

Research Article

**BACTERIAL OCCURRENCE IN WILD AND CULTURED
Clarias gariepinus FROM YOLA, ADAMAWA STATE,
NIGERIA**

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ABSTRACT

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An important cause of contamination in fisheries and aquaculture products is bacteria. They continue to be a major impediment towards obtaining sustainable fisheries and aquaculture production. They cause several public health hazards that producers, marketers, and consumers of food fish are deeply concerned about. The current study assessed the occurrence of bacteria in *Clarias gariepinus* from Yola, Adamawa state, Nigeria. Thirty (30) *C. gariepinus* were collected from the wild and a fish farm. Physicochemical measurements of the water were made at the time of the fish collection. The fish samples collected were transported to the laboratory for bacteriological analysis. Tissues were collected from the stomach, liver, and gills of the sampled fish and isolated for the occurrence of bacteria in them. The isolated bacteria were identified and characterized. The data that were collected were subjected to descriptive statistics analysis. The tissues of the examined *C. gariepinus* contained bacterial species including *Escherichia coli*, *Staphylococcus aureus*, *Enterobacter aerogenes*, *Staphylococcus* sp., *Enterobacter cloacae*, *Streptococcus iniae*, *Citrobacter diversus*, *Proteus mirabilis*, *Klebsiella pneumoniae*, *Pseudomonas mallei*, and *Yersinia enterocolitica*. The occurrence of these bacteria in the tissues of the fish samples examined raises possible public health concerns about fish and fish products from the lake and fish farm under investigation.

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INTRODUCTION

In Nigeria and other sub-Saharan African nations, where around 35 million people rely entirely on or in part on the fisheries sector for their living, fish is a significant source of revenue and food (Food and Agriculture Organization (FAO, 2021). The typical Nigerian household has continued to find fish to be an economical source of animal protein that also provides lipids, minerals, and vitamins (Haruna, 2006). According to Ibeun (2006), Nigeria has a surface area of freshwater lakes, reservoirs, and ponds that is estimated to be 12.5 million hectares, and this area has the potential to produce 521,000 metric tonnes of fish annually (FAO, 2014).

Nigeria and the rest of the world both have a rapidly expanding fish production business. The current expansion of intensive food fish production is being driven by the rising demand for fish as food. Public health concerns, such as diseases and contaminations among fish consumers are now being raised as a result (FAO, 2012; Idowu, 2019).

The most frequent contaminants (pathogens) that aquatic animals encounter in both natural and cultivated water bodies are believed to be bacteria (Idowu *et al.*, 2017a). Aquatic environments frequently include bacteria, and many of them have an infectious character (Idowu, 2019). However, when aquatic animals (fish) are physiologically out of balance, nutritionally inadequate, or are exposed to other stresses, such as poor water quality and overstocking, these bacteria turn pathogenic. The real function of these bacteria varies, though, from being a major pathogen to an opportunistic invader that affects the disease

processes of a host that is inactive (Idowu *et al.*, 2017a). Public health is concerned about the potential for their spread from fish to humans through fish food intake (Romero *et al.*, 2012). Consumers of fish food and products today are increasingly concerned with their health and curious about how safe the fish they eat (Zhou *et al.*, 2020; Hassan *et al.*, 2021; van Bussel *et al.*, 2022). They are growing more interested in the food fish's health and nutritional benefits, as well as how their production affects the environment (Karunasagar, 2012; van Bussel *et al.*, 2022).

The study was aimed at the occurrence of bacterial infection in both wild and cultured *Clarias gariepinus* in Yola, Adamawa state, Nigeria.

MATERIALS AND METHODS

Study sites

The selected fish farm and lake, where the experimental fish samples for this study were collected, are situated between latitudes 9°17'N and 12°25'E in Yola, Adamawa state. The selected lake, Lake Gerio is situated between latitudes 9° 81'N and 9° 17'N and longitude 12° 25'E on the outskirts of the Jimeta-Yola metropolis in Adamawa state, Nigeria. The lake was formerly a small gully that eventually grew larger due to water from rain and the River Benue (Abubakar, 2005). The lake has a mean depth of around 3 meters and a development-friendly area for fisheries of about 250 hectares (Abubakar, 2005). All year long, people fish in and around the lake, and they also irrigate their farms. The research was done between March and May 2020.

