



Research Article

Bacteria and Parasite Fauna of Cultured and Wild *Clarias gariepinus* in Benue State, Nigeria

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ABSTRACT

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Variation in bacteria and parasite load of *Clarias gariepinus* from pond and wild environments was determined. Of the 30 samples of *C. gariepinus*, while 6 healthy from the pond environment were examined with 7 different bacteria isolates, 7 diseased *C. gariepinus* were examined with 7 bacteria isolates. Also, while 3 healthy samples of *C. gariepinus* from the wild environment were examined with 6 different bacteria isolates, 14 diseased samples were examined with 10 bacteria isolates. *Staphylococcus aureus* (73.33%) and *Escherichia coli* (67.67%) were the most prevalent followed by *Aeromonas hydrophyla* (40.00%) and *Streptococcus spp.* (36.67%) among the 10 bacteria isolates recovered from the samples of *C. gariepinus*. Out of the 30 samples of *C. gariepinus* from the pond environment, 6(20.00%) were infested with 3 species of parasites; *Eustrongylides spp.* (50.00%), *Camallanus spp.* (83.33%) and *Camallanus riparius* (33.33%). Out of the 30 samples of *C. gariepinus* from the wild environment, 11(36.67%) were infested with 4 species of parasites; *Eustrongylides spp.* (54.55%), *Camallanus spp.* (72.73%), *Caenorhabditis briggsae* (36.36) and *Chironomus riparius* (6.67%). Generally, samples of *C. gariepinus* from the pond environment were more parasitized than those from the wild environment. Relative to other body parts, the intestine was most associated with bacteria isolates compared to the gills and skin. During the study period, 3 isolates of parasites (*Eustrongylides spp.*, *Camallanus spp.* and *Caenorhabditis briggsae*) were recovered and observed to be most prevalent in the intestine of samples of *C. gariepinus* from the pond environment, 3 parasite species were also recovered from the parasitized samples of *C. gariepinus* from the wild. Of the body parts of *C. gariepinus* from the pond and wild environments, the intestine had the highest percentage of parasite infestation of 86.67% from the pond and 83.33% from the wild while the least 13.33% from the pond and 16.67% from the wild environments were recorded for the gills.

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INTRODUCTION

Fish is one of the major and most affordable sources of quality protein that is available worldwide for human consumption (Olugbojo and Ayoola, 2015). It is one of the main food components of humans for many centuries and still contains an important part of the diet of many countries (Eze *et al.*, 2011). Fishes are consumed for their high biological values based on high protein retention in the body, low level of cholesterol and presence of essential amino acids. Fish serves as an important source of income generation for fishermen and fish farmers and its cultivation is a source of employment in developing countries (Felix *et al.*, 2018).

The African catfish (*Clarias gariepinus*) is a vital freshwater fish in Nigeria's aquaculture industry (Federal Department of Fisheries, 2007), due to its ability to tolerate a varying range of environmental conditions, fast growth rate, high fecundity rate, ease of artificial breeding and high market value (Eyo *et al.*, 2014). The consumption of catfish is also increasing in both rural and urban centres in Nigeria due to its high nutritive values (Federal Department of Fisheries, 2007; Emikpe *et al.*, 2011). However, the consumption of fish represents a risk of bacterial and parasitic infection due to contamination from the aquatic habitat, which is easily polluted by wastes from homes, farmlands, industries, and the frequent use of animal manure as pond fertilizer in fish farming. These contaminants can render such fish unfit for human consumption (Danba *et al.*, 2015) due to the presence of bacteria in their alimentary tract originating from food and water sediments which can cause pathogenic diseases (Adedeji *et al.*, 2011).

Bacteria found in fish majorly belong to genera of *Pseudomonas*, *Staphylococcus*, *Flavobacterium*, *Vibrio*, *Micrococcus*, *Bacillus*

and *Aeromonas* (please insert reference). Some exist as microflora in pond water and large water bodies, and they can be found on the gills, skin, fin or the intestinal tracts of fish under normal conditions. Under stressful environmental conditions, some microflora may invade and produce epizootic diseases while some are also pathogenic organisms (Oladosu-Ajayi *et al.*, 2011). The pathogenic bacteria associated with fish as classified by Kvenberg (1991) are indigenous and non-indigenous bacteria; the non-indigenous bacteria such as *Escherichia coli*, *Clostridium botulinum*, *Shigella dysenteriae*, *Staphylococcus aureus*, *Listeria monocytogens* and *Salmonella* spp. contaminate the fish or their habitat while the indigenous bacteria pathogens such as *Vibrio* and *Aeromonas* species are found living naturally in the fish's habitat (Rodricks, 1991) which are not harmful to fish but may be harmful to man when consumed (Salihu *et al.*, 2012).

