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Composition, distribution and antibiotic sensitivities of bacteria associated with cultured *Clarias gariepinus* (Burchell 1822)

Fatuyi Olanipekun Ekundayo[1]*, Daniel Olusegun Diyaolu[2] and Emmanuel Adedayo Fasakin[2]

[1]Department of Microbiology, Federal University of Technology, P. M. B. 704, Akure, Nigeria.
[2]Department of Fisheries and Aquaculture Technology, Federal University of Technology, P.M. B. 704, Akure, Nigeria.
Email: foekundayo2002@yahoo.com

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Aims: The heterotrophic bacteria of African catfish, *Clarias gariepinus* at fingerlings and adult stages of growth were quantitatively and qualitatively examined.
Methodology and results: Bacteriological analysis was carried out on sampled organs (skin, gills, and intestines) of fingerlings, adult fish, and their respective culture environments (water and sediments) by standard microbiological techniques. Sensitivity of the isolated bacteria to antibiotics were also determined. The total bacterial counts in fingerlings skin ranged from $1.3\pm0.3x10^3$ to $5.4\pm2.3x10^3$ cfu/cm^2; gills, $3.8\pm1.6x10^3$ to $1.1\pm0.4x10^5$ cfu/g; intestines, $3.5\pm2.2x10^5$ to $5.4\pm4.3x10^6$ cfu/g and fingerlings culture water, $1.5\pm0.8x10^3$ to $2.9\pm1.6x10^3$ cfu/mL. The sediments of adult fish had higher bacterial loads ($1.5\pm0.7x10^5$ to $2.4\pm1.4x10^6$ cfu/g) than that of water ($3.4\pm0.6x10^3$ to $8.4\pm4.2x10^3$ cfu/mL), skin ($4.8\pm1.4x10^3$ to $3.4\pm1.4x10^4$ cfu/cm^2) and gills ($6.6\pm1.3x10^3$ to $3.5\pm2.0x10^4$ cfu/g). In all, fourteen bacteria genera were identified which were predominantly Gram negative rods (*Aeromonas*, *Alcaligenes*, *Chromobacterium*, *Citrobacter*, *Enterobacter*, *Escherichia*, *Klebsiella*, *Proteus*, *Pseudomonas*, *Salmonella* and *Serratia*). Some Gram positive bacteria (*Micrococcus*, *Staphylococcus*, *Streptococcus* and *Bacillus*) were also identified. The isolated organisms showed high level of sensitivity to ciprofloxacin, perfloxacin and gentamicin with moderate sensitivity to amoxicillin, erythromycin, tetracycline and streptomycin, but were resistant to ampicillin and zinnacef.
Conclusion, significance and impact of the study: Ciprofloxacin, perfloxacin and gentamicin could be used in reduction of heterotrophic bacteria of *C. gariepinus*.

Keywords: Clarias gariepinus, heterotrophic bacteria, fingerlings, adult fish, antibiotics.

INTRODUCTION

Clarias gariepinus is a hardy fish that is suitably adapted to living in polluted waters due to the presence of mucous lectins on the skin of the fish which protects it against most aquatic bacteriophages (Tsutsui *et al.*, 2011). It is one of the most suitable species for aquaculture in Africa and since the 1970's, has been onsidered to hold great promise for fish farming especially Nigeria (Ogunshe and Olabode, 2009). The Nigerian aquaculture industry dominated by *Clarias* culture (Adewumi, 2005) is characterized by poor documentation of fish associated microbial and fungal diseases (Oni, 2007). There are numerous bacterial organisms in an aquatic environment that affect the health of the cultured fish. Most are opportunistic pathogens, living freely in the environment and as flora of fish, and only causing disease if the fish is immune-compromised or if the environmental conditions are sub-optimal (King *et al*., 2008). These microorganisms not only influence fish health but are also known to affect post harvest quality of fish (Al-Harbi and Uddim, 2008). Diseases cause economic losses to farmers not only from mortality but also treatment expenses and postponement or loss of opportunity to sell the fish at scheduled time (Adedeji *et al*., 2011). Microbiological evaluation of raw fish and growing water would therefore be important to assure the consumers about the quality and safety of fish products (Laung *et al*., 1992; Al-Harbi and Uddim, 2008).

Antibiotics are currently employed to treat animals infected by bacteria, as well as preventing establishment of pathogenic bacteria within aquaculture systems (Kesarcordi-Watson *et al*., 2008). Knowledge of etiological agents of infections and their sensitivities to available drugs is of immense value to the rational selection, use of antimicrobial agents and development of appropriate prescribing policies (Abubakar, 2009).