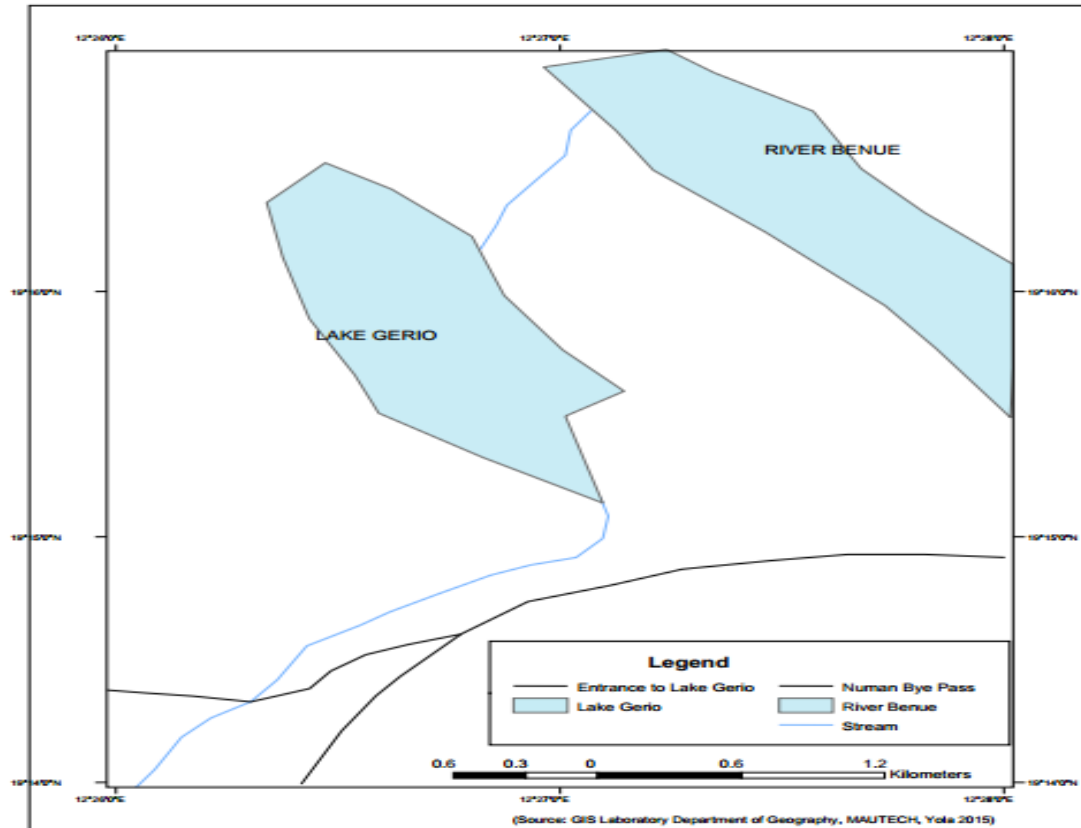


Figure 1: Map of Lake Gerio *Source: Idowu et al. (2017b).*

Fish sampling

A total of thirty *C. gariepinus* were sampled for the study out of which fifteen each were from a selected fish farm and Lake Gerio respectively. The fish samples were transported in an ice chest to the Bacteriological Laboratory, Department of Microbiology, Modibbo Adama University of Technology, Yola. Using a digital thermometer, Secchi disc, pH meter, and dissolved oxygen meter, respectively, water physicochemical parameters including temperature (OC), turbidity (cm), pH, and dissolved oxygen (DO) were measured at the time of fish collection.

Fish tissue sampling and bacterial isolation

Tissues from the gills, stomach, and liver of the experimental fish were sampled aseptically within six hours of the fish being sampled. The bacteriological examinations were carried out as described by Onwenefah and Adedeji (2013). The isolated bacteria were characterized based on colony morphology, gram nature, form, motility, and their behaviour in media. They were identified by Bergey's Manual of

Determinative Bacteriology (Garrity, 2001) and Clinical Veterinary Microbiology (Quinn *et al.*, 1994). These were compared with those from earlier reports (Austin and Austin, 1999; Takyi, *et al.*, 2012).