Investigations on parasite communities are useful for knowledge of community structure and dynamics (Esch *et al.*, 1990) and for estimating environmental influences. Numerous factors affect the parasitic fauna of fishes; these factors include changes in the physical and chemical properties of the aquatic environment and changes in the physiological and biological conditions of hosts (Ferrari-Hoeinghaus *et al.*, 2006). Fish parasitic fauna can also be influenced by biotic factors (host-related factors) such as diet, body size, reproductive behaviour, vagility migratory habits (Violante-Gonzalez *et al.*, 2008; Tavares and Lague, 2008), host age, host size and parasite size, host specificity and host sex (Iyaji *et al.*, 2009). Factors that have a bearing on habitat/environmental and biological aspects

can also affect the structure and species composition (Violante-Gonzalez *et al.*, 2008).

In Nigeria, different parasite species have been reported from the wild and cultured fish species;

Afolabi *et al.*, (2020) reported *Camallanus spp.* in their comparative study of African catfish parasites from cultured and natural habitats, Bichi, and Yelwa, (2010) recovered *Bothriocephalus spp.* from *C. gariepinus* (Teugels) at Bagauda Fish Farm, Kano, Auta *et al.*, (2019) recovered *Bothriocephalus spp.* from *C. gariepinus* caught in selected points along River Kaduna, Nigeria, Absalom *et al.*, (2018) documented the presence of *D. latum* in *C. gariepinus* from River Gudi Nigeria, Solomon *et al.*, (2018) reported *Camallanus spp.* from *Bagrus bayad* from Lower River Benue Makurdi, Nigeria; Omeji *et al.*, (2018) reported *D. latum* from *Synodontis euptera* and *Auchenoglanis occidentalis* from Lower River Benue, Nigeria, Osho, (2017) reported *D. latum*, *Camallanus spp.* and *L. intestinalis* from *Parachanna obscura* in River Ogun, Southwest Nigeria. Omeji *et al.*, (2013) reported infestation of *C. gariepinus* by *Estrongylides spp.* and *Camallanus spp.* from earthen and concrete ponds in Makurdi, Benue State, Ejere *et al.*, (2014) reported *Neoechinorhynchus*

prolixum, *Pomphorhynchus spp.*, *Acanthocephalus spp.* unidentified *acanthocephalan*, *Camallanus polypteri*, *Capillaria pterophylli*, *C. cichlasomae*, *Procamallanus laeviconchus*, *Philometroides africanus* and *Railletnema synodontis* from five freshwater fish species in the Warri River, Nigeria, Omeji *et al.* (2022) reported *Diphyllobothrium latum* *Capillaria spp.*, *Camallanus spp.*, and *Eustrongylides spp.* of *C. gariepinus* from selected fish farms in Makurdi, Benue State, Nigeria.

The presence of these parasites in fish could cause pathological effects such as mechanical damage (fusion of gill lamellae, tissue replacement), physiological damage (cell proliferation, immunomodulation, altered growth, detrimental behavioural responses,) and/or reproductive damage (Knudsen *et al.* 2009, Al-Jahdali and Hassanine 2010) in the fish and even reducing the market value of the infested fish. The parasites could become zoonotic if the fish are not properly cooked before consumption (Kawe *et al.*, 2016). This study was therefore conducted to investigate the presence of bacteria and parasites of cultured and Wild *Clarias gariepinus* in Benue State, Nigeria.

approximately 1400 km (870 mi), spanning from the Adamawa Plateau of

MATERIALS AND METHODS

Study area

The study was conducted in Nyiev district, North-East of Makurdi Local Government Area of Benue State, Nigeria. The commercial fish farm (pond/cultured environment) sampled in this study is located at Hudco quarters in Makurdi. The Lower River Benue where the wild breed of catfish was sourced is the major tributary of the Niger River, which is

northern Cameroon and flows into Nigeria from the Mandara mountains through Jimeta Ibi and Makurdi before meeting the River Niger at Lokoja.

Collection of fish specimens for parasitological study

Thirty (30) samples of *Clarias gariepinus* were purchased from a reputable fish Farm and the wild environment (Lower River Benue) in Makurdi, Benue State for the study.