The objectives of this study were to determine the composition and distribution of bacteria in fingerlings and adults of *C. gariepinus* in relation to their respective

*Corresponding author

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culture environment and examine the sensitivity patterns of the isolated bacteria to some commonly used antibiotics.

MATERIALS AND METHODS

Description of experimental farm

All fish samples used in this study were obtained from the Research and Teaching Farm, Federal University of Technology Akure. *C. gariepinus* fingerlings were cultured in the outdoor concrete tanks (4 m^3 capacity) supplied with water pumped from the reservoir, while the adult fish were reared in the earthen ponds (200 m^3 capacity) of average depth of 1.2 m. The fingerlings and adult fish were stocked at 25 fish/m^3 and 15 fish/m^3 of water column respectively.

Collection of samples

Three fingerlings tanks and three adult fish ponds were selected for this study. Three fish were randomly selected and culture water was sampled with sterile 1 L glass bottle from each tank/pond and taken to the laboratory in sterile containers. In addition, pond sediments were also collected at the same locations in each pond where water samples were obtained. All collected samples for bacteriological analyses were taken to the laboratory within 30 min of collection for bacteriological analyses. Surface water quality parameters - temperature, dissolved oxygen, pH, conductivity, salinity and turbidity-of all water samples were determined prior to bacteriological examination, using Hanna Multiparameter (HI 9282) in accordance with manufacturer's specifications.

Isolation, enumeration and characterization of bacteria from fingerlings and adult fish samples

Each fingerling sample was weighed aseptically and sacrificed. The skin (2 cm^2) was removed by means of sterile scapel and suspended in 20 mL of dilution blank. The fish was surface-sterilized with 70% ethanol and then dissected. The gills and intestines were aseptically removed, weighed and homogenized separately with 10 mL of dilution blank (9 g of NaCl in 1 L of sterile water). After homogenization, the samples (skin, gills, intestine and culture water) were diluted serially. Collected sediment samples were centrifuged at 3000 rpm for 5 min and 1 g of each uniform sediment sample was suspended in 10 mL of dilution blank.

Aliquot (0.1 mL) of all serial dilutions were inoculated into tryptone soya agar (from Biotech laboratory Ltd, United Kingdom) plates by the pour plating method. The plates were incubated at 37 °C for 48 h, and colony forming units (cfu) were counted to determine the bacterial population of each sample. Bacterial isolates were characterized morphologically and biochemically using the criteria by Holt *et al.* (2000) and American Fisheries Society–Fish Health Section (2007).

Antibiotics sensitivity assay

Antibiotics sensitivity patterns of the isolated bacteria were determined by disc diffusion method (NCCLS, 2003) using the following antibiotics (µg/disc) obtained from MAXICARE Medical Laboratory, Nigeria: perfloxacin (10), gentamycin (10), ampicillin (30), amoxicillin (30), zinnacef (20), rocephin (30), ciprofloxacin (10), streptomycin (30), tetracycline (30), and erythromycin (10). The diameter of the zone of inhibition of each antibiotic disc was measured and recorded as "sensitive" (where the zone > 15 mm) or "resistance" (where the zone $\leq$ 15 mm) and percentage susceptibility to each drug by each bacterial group was calculated based on the number of test bacteria (NCCLS, 2003).

Statistical analyses

The data on the water quality parameters determined and the numbers of bacteria (cfu) of all samples were recorded as mean ± standard deviation. All data were subjected to one-way analysis of variance (ANOVA) and differences between means were separated by Duncan Multiple Range Tests using Computer Software SPSS version 11.0.

RESULTS

Analysis of water quality

The results of water quality analysis of the culture water of both fingerlings and adult *C. gariepinus* are presented in Table 1. While most of the parameters analysed were not significantly different from each other, the pH of adult fish pond (6.09±0.22) is observed to be slightly lower than that of fingerlings tanks (6.58±0.09). Adult fish pond water also has higher turbidity (227.33±17.00) than fingerlings tank water (183.66±32.11).