Statistical Analysis

The data were analysed by descriptive statistics (percentage) and correlation using SPSS v20

RESULTS

Physicochemical Parameters of Fish Sampling Sites

The average values of the water's physicochemical parameters from the fish sampling sites were shown in Table 1. The highest pH value was 6.6 ± 0.15 at Lake Gerio in May. The highest temperature value, $31.7 \pm 1.0^\circ\text{C}$, was recorded in the month of April. The highest readings for turbidity, $41.9 \pm 12.6\text{cm}$ and dissolved oxygen (DO), $6.9 \pm 3.8\text{mg/l}$ were made in the months of March and April, respectively. The highest pH value from the fish farm was 6.8 ± 2.2 , and the maximum temperature was $30.2 \pm 2.0^\circ\text{C}$, both in the months

of May and April, respectively. The highest turbidity reading of 31.9 ± 5.6 cm was recorded in

May. The highest DO reading, 4.7 ± 1.0 mg/l was observed in April.

Table 1: Water quality parameters measured

Site/Month	Lake Gerio				Fish Farm			
	pH	Temp ($^{\circ}$ C)	Turbidity (cm)	DO (mg/l)	pH	Temp ($^{\circ}$ C)	Turbidity (cm)	DO (mg/l)
March	6.4 ± 1.1	29.2 ± 0.7	41.9 ± 12.6	6.3 ± 0.8	6.2 ± 1.8	29.8 ± 1.9	23.3 ± 8.5	4.3 ± 1.3
April	6.5 ± 1.8	31.7 ± 1.0	40.3 ± 4.3	6.9 ± 3.8	6.2 ± 5.5	30.2 ± 2.0	31.5 ± 6.0	4.7 ± 1.0
May	6.6 ± 1.5	31.3 ± 0.3	40.4 ± 7.4	6.7 ± 6.7	6.8 ± 2.2	28.4 ± 8.0	31.9 ± 5.6	4.3 ± 1.3
Mean \pm SE	6.5 ± 0.9	30.6 ± 0.3	40.9 ± 3.8	6.6 ± 2.5	6.4 ± 1.6	29.5 ± 0.4	28.9 ± 3.0	4.4 ± 1.6

Identification of bacterial isolates from tissues of examined fish

Table 2 showed the biochemical reactions of the isolated bacterial species from the tissues of the fish under examination. Table 3 illustrates the diversity of bacterial isolates from *C. gariepinus* tissues. The gills, stomach, and liver of the examined *C. gariepinus* were found to contain bacteria species such as *Escherichia coli*, *Staphylococcus aureus*, *Staphylococcus saprophyticus*, *Enterobacter*

aerogenes, *Streptococcus iniae*, *Enterobacter cloacae*, and *Citrobacter diversus*. *Staphylococcus aureus* was found in the gills, stomach, and liver of the examined *C. gariepinus* from Lake Gerio at the rate of 37.5%, 22.2%, and 38.1% respectively. The examined *C. gariepinus* from the fish farm had no occurrences of *S. aureus*. *Enterobacter cloacae* was found in 6.7% of the gills, 26.7% of the stomach and 14.3% of the liver of the examined *C. gariepinus* from the fish farm.

Table 2: Biochemical reactions of identified bacterial species

Species/ test	Indole	Simmon-citrate	Catalase	coagulase	Gram test	Shape
<i>E. coli</i>	+	-	+	-	-	B
<i>S. aureus</i>	+	-	+	+	+	C
<i>S. saprophyticus</i>	-	-	+	-	+	C
<i>E. aerogenes</i>	-	+	+	-	-	B
<i>Staphylococcus sp.</i>	-	-	+	+	+	C
<i>Enterobacter cloacae</i>	-	-	+	-	-	B
<i>S. iniae</i>	-	-	-	-	+	C
<i>Citrobacter diversus</i>	+	+	+	-	-	B
<i>Proteus mirabilis</i>	-	+	+	-	-	B
<i>Klebsiella pneumoniae</i>	-	+	+	-	-	B
<i>Neisseria sicca</i>	-	+	+	-	-	B
<i>Pseudomonas mallei</i>	-	-	+	-	-	B
<i>Y. enterocolitica</i>	-	+	+	-	-	B

Key: B= Bacillus, C= Cocci, += Positive, - = Negative.