Sex determination and measurement of length and weight

Purchased fish samples were transported to the Fisheries Laboratory, Joseph Sarwuan Tarka University, Makurdi for morphological, parasitological, and bacteriological studies. In the laboratory, the taxonomic identity of the sampled fish was confirmed; the sexes of the fish were determined by examination of their papillae, total length and standard length were measured to the nearest 0.1 cm using a meter rule mounted on a dissecting board and while the weight was measured to the nearest 0.1g using an electronic weighing balance (Golden Mettler, Model: GW: 1.3kg, NW; 1kg- US).

Examination of parasites

Freshly caught fish were examined for parasites using procedures described by Arthur and Albert (1994) as follows:

Examination of ectoparasites

The external surfaces-fins, gills and skins were gently brushed into a plastic Petri dish having a normal saline solution (0.90% w/v of NaCl) and examined with a hand lens for the presence of ectoparasites. Scrapings from the skin, fins and gills of each fish were smeared on glass slides follow by addition of few drops of 0.9% saline solutions and examined under 10x magnification of a light binocular microscope for the presence of external parasites. Fish gills were later dissected out and each gill filament and arch were examined with a hand lens for the presence of parasites. Identification guidelines based on morphological features of parasites were used for the identification of parasites in this study (Paperna, 1996, Florio *et al.*, 2009).

Examination and identification of endoparasites

Fish samples were dissected to expose the viscera. The visceral organs were examined for the presence of cysts and larval endoparasites. The guts were removed and placed in Petri dishes and the contents were flushed with normal saline into beakers and then shaken to loosen mucus and other intestinal debris. Parasites were recovered from the residue after centrifugation at 1000 rpm and decanting of supernatant. Recovered parasites were mounted on slides and viewed under 40x objective using Zpix Digital Microscope (Mm 640). All parasites recovered were counted and recorded. Fish not examined were refrigerated (-40C) overnight and examined the following day for parasites (Ekanem *et al.*, 2011).

Morphological identification of *Eustrongylides spp.* was based on careful examination of faint characters at the anterior end of the reproductive system. These traits include the size and shape of buccal capsules, internal and external leaf crowns and its extra-chitinous support. Morphological identification of *Camallanus spp.* was based on the presence of a buccal capsule with longitudinal internal ridges, some of which were very short. The esophagus consisted of muscular and glandular portions, the middle position of the excretory pore to the muscular oesophagus, the anterior location of deirids to the nerve ring, posterior end of males with two unequal spicules and caudal papillae; nonetheless, it is smooth and straight in females. Morphological identification of *Caenorhabditis brigssae* was based on long stoma and tubular, cuticle lined, constricted inward at the posterior end in three bulges, each with two widely spaced teeth. The male is slender with a bursa supported by three

groups of three rays on each side; paired spicules are not fused at tips. Morphological identification of *Chironomus riparius* was based on their reddish bodies due to a large amount of haemoglobin in their blood. Morphological identification of

parasites was done using appropriate keys (Paperna, 1996; Chambrier and Vaucher, 1999).

Determination of mean intensity, prevalence (%) and mean intensity (of infection I_m)

Mean intensity = $\frac{\text{Total number of parasites}}{\text{Number of infected fish}}$

Number of infected fish

(Bush *et al.*, 1997)

Prevalence (%) = $\frac{\text{Number of fish infected}}{\text{Number of fish examined}} * 100$

Number of fish examined * 100

Preparation of fish samples for bacteriological analysis

Fish samples were processed aseptically for bacteriological examination using serial dilution. 6 sterile tubes were set for each fish and 9mls of sterile peptone water were placed in each tube. Each fish was collected using sterile forceps and dissected on a dissection board. A sterile surgical blade was used to dissect, expose, and collect the needed parts (gills, intestine and skin) of the fish samples.

Bacteriological examination of fish samples

The fish samples were examined bacteriologically using the culture technique as described by Cheesborough (1998; Obiajuru and Ozumba, 2009). Each fish was aseptically dissected to remove the required parts of the fish for culture. The selected part of the fish samples was cultured on MacConkey and blood agar media using the streak plate technique. A sterile white loop was used to collect a

loopful of the different fish parts and incubated on the surface of MacConkey and blood agar. The incubated plates were incubated for 24 hours at 37°C and examined for bacteria growth.

After incubation, discrete colonies of different isolates on the plates were later sub-cultured on fresh MacConkey agar, blood agar and tryptone soy agar plates to obtain pure cultures for characterization and examination of growth morphologies. They were further incubated for another 24 hours at 37°C. The pure cultures of different isolates were sub-cultured on agar slant and incubated for 24 hours at 37°C and later stored in a refrigerator for identification tests

Identification of bacterial isolates

Biochemical testing and bacteria identification were performed on bacterial isolates following guides from Bergey's manual of systemic bacteriology. Also, the different isolates from the various parts of the fish samples were identified using their

morphological growth and colonial characteristics on MacConkey agar, blood agar and tryptone soy agar (1998; Obiajuru and Ozumba, 2009).