Quantitative estimation of bacteria

Bacterial counts were generally higher in adult fish (except its gills) than fingerlings. However, bacterial counts were lower in the gills of adult ($6.60\pm1.33\times10^3$ to $3.53\pm2.03\times10^4$ cfu/g) than those of fingerlings ($3.77\pm1.59\times10^3$ to $1.06\pm0.42\times10^5$cfu/g). The bacteria loads from fingerlings were found to be highest in intestines of fingerlings ($3.46\pm2.17\times10^5$ to $5.38\pm4.32\times10^6$ cfu/g) and lowest in culture water ($1.51\pm0.84\times10^3$ to $2.93\pm1.63\times10^3$ cfu/mL). Similarly, the bacterial loads from adult fish pond were found to be highest in intestines of fishes ($9.60\pm1.35\times10^5$ to $3.03\pm1.49\times10^7$cfu/g) and lowest in culture water ($3.50\pm0.62\times10^3$ to $8.04\pm4.22\times10^3$) (Table 2).

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Table 1: Water quality parameters of fingerlings tanks and adult fish ponds.

Sources	Temperature (°C)	Dissolved oxygen	pH	Salinity (ppm)	Turbidity (ppm)	Conductivity (mΩ)
Fingerlings tank	25.89±0.50	5.45±0.20	6.58±0.09	0.15±0.04	183.66±32.11	0.0027±0.00042
Adult fish ponds	26.87±0.29	5.48±0.23	6.09±0.22	0.14±0.04	227.33±17.00	0.0022±0.00030

Table 2: Colony counts (means ± standard deviation) of aerobic bacteria isolated from different organs of *C. gariepinus.*

Sources	Fingerlings			Adult fish		
	Tank 1	Tank 2	Tank 3	Pond 1	Pond 2	Pond 3
Weight of fish (g)	11.62±1.31	13.13±0.72	9.95±0.21	225.67±53.74	148.33±42.21	174.00±34.92
Fish organs						
Skin (cfu/cm^2)	$5.40\pm2.26\times10^{3a}$	$5.40\pm2.26\times10^{3a}$	$1.27\pm0.25\times10^{3b}$	$4.83\pm1.36\times10^{3a}$	$3.39\pm1.43\times10^{4a}$	$1.99\pm1.41\times10^{4a}$
Gills (cfu/g)	$1.73\pm1.35\times10^{4b}$	$3.77\pm1.59\times10^{3b}$	$1.06\pm0.42\times10^{5a}$	$1.54\pm0..93\times10^{4a, b}$	$3.53\pm2.03\times10^{4a}$	$6.60\pm1.33\times10^{3a}$
Intestines (cfu/g)	$5.38\pm4.32\times10^{6a}$	$3.46\pm2.17\times10^{5a}$	$7.78\pm0.31\times10^{5a}$	$7.63\pm4.69\times10^{6b}$	$9.06\pm1.35\times10^{5b}$	$3.30\pm1.49\times10^{7a}$
Culture environment						
Culture water (cfu/mL)	$1.95\pm1.77\times10^{3a}$	$1.51\pm0.84\times10^{3a}$	$2.93\pm1.63\times10^{3a}$	$8.04\pm4.22\times10^{3a}$	$3.50\pm0.62\times10^{3a}$	$6.87\pm2.11\times10^{3a}$
Sediments (cfu/g)	Nil	Nil	Nil	$1.45\pm0.74\times10^{5b}$	$1.69\pm0.17\times10^{5b}$	$2.41\pm1.66\times10^{6a}$

Means (n=3) with different superscripts on the same row are significantly different at $p< 0.05$

Bacteria isolated from fingerlings and adult *C. gariepinus*

Fourteen bacterial genera were identified (Table 3) and these were predominantly Gram negative rods (*Aeromonas*, *Alcaligenes*, *Citrobacter*, *Enterobacter*, *Escherichia*, *Klebsiella*, *Proteus*, *Pseudomonas*, *Salmonella*, *Serratia*) although some Gram positive cocci (*Micrococcus*, *Staphylococcus*, *Streptococcus*) and rods (*Bacillus*) were also present.

Percentage distribution of isolated bacteria

In fingerlings samples, motile *Aeromonas* sp. was found to be dominant on the skin (32.26%), gills (41.18%) and culture water (17.24%), but absent in the intestines (Table 4) and sediments of culture environment (Table 5). In the gills, *Aeromonas* sp. was predominant in fingerlings (41.18%) and adult fish (34.48%). Gram negative bacteria of the family Enterobacteriaceae were predominant in the intestine of fingerlings, totalling 84.38% apart from *Pseudomonas* (15.62%). Likewise, this group of bacteria was predominant in the intestine of adult fish (83.68%) apart from *Pseudomonas* (10.20%) and *Staphylococcus* (6.12%). Gram positive organisms (67.74 %) – *Bacillus, Staphylococcus*, *Micrococcus* and *Streptococcus* – were isolated from the skin in addition to *Aeromonas* (32.26%). Two organisms, *Alcaligene* (6.89%) and *Serratia* (8.62%) were isolated from the culture water out of the above fourteen organisms without any reoccurrence in any part of the fish or its organs.