Table 3: Bacteria diversity in the tissues of *C. gariepinus*

Bacteria	Lake Gerio			Fish Farm		
	Gill No (%)	Stomach No (%)	Liver No (%)	Gill No (%)	Stomach No (%)	Liver No (%)
<i>Escherichia coli</i>	-	-	1 (4.8)	1 (6.7)	4 (26.7)	2 (14.3)
<i>Staphylococcus aureus</i>	9 (37.5)	4 (22.2)	8 (38.1)	-	-	-
<i>Staphylococcus saprophytica</i>	3 (12.5)	1 (5.6)	3 (14.3)	3 (20)	-	-
<i>Entrobacter aerogenes</i>	1 (4.1)	1 (5.6)	2 (9.5)	-	1 (6.7)	-
<i>Staphylococcus spp</i>	9 (37.5)	3 (16.7)	6 (28.6)	5 (33.3)	6 (40)	7 (50)
<i>Entrobacter clocae</i>	2 (8.3)	2 (11.1)	-	2 (13.3)	1 (6.7)	2 (14.3)
<i>Strptococcus iniae</i>	-	1 (5.6)	1 (4.8)	-	-	1 (7.1)
<i>Citrobacter diversus</i>	-	5 (27.8)	-	-	1 (6.7)	-
<i>Proteus mirabilis</i>	-	1 (5.6)	-	-	-	-
<i>Klebsiella pneumonie</i>	-	-	-	1 (6.7)	-	1 (7.1)
<i>Neisseria Sicca</i>	-	-	-	1 (6.7)	-	-
<i>Pseudomonas mallei</i>	-	-	-	2 (13.3)	-	1 (7.1)
<i>Yersinia entrocolitica</i>	-	-	-	-	2 (13.3)	-
TOTAL	24	18	21	15	15	14

Figure 2 showed the distribution of bacterial isolates from *C. gariepinus* tissues from the study sites. The highest bacterial distributions were recorded in all the tissues investigated in

the examined *C. gariepinus* from Lake Gerio. The number of bacterial distributions (24) was observed in the gills of the *C. gariepinus* sampled from Lake Gerio.

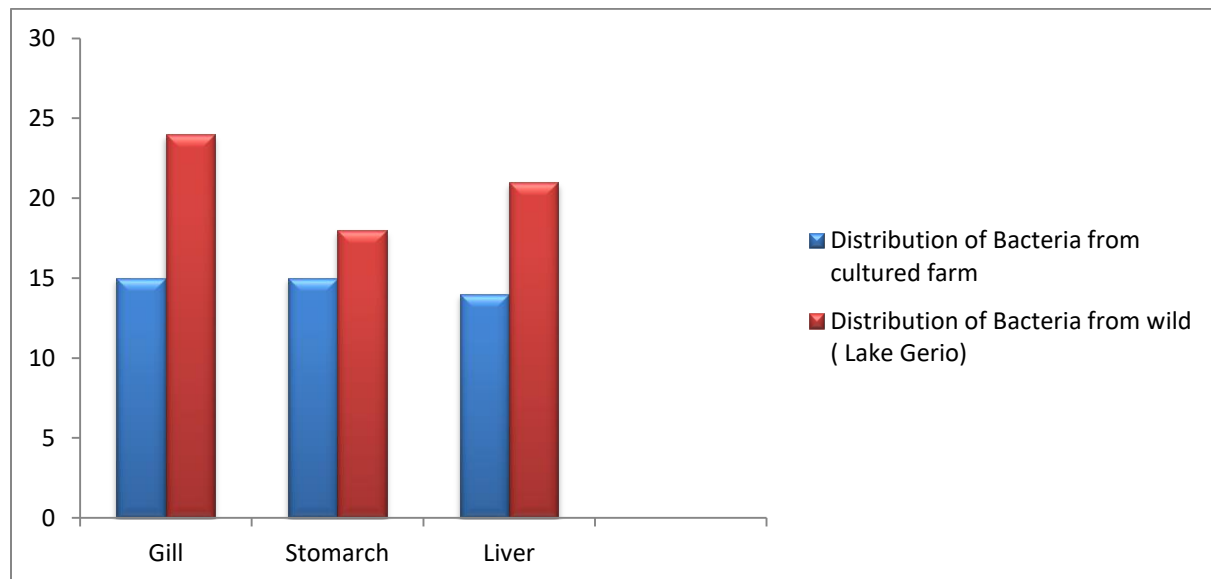


Figure 2: Bacteria diversity in *Clarias gariepinus* from the experimental sites

DISCUSSION

The physicochemical characteristics of the two sites were within the permissible limits for *C. gariepinus* according to the water quality data generated in this study. Fish life circumstances might be excellent or poor based on elements of water quality. Optimal lake and pond water conditions encourage fish growth and reproduction while lowering disease susceptibility in fish (Bolorunduro and Abdullah, 1996). Bacteria are typical elements of lakes and ponds, and they are found on the fish that live there. Fish have the innate capacity (immunity) to resist the harmful actions of bacteria and appear healthy without exhibiting any signs of infection or disease (Agriculture, Fisheries and Conservation Department [AFCD], 2009; Idowu *et al.*, 2017b). In the current study, the examined fish from Lake Gerio and fish farms were reportedly having the presence of several bacteria species in them. This suggests that the good water quality of fish farms and lakes and the apparent healthy nature of the fish in them do not necessarily mean that the water bodies and the fish are free or safe from pathogenic bacteria (Francis-Floyd, 2005; Roberts, 2012).