Statistical analysis

Effect of host sex and fish origin on infestation abundance and intensity of each parasite species were calculated in

Microsoft Excel Spreadsheet Program version 2016 and presented as simple proportions. Data on the bacterial load of the fish samples from the cultured and natural environment were subjected to an independent sample t-test. Data on the bacterial load of the fish samples from the cultured and natural environment were subjected to an independent sample t-test.

RESULTS

Results of the prevalence of ecto and endo parasitic isolates of samples of *C. gariepinus* from the pond and wild environments are shown in Tables 1 and Table 2, respectively. In Table 1, of the 30 samples of *C. gariepinus* used, while 5(16.67%) from the pond environment were not parasitized, 6(20.00%) were parasitized with a species of parasite (*Eustrongylides spp.*, 21.33%). Out of 30 samples of *C. gariepinus* from the wild environment, while 8(20.67%) healthy fish were not parasitized, 11(36.67%) were parasitized with a species of parasites (*Eustrongylides spp.*, 7.51%). The recovered parasite occurred only on the gill of the infested fish samples. Generally, samples of *C. gariepinus* from the pond environment were more parasitized than those from the wild environment.

In Table 2, of the 30 samples of *C. gariepinus* used, while 5(16.67%) from the pond environment were not parasitized, 6(20.00%) were parasitized with 3 species of parasites (*Eustrongylides spp.* (40.40%), *Camallanus spp.* (83.33%) and *Camallanus riparius* (33.33%). Also, of the 30 samples of *C. gariepinus* from the wild environment, while 8(20.67%) healthy fish were not parasitized, 11(36.67%) were parasitized with 4 species of parasites including *Eustrongylides spp.* (35.31%), *Camallanus spp.* (72.73%), *Caenorhabditis brigssae* (36.36%) and *Chironomus riparius* (6.67%), respectively.

Generally, samples of *C. gariepinus* from the pond environment were more parasitized than those from the wild environment. Also, of the parasite, *Camallanus spp.* had the highest prevalence (43.33%) while *C. riparius* was the least recorded species (6.67%)

Table 1: Prevalence (%) of ectoparasitic isolates from cultured and wild *C. gariepinus*

Fish status/Site	No. (%) fish Examined	Percentage (%) parasite isolates of infected fish body parts	
		<i>Eustrongylides spp.</i>	
		Gill	Skin
HCGP	5(16.67)	0.00	0.00
HCGW	8(26.67)	0.00	0.00
PCGP	6(20.00)	21.33	0.00
PCGW	11(36.67)	7.51	0.00

HCGP = Healthy *Clarias gariepinus* from pond, HCGW = Healthy *Clarias gariepinus* from wild

PCGP = Parasitized *Clarias gariepinus* from pond, PCGW = Parasitized *Clarias gariepinus* from wild

Table 2: Prevalence (%) of endoparasites isolates from cultured and wild *C. gariepinus*

Fish status/Site	No. (%) fish Examined	<i>Eustrongylides</i> spp.	<i>Camallanus</i> spp.	<i>C. brigssae</i>	<i>C. riparius</i>
HCGP	5(16.67)	0.00	0.00	0.00	0.00
HCGW	8(26.67)	0.00	0.00	0.00	0.00
PCGP	6(20.00)	40.40	83.33	0.00	33.33
PCGW	11(36.67)	35.31	72.73	36.36	6.67

HCGP = Healthy *Clarias gariepinus* from pond, HCGW = Healthy *Clarias gariepinus* from wild
 PCGP = Parasitized *Clarias gariepinus* from pond, PCGW = Parasitized *Clarias gariepinus* from wild, *C. brigssae* = *Caenorhabditis brigssae*, *C. riparius* = *Chironomus riparius*

Results of the parasite isolates of selected organs of parasitized *C. gariepinus* from the pond and wild environments during the study period are shown in Table 3. From the pond environment, 3 isolates of parasites (*Eustrongylides* spp., *Camallanus* spp. and *Caenorhabditis brigssae*) were recovered and observed to be most prevalent in the intestine.

From the wild environment, 3 parasite species were also recovered from the parasitized samples of *C. gariepinus*. The parasite species include *Eustrongylides* spp., *Camallanus* spp. and *Chironomus riparius*. These parasites were most prevalent in the intestine compared to the gill and skin.