Antibiotics sensitivity patterns of isolated bacteria

All the test bacteria were inhibited (100% inhibition) by ciprofloxacin and resistant (100% resistant) to ampicillin. Except for *Serratia* and *Citrobacter*, all other test bacteria were also resistant to tetracycline and amoxicillin. Also, perfloxacin, rocephin and gentamicin showed more than 50% inhibition while streptomycin and erythromycin showed less than 50% inhibition against all test bacteria (Table 6).

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Table 3: Morphological and biochemical characteristics of isolated bacteria.

Isolated bacteria	Colony morphology	Gram stains	Mo	Cat	Ox	MR	VP	Fermentation of sugar						Growth on EMB	Ci	Ur	In	H_2S
								Glu	Lac	Dul	Man	Ino	Ara					
Aeromonas sp.	Circular, smooth, white, convex	-R	+	+	+	+	+	+	-	-	+	-	+	-	-	-	+	+
Alcaligene sp.	Circular, broad, grey, raised, opaque	-R	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+
Bacillus sp	Irregular, white, smooth , dull, raised	+R	+	+	N	+	+	+	-	-	-	-	+	N	+	-	-	-
Citrobacter sp.	Circular, non-pigmented, mucous	-R	+	+	-	+	-	+	+	-	+	+	-	-	+	-	+	+
Escherichia coli	Circular, convex, smooth, creamy	-R	+	+	-	-	+	+	+	-	+	-	+	+	+	-	+	-
Enterobacter sp.	Circular, creamy, raised, translucent	-R	+	+	-	-	+	+	-	-	+	+	-	-	+	-	-	-
Klebsiella sp.	Circular, creamy, smooth, dull.	-R	-	+	-	-	+	+	+	+	+	+	-	-	+	+	-	-
Micrococcus sp.	Circular, white, entire, convex	+C	-	+	N	-	-	+	-	-	+	-	-	-	-	-	+	-
Proteus sp.	Swarming, rough, shiny	-R	-	+	-	+	-	+	+	-	-	-	+	-	-	+	+	+
Pseudomonas fluorescens	Greenish, irregular, smooth, urbonate, shiny	-R	+	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-
Salmonella sp.	Circular, creamy, low convex, translucent	-R	+	+	-	+	-	+	-	-	+	-	+	-	-	-	-	+
Serratia sp.	Red, irregular, raised	-R	+	+	-	-	+	+	-	-	-	+	-	-	+	+	-	+
Streptococcus sp.	Circular, broad, yellow convex	+C	+	-	N	-	-	+	-	-	-	+	-	N	-	-	-	-
Staphylococcus sp.	Circular, small, yellow, mucous	+C	-	+	N	-	+	+	-	-	-	-	+	N	-	-	-	-

KEY: Mo, motility; Cat, catalase; Ox, Oxidase; MR, Methyl Red; VP, Voges Proskaeur; Glu, Glucose; Lac, Lactose; Dul, Dulbitol; Ino, Inositol; Ara, Arabinose; EMB, Eosin Methylene Blue; Ci, Citrate; Ur, Urea; In, Indole; H_2S, Hydrogen Sulphide; –R, Gram negative rod; +R, Gram positive rod; –C, Gram negative cocci; +C, Gram positive cocci; –, Negative reaction; +, Positive reaction; N, Not done.

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Table 4: Percentage distribution of aerobic bacteria isolated from the culture of *C. gariepinus* fingerlings.