Staphylococcus spp., *Enterobacter* spp., *Streptococcus* spp., *Pseudomonas* spp., *Aeromonas* spp., and *Klebsiella* spp. were among the bacterial species that have been found in fish species from lakes and fish farms (Soliman, 1999; Ikpi and Offem, 2011; Takyi *et al.*, 2012). The findings of this study are comparable to those of Takyi *et al.* (2012), whose investigation into bacterial infections in two commonly cultivated fish species—*Oreochromis niloticus* and *C. gariepinus*—in southern Ghana revealed bacterial diversity comparable to that found in the current study. According to the findings of the current study's bacteriological analysis, there were more diverse bacteria found in the studied *C. gariepinus* from Lake Gerio than in the fish farm. This might be due to

microorganisms from nearby waste materials and runoff water directly contaminating the lake (Wamala *et al.*, 2018). Additionally, lake water bodies have reportedly been used as a reservoir for sewage and agricultural runoff, as well as water that has been drained from nearby fish farms (Ibrahem *et al.*, 2008; Adedeji *et al.*, 2011).

Although Gram-positive bacteria were also discovered, particularly *Staphylococcus* spp., Gram-negative bacterial species predominated the isolated bacteria from this investigation. The abundance and diversity of the bacteria reported in the study could be a sign that the study areas under investigation have higher concentrations of infectious bacteria, which could pose a threat to the health of the public as well as the fish and people who would eventually consume them (Flick, 2008; Ampofo and Clerk, 2010). The bacteria species discovered in this investigation were recovered from samples of *C. gariepinus* that appeared to be in good health. This could be a sign that the good water conditions of the study sites where the examined *C. gariepinus* were sampled had contributed to reducing the stress challenges that fish usually faced as a result of poor water conditions that increase fish's vulnerability to bacterial infection and disease development (Danba *et al.*, 2014). Also, this could be because some bacterial species' harmful activities were suppressed by the innate defence response of the fish samples (AFCD, 2009; Efuntoye *et al.*, 2012).

Some of the bacterial species identified in the present study have been reported to be of health significance in fish and the consumers of fish food (Flick, 2008; Danba *et al.*, 2014; Adeshina *et al.*, 2016). This shows that the discovery of these bacteria during this study might raise safety concerns for both the fish and people who eat them. Numerous bacterial species, including those belonging to the genera *Citrobacter*, *Pseudomonas*, *Klebsiella*,

and *Staphylococcus*, have been identified as potential human pathogens (Ampofo and Clerk, 2010; Adeshina *et al.*, 2016). The present study's isolation of species from these bacterial genera provides evidence that humans who would consume fish and fish products from the lake and fish farm may face health risks (Adeshina *et al.*, 2016). Although *Klebsiella pneumoniae* is thought to be commensal in the aquatic environment, it has been shown that high contamination levels in fish may provide health risks to those who eat the contaminated fish (Ampofo and Clerk, 2010).

Escherichia coli have been linked to gastrointestinal infections in humans, and it has been claimed that the presence of the bacteria in food or water can be a sign that other bacteria are present that are the causes of other gastrointestinal ailments (World Health Organization [WHO], 2018). The consumption of fish caught at these sites by humans could be inferred as another significant public health concern. Two of the bacteria reported in this study, *E. coli* and *Staphylococcus* sp. can survive in fish that are not properly cooked and fish that are kept at freezing point (Takyi *et al.*, 2012; WHO, 2018). This suggests that there may be a transfer of these bacteria to humans who consume fish collected from the study sites.

CONCLUSION

The study investigated the occurrence of bacteria in *C. gariepinus* from Lake Gerio and the fish farm in Yola and identified diverse bacterial species that pose a threat to the general public's health. This study found that certain pathogenic bacteria species that are dangerous to human health can exist in fish that appear to be healthy and show no signs of infection or disease. Further research can be conducted to learn more about how bacterial diseases spread from animals to humans.

Conflicts of Interest

Regarding this work, there were no conflicts of interest among the authors.

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