Table 3: Species of parasites isolated from selected organs of *C. gariepinus* from pond and wild environments.

Parasite isolates	Fish Parts		
	Gill	Intestine	Skin
PICGP			
<i>Eustrongylides</i> spp.	+	+	-
<i>Camallanus</i> spp.	-	+	-
<i>C. brigssae</i>	-	+	-
PICGW			
<i>Eustrongylides</i> spp.	+	+	-
<i>Camallanus</i> spp.	-	+	-
<i>C. riparius</i>	-	+	-

PICGP = Parasite isolates of *C. gariepinus* from the pond
 PICGW = Parasite isolates of *C. gariepinus* from the wild

Results of the percentage parasite infestation of *C. gariepinus* based on the site of parasite recovery are shown in Figure 1. Of the body parts of *C. gariepinus* from the pond and wild environments, intestine had the highest percentage parasite infestation of 86.67% from

the pond and 83.33% from the wild while the least 13.33% from the pond and 16.67% from the wild environments were recorded for the gills. Skin of the sample *C. gariepinus* recorded 0.00% each from the pond and wild environments.

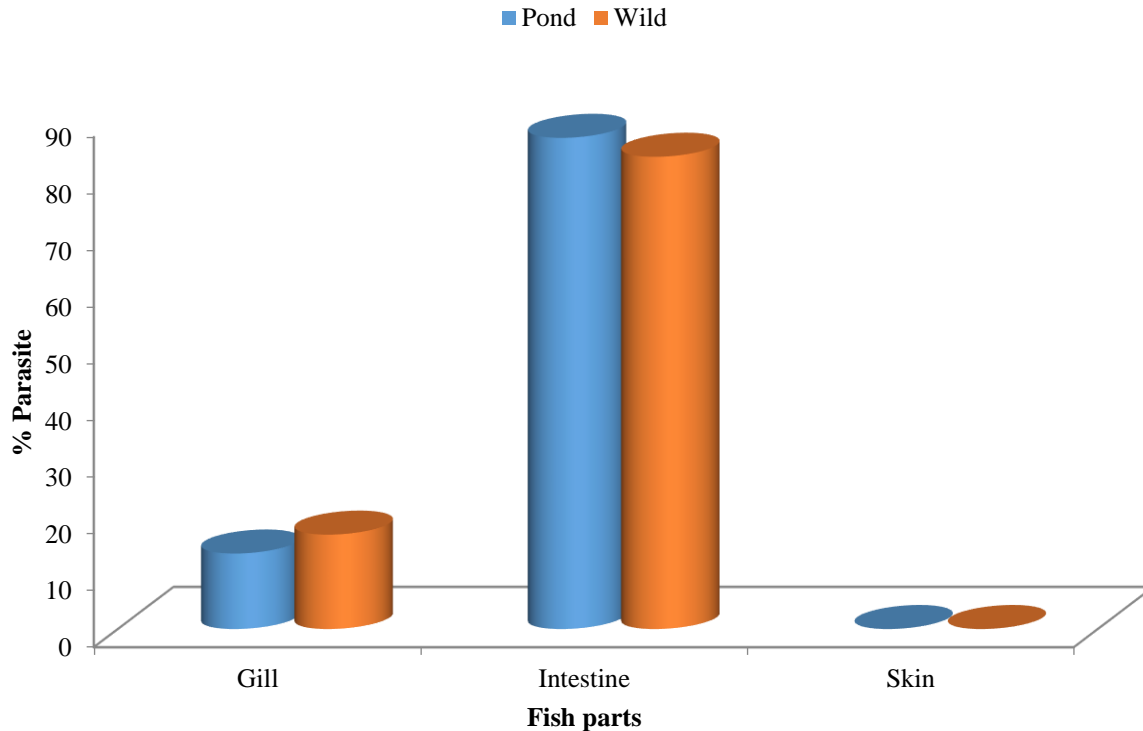


Figure 1: Percentage parasites of *C. gariepinus* based on site of recovery from the pond and wild environments

Results of the prevalence of bacterial isolates of healthy and diseased *C. gariepinus* from the pond and wild environments are shown in Table 4. Of the 30 samples of *C. gariepinus* used for the study, while 6 healthy from the pond environment were examined with 7 different bacteria isolates, 7 diseased *C. gariepinus* were examined with 7 different bacteria isolates. Also, while 3 healthy samples of *C. gariepinus* from the wild environment were examined with 6 different bacteria isolates, 14 diseased samples of *C. gariepinus* were examined with 10 bacteria isolates.