Isolated bacteria	Culture water	Fish organs		
		Skin	Gills	Intestines
Aeromonas sp.	17.24	32.26	41.18	-
Alcaligene sp.	6.89	-	-	-
Bacillus sp.	3.45	16.13	29.41	-
Citrobacter sp.	-	-	-	12.50
Eicherichia coli	-	-	-	15.62
Enterobacter sp.	10.34	-	-	18.75
Klebsiella sp.	12.07	-	-	12.50
Micrococcus sp.	8.62	9.68	-	-
Proteus sp.	6.89	-	-	15.62
Pseudomonas fluorescens	6.89	-	17.65	15.62
Salmonella sp.	-	-	11.76	9.38
Serratia sp.	8.62	-	-	-
Streptococcus sp.	10.34	22.58	-	-
Staphylococcus sp.	8.62	19.35	-	-

Table 5: Percentage distribution of aerobic bacteria isolated from the pond culture of adult *C. gariepinus.*

Isolated bacteria	Culture environment		Fish organs		
	Pond water	Sediment	Skin	Gills	Intestines
Aeromonas sp.	22.22	-	17.95	34.48	-
Alcaligene sp.	11.11	-	7.69	-	-
Bacillus sp.	-	13.11	20.51	13.79	-
Citrobacter sp.	-	-	-	-	18.37
E. coli	-	4.92	-	-	12.24
Enterobacter sp.	16.67	-	10.26	-	16.33
Klebsiella sp.	11.11	19.67	-	-	10.20
Micrococcus sp.	5.56	8.20	12.82	20.69	-
Proteus sp.	27.78	3.28	-	-	12.24
Pseudomonas fluorescens	5.56	-	-	31.03	10.20
Salmonella sp.	-	16.39	-	-	14.29
Serratia sp.	-	8.20	-	-	-
Streptococcus sp.	-	11.48	12.82	-	-
Staphylococcus sp.	-	14.79	17.95	-	6.12

DISCUSSION

Diverse array of microorganisms occur in aquatic environments where they live as heterotrophic, saprophytic or pathogenic organisms. These organisms share common environment with fish under culture and thus become resident fish flora, but can cause major fish epizootics under stressful cultured conditions (Adewole and Lateef, 2004). Besides disease occurrence in fish, the potential of water to harbour microbial pathogens that cause subsequent illness in humans is well documented for both developed and developing countries (Okonko *et al*., 2009). As a result, foods from aquatic sources are handled with caution to avoid food poisoning, as water-related diseases continue to be one of the major health problems globally (Adebayo-Tayo *et al.*, 2012). By monitoring the types and loads of bacteria of growing fish and culture environments, the health as well as quality of fish can be measured since this will affect the storage life and quality of fish products (Al-Harbi and Uddim, 2008).

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Table 6: Antibiotics sensitivity patterns of aerobic bacteria isolated from *C. gariepinus* culture.

Isolated bacteria	% Sensitivity									
	P	G	A	Am	Z	R	C	S	T	E
Aeromonas sp.	66.7	53.3	0	0	0	20	100	0	33.3	0
Alcaligene sp.	100	100	0	0	0	66.7	100	33.3	0	33.3
Bacillus sp.	100	100	0	23.1	0	100	100	38.5	20	53.8
Citrobacter sp.	70	100	0	70	10	90	100	70	50	100
E. coli	100	100	0	0	0	18.2	100	0	18.2	0
Enterobacter sp.	100	100	0	0	0	80	100	0	0	0
Klebsiella sp.	100	100	0	30.8	0	76.9	100	15.4	15.4	86.7
Micrococcus sp.	100	100	0	0	16.7	66.7	100	83.3	0	50
Proteus sp.	69.2	100	0	50	0	36	100	0	0	0
Pseudomonas fluorescens	83.3	33.3	0	16.7	0	50	100	16.7	0	0
Salmonella sp.	66.7	100	0	0	0	66.7	100	66.7	33.3	66.7
Serratia sp.	100	75	0	75	0	100	100	100	75	25
Streptococcus sp.	75	100	0	0	25	25	100	0	0	0
Staphylococcus sp.	100	75	0	0	25	100	100	0	0	0

Key: P, Perfloxacin; G, Gentamicin; A, Ampicillin; Am, Amoxicillin; Z, Zinnacef; R, Rocephin; C, Ciprofloxacin; S, Streptomycin; T, Tetracycline; E, Erythromycin.

In this study, significantly higher bacterial counts were found in adult fish organs and their respective culture systems than in fingerlings, with intestines having the highest values in both cases. Lower bacterial counts were also observed in culture water than on fish. These variations have been observed in cultured common carp and pond environments (Al-Harbi and Uddim, 2008). However, the values obtained in this study are in contrast with the reports of Adedeji *et al*. (2011) who recorded high indices of 10^{10} to 10^{13} cfu in the skins and intestines of wild and cultured *C. gariepinus*. The reason for this contrast might be the sources of the fish, since fish from polluted waters usually contain abnormally high microbial loads.

