good" cholesterol. During the dry season at Epe Lagoon, *Synodontis clarias* was found to have a high HDL level. The blood contains triglycerides, a kind of fat that is used as fuel. The risk of heart attack and stroke is increased when high triglycerides are combined with either low HDL or high LDL cholesterol. During the dry season in the Epe and Lekki lagoons, respectively, the levels of triglycerides were considerably higher in both fish species. In this study, both fish species at Epe Lagoon had considerably higher glucose levels ($p<0.05$) during the dry season. Significant increases in plasma glucose concentrations could be caused by a greater need for energy, which raises plasma levels of catecholamines and corticosteroids (Amachree *et al*., 2005). These chemicals are known to cause excessive adrenalin secretion, which promotes the breakdown of glycogen to glucose by blocking the neuro effector sites in the adrenal medulla (Orokotan *et al.,* 2025). These increases could possibly result from stressed fish's increased gluconeogenesis response as they try to meet their increased energy needs (Winkaler *et al.,* 2007).

CONCLUSION AND RCOMMENDATIONS

The serum biochemical parameters of *Synodontis clarias from* the Lekki and Epe lagoons showed significant seasonal variations, which may be attributed to so, so and so. according to the study. Fish physiology is strongly influenced by the environment, as evidenced by the large differences in enzymatic activity (AST, ALT, and ALP) and metabolic indices (glucose and lipid profile) between dry and wet seasons. While the wet season was marked by lower values, perhaps as a result of dilution effects, better water quality, or different feeding conditions, higher enzyme activities and metabolic constituents during the dry season generally indicate increased metabolic stress or intensified physiological activity. Nonetheless, a few metrics revealed location-specific variations, emphasizing the ecological distinctions between the Epe and Lekki lagoons.

The following recommendations are made in light of the study's findings:

1. To identify early physiological stress, lagoon management and fish health assessment programs should include routine biochemical parameter monitoring.
2. To support ecological interpretations, comparative studies with more fish species and longer sample times are advised.
3. To guarantee sustainable fish populations, conservation and management plans for the Lekki and Epe lagoons should take seasonal stress patterns into consideration.

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