Generally, of the 10 bacteria isolates recovered from the samples of *C. gariepinus*, *Staphylococcus aureus* (73.33%) and *Escherichia coli* (67.67%) were the most prevalent while the least prevalent were *Streptococcus sp.* (36.67%) and *Aeromonas hydrophilia* (40.00%).

Results of the bacteria isolate of selected organs of healthy *C. gariepinus* from the pond and wild environments are shown in Table 5 while Table 6 shows the results of diseased *C. gariepinus* from the pond and wild environments.

In Table 5, 8 isolates of bacteria were recovered from healthy samples of *C. gariepinus* during the study period. It was observed that *S. aureus*, *Enterobacter spp.*, *Escherichia coli*, *Klebsiella spp.* and *Shigella spp.* were most prevalent. Of the body parts of samples of *C. gariepinus*, intestine was most associated with bacteria isolates compared to the gills and skin.

In Table 6, 10 bacteria isolates were recovered from the diseased samples of *C. gariepinus*. Of the isolates, *S. aureus*, *Aeromonas spp.*, *Salmonella spp.*, *E. coli* and *Klebsiella spp.* were most prevalent. Of the body parts of samples of *C. gariepinus*, intestine also had the most bacteria isolates compared to the gill and skin.

Table 4: Prevalence of bacteria isolates of *C. gariepinus* from pond and wild environments

Fish status/Site	No. (%) fish examined	Prevalence (%) of bacteria isolates of infected fish									
		<i>S. aureus</i>	<i>Ent. spp.</i>	<i>Strep. spp.</i>	<i>Pseudo. spp.</i>	<i>Proteus spp.</i>	<i>A. hydrophili a</i>	<i>Salmonell a sp.</i>	<i>E. coli</i>	<i>Klebsiella spp.</i>	<i>Shigella spp.</i>
HCGP	6 (20.00)	66.67	33.30	50.00	0.00	50.00	0.00	0.00	16.60	16.67	33.33
HCGFW	3(10.00)	66.67	33.30	0.00	33.33	0.00	0.00	0.00	33.30	66.67	33.33
DCGFP	7(23.33)	71.43	57.10	42.86	85.72	100.00	0.00	0.00	0.00	28.57	14.29
DCGFW	14(46.67)	78.57	50.00	37.71	85.71	42.86	85.71	85.71	100.0	64.29	78.57
Total (%)	30(100.0)	73.33	46.67	36.67	63.33	53.33	40.00	53.33	67.67	46.67	50.00

HCGP = Healthy *Clarias gariepinus* from pond
HCGW = Healthy *Clarias gariepinus* from wild
DCGP = Diseased *Clarias gariepinus* from pond
CGW = Diseased *Clarias gariepinus* from wild
S. aureus = *Staphylococcus aureus*
Ent. Spp. = *Enterobacter spp.*
Strep. Spp. = *Streptococcus spp.*
Pseudo. Spp. = *Pseudomonas spp.*
Hydrophilia = *Aeromonas hydrophilia*
E. coli = *Escherichia coli*

Table 5: Species of bacteria isolated from selected organs of healthy *C. gariepinus* from pond and wild environments.

Bacteria isolates	Fish Parts		
	Gill	Intestine	Skin
<i>Staphylococcus aureus</i>	+	+	+
<i>Enterobacter spp.</i>	+	+	-
<i>Streptococcus spp.</i>	-	+	-
<i>Pseudomonas spp.</i>	-	+	-
<i>Proteus spp.</i>	-	+	-
<i>E. coli</i>	+	+	+
<i>Klebsiella spp.</i>	+	+	-
<i>Shigella spp.</i>	+	+	+

Table 6: Species of bacteria isolated from selected organs of diseased *C. gariepinus* from pond and wild environments

Bacteria isolates	Fish Parts		
	Gill	Intestine	Skin
<i>Staphylococcus aureus</i>	+	+	+
<i>Enterobacter spp.</i>	+	+	-
<i>Streptococcus spp.</i>	-	+	-
<i>Pseudomonas spp.</i>	-	+	-
<i>Proteus spp.</i>	-	+	-
<i>Aeromonas spp.</i>	+	+	+
<i>Salmonella spp.</i>	+	+	+
<i>E. coli</i>	+	+	+
<i>Klebsiella spp.</i>	+	+	-
<i>Shigella spp.</i>	+	+	-

DISCUSSION

This study was carried to detect parasites and bacteria from *C. gariepinus* from the pond and wild environments. The parasites recovered from the pond and wild *C. gariepinus* were *Eustrongylides spp.*, *Camallanus spp.*, *C. brgsae* and *C. ripariu*; while *Eustrongylides spp.*, were recovered from the gill and intestine of the infested fish samples, *Camallanus spp.*, *C. brgsae* and *C. riparius* were recovered from the intestine. Recovery of these parasites in this present study is not surprising as they have been previously recovered (Solomon, *et al.*, 2018; Adikwu 2017; Omeji *et al.*, 2014). The presence of these parasites in the studied fish

could cause some pathological effects in the fish by reducing their growth, productivity, health status, development and even the market value.

The problem of fish infestation by parasites in the study area (pond) could be due to pond fertilization using organic manure from commercial farms, especially poultry. The use of organic materials as fertilizers in fish farming may not only harbor pathogenic parasites but also confers resistance to antibiotics by transferring antibiotic residuals or resistant parasites to fish especially if such manure is obtained from commercial farms (Adegoke *et al.*, 2016). According to the authors, Organic fertilizers are an essential

source for plant nutrients and a soil conditioner in agriculture. Due to its sources and the composition of the organic inputs as well as the type, functionality and failures of the applied treatment process, the organic fertilizer may contain various amounts of infectious agents and toxic chemicals, especially the antibiotics that can be introduced to the subsequent food chain. A range of human and animal pathogens of parasitic origin and even bacterial and viral have been the cause of food-borne epidemics due to unintended contamination from organic fertilizers. The use of antibiotics by humans and in animal feeds will also end up in the organic fertilizers. These antibiotics and other chemicals, depending on the sources of the organics, will enhance the likelihood of occurrence of resistant and multi-resistant strains of microorganisms in the pond and even wild environments and have been reported to cause ecotoxicological environmental effects and disruption of the ecological balance.

The high prevalence of parasites in the pond compared to the wild environment could be due to the improper management technique of eliminating the conditions that could favor parasite infestation such as pollution, occasional surveillance, reduction in overcrowding and periodic checks of the water body for parasites. This study agrees with the reported work of Enyidi and Maduakor (2017). In the fish farms, farmers are allowed to dispose of their waste and faecal matters therein which subsequently washed into the pond thus providing suitable conditions for parasites to thrive.

Also, the high prevalence of parasites in the pond compared to the wild environment could be due the accumulation of waste feeds in ponds which stimulates the growth of parasites including human pathogens which can contaminate products and lead to food-borne diseases. The use of artificial feeds

supplemented with antibiotics in the feeds could lead to residues remaining in the fishponds which in turn could lead to the emergence of parasites (Carpenter, 2001).

The parasites recovered from different body parts of *C. gariepinus* used for this study have been previously recorded by other researchers (Imam and Dewu 2010; Keremah and Inko-Tariah 2013; Eyo *et al.* 2014; Uruku and Adikwu 2017).

More ectoparasites were recorded from the gill of *C. gariepinus* than the skin. This agrees with the findings of Emere and Egbe (2006) and Omeji *et al.* (2011) who reported a higher number of parasites in the gills compared to the skin. The authors concluded that the gills are the center of filter-feeding and also an important site used for gaseous exchange in fish. The sieving ability of the gill rakers may help to trap some parasites. On the other hand, this finding is contrary to the findings of Afolabi *et al.*, (2020) who reported more ectoparasites from the skin of *C. gariepinus* than the gills. The authors suggested that the skin is easily accessible by these parasites due to direct contact of the skin with the surrounding water or continuous movement of water over the skin.

Generally, endoparasites were more prevalent in the pond and wild *C. gariepinus* compared to the ectoparasites; these parasites were all found in the intestine of the infested fish samples. The highest prevalence of parasites in the intestine compared to the gills and skin could imply that it is the most preferred predilection site; this could be due to the favourable conditions that enhance their survival (Owolabi, 2008). Similar finding was reported by reported Kawe *et al.*, (2016).

In terms of the percentage parasite species recovered from the pond and wild *C. gariepinus*,

Camallanus spp. was the most prevalent while *C. riparius* was the least. The highest percentage parasite recorded for *Camallanus spp.* from the pond in this finding is like the finding of Afolabi et al (2020) while the highest percentage parasite recorded for *Camallanus spp.* from the wild is contrary to their finding. In their reported work on comparative study of African catfish parasites from cultured and natural habitats, the authors concluded that *Camallanus spp.* was the most abundant in cultured habitat while *P. symphysodonis* was the most abundant in natural habitat.

10 isolates of bacteria from the different body parts of *C. gariepinus* ranging from gills, intestine and skin. The findings of this study agree with the reported work of Sowunmi et al., (2008) who reported the presence of similar genera of bacteria from the gills and buccal cavity of *C. gariepinus* and *Tilapia zillii* from Lekki Lagoon, southern Nigeria.

Isolation of bacterial species from catfish is not novel as it has previously been reported by some researchers (Akaniro et al. (2020, Osungbemi et al., 2014, Uddin, and Al-Harbi, 2012). Some of the isolates obtained were identified to belong to specific groups of bacteria known as enteric bacteria, these include *Salmonella spp.*, *Shigella spp.* and *Escherichia spp.* Enteric bacteria have been implicated as causative agents of various enteric diseases generally referred to as gastroenteritis (Olaniyi et al, 2019, Petronillah et al. 2014).

In the study, most of the bacteria isolated from the fish samples might have come from water either via injection with food or engulfment of water. Among the bacteria, *Proteus species* play vital role in purification due to its ability to produce proteolytic enzymes (Pyalkin 1999).

The quest to increasing aquaculture yields via pond fertilization especially those involving the dumping of domestic poultry and organic wastes into the aquaculture system ultimately affects the microbiology and chemistry of the culture system (Ogbole, 1995). Fertilizing fishponds using organic manure from commercial farms, especially poultry is a common practice among fish farmers in the study area; this is the most accountable source of enteric bacteria isolated from the study area. This assertion agrees with the reported work of Akaniro et al. (2020). In a similar study conducted in Egypt, frequency of isolation of enteric pathogens; *Salmonella spp.* and *E. coli* from water and fish raised in ponds receiving unfermented chicken manure significantly exceeded those that were unfertilized (Elsaidy et al 2015). In addition, enteric bacteria in both water and *Clarias gariepinus* is because of contamination with faecal matter as these pathogens don't form part of fish normal flora but homoithers. The use of organic materials as fertilizers in fish farming may not only harbor enteric pathogens but also confers resistance to antibiotics by transferring antibiotic residuals or resistant bacteria to fish especially if such manure was obtained from commercial farms that also use antibiotics (Elsaidy et al. 2015).

Isolation of *Aeromonas species* from all parts of the diseased fish samples agrees with the findings of Ifeyinwa et al., (2011), Okpokwasili and Ogbalie (2000) who reported that species of *Aeromonas* are autochthonous to the Nigeria agriculture system.

The ponds and rivers that harbour the fish may be the source of contaminants due to indiscriminate deposition of human, animal excreta and other environmental wastes into natural water, land and during the rainy season especially, as the faecal matter from various sources are washed from contaminated land

into different water bodies. Free roaming animals and pets especially dogs also contribute to faecal contamination of surface water. Run-off from roads, parking lots and yards can carry animal wastes into natural water course and ponds. Birds can also be a significant source of bacteria. Swans, Geese and other waterfowls can all elevate bacteria counts in water bodies and ponds (Doyle and Ericson, 2006). Poor environmental sanitation in some areas and indiscriminate disposal in different places could contribute to the pond contamination. This assertion is supported by Ifeyinwa *et al.*, (2011). The higher prevalence of bacteria and parasite isolates in the fish samples from the pond environment compared to the wild environment in this study could be attributed to poor water quality in the aquaculture system.

In this study, the most prevalent bacteria isolate were *S. aureus* and *E. coli* with 73.33 % and 67.67% frequency of occurrence, respectively. These organisms are often regarded as normal flora of human intestine and were isolated with faecal materials. The higher prevalence of these organisms in this study suggested that the pond water was probably contaminated with faecal materials. Among the body part of the fish samples in this study, intestine was most infected by bacteria compared to the gill and

skin. This could be because the fish acquired these organisms via engulfment of water.

CONCLUSION

The present study shows the presence of bacteria and parasite Fauna of Cultured and Wild *Clarias gariepinus* in Benue State, Nigeria with heavy parasitic burden in *C. gariepinus* sampled from the pond environment compared to the wild. The prevalence of African catfish parasites and bacteria in ponds is dependent upon management system of the farm. Parasites can exist in an environment without attacking the fish, but environmental stressors can act as triggers. There can be high mortality recoded from these pathogens, but adoption of hygiene and integrated management will reduce their prevalence. Since it has been observed that parasitic infection of fish affects its productivity, marketability, palatability, death of a good number of fishes especially in the wild as well as the potential zoonotic effect on the consumers, it is therefore necessary to develop effective control measures and good culinary practices should be adopted to decimate the potential risks to human health. Further study to examine other parasites and bacteria especially their larval stages is highly advocated to forestall the zoonotic consequences in human who consume the fish as a source of protein.

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