Bacteria belonging to fourteen genera (*Aeromonas*, *Alcaligenes*, *Bacillus*, *Citrobacter*, *Enterobacter*, *Escherichia*, *Klebsiella*, *Micrococcus*, *Proteus*, *Pseudomonas*, *Salmonella*, *Serratia*, *Staphylococcus* and *Streptococcus*) were isolated from the skin, gills and intestines of cultured *C. gariepinus* and their cultured environment. While some of them, such as *Aeromonas*, *Pseudomonas*, *Serratia*, *Streptococcus*, *Escherichia*, *Enterobacter* and *Salmonella* are periodically implicated as fish pathogens (Starliper, 2001; Brenkman *et al.*, 2008; Akoachere *et al*., 2009; Loch *et al*., 2012), reports of infections caused by other isolated bacteria on fish are very rare. It should be pointed out that organisms recovered in this study are those that share similar culture conditions with fingerlings and adult *C. gariepinus.* In addition, this study targets bacteria that grow on standard media, thus excluding those with specialised growth requirements

The organisms recovered in this study are generally those associated with tropical freshwater environment and have been isolated from water, sediments, planktons, invertebrates and digestive tracts of many aquatic animals (Austin and Austin, 2007). Motile *Aeromonas* dominated the skin, gills and culture water of both fingerlings and adult *C. gariepinus*. Earlier reports have recognized species of *Aeromonas* as autochthonous microflora of aquatic environments which have been considered important pathogens for cold or warm blooded animals (Maniati *et al.*, 2005; Sreedharan *et al*., 2012). They are regarded as major pathogens of finfishes and shellfishes, causing significant economic losses in the aquaculture industry worldwide (Palu *et al*., 2006). It is therefore very essential to control or reduce the proliferation of these organisms during African catfish culture to minimize the risks of disease occurrence.

From this study, members of the family Enterobacteriaceae were found to be dominant in the intestines of *C. gariepinus,* most of which may not be harmful to the fish directly. Because of the high preponderance of these organisms to cause disease in humans through various routes, their presence in fish is unwanted, as there are numerous reports of infections associated with the members of Enterobacteriaceae in humans (Holt *et al.*, 2000).

All the bacterial isolates were most sensitive to ciprofloxacin followed by perfloxacin, gentamicin and rocephin. Ciprofloxacin may be a good preservative after harvest of fish for biological studies but will not be eaten to prevent drug abuse. It is not advisable to use it on living fish to prevent destruction of beneficial bacteria involved in metabolic, digestive and respiratory processes. The best two antibiotics that can be administered orally to get rid of coliforms such as *E. coli* and *Salmonella* from catfish is gentamicin or ciprofloxacin. However, perfloxacin had a

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better advantage than gentamicin because it reduced the load of *Pseudomonas* which can deteriorate the fish after harvest. Erythromycin and streptomycin were capable of inhibiting *Salmonella*. Yucel *et al*. (2005) found that *Aeromonas hydrophila*, *A. veroni* bv. sobria and *A. caviae* were susceptible to ciprofloxacin. Wolska *et al*. (1999) also reported that 99% of *Pseudomonas aeruginosa* strains were susceptible to ciprofloxacin. Perfloxacin is prescribed in this research for *Aeromoas* infection because it will not inhibit other useful bacteria unlike ciprofloxacin did.

None of the isolates was sensitive to ampicillin. Such resistance to antibiotics had been earlier reported among the bacterial species isolated from *C. gariepinus* (McPhearson *et al*., 1991, Ogunshe and Olabode, 2009) and has been a common occurrence in aquaculture (Spanggard *et al*., 1993). The occurrences of antibiotics resistance among different bacterial groups are very complex. Apart from natural resistance exhibited by some organisms, resistance have been reported to occur mainly as the consequences of the abuse of antimicrobial agents in aquaculture (Smith *et al.*, 1994; WHO, 1999). Spanggard *et al.* (1993) suggested that bacterial groups that co-habit a common environment may share a pool of R-factor plasmids and therefore have similar antibiotics patterns. Beside these, other sources of resistant bacteria in aquaculture systems may be due to rapid multiplication of few antibiotic-resistant organisms originally inhabiting the system or introduced from enteric tracts of fish. This multiplication is usually aided by degradation of uneaten feed and organic manure used for pond fertilization (Husevag *et al.*, 1991).

CONCLUSION

In view of the effects of some bacteria as potential disease-causing organisms and agents of fish spoilage, it is necessary to control these bacteria on catfish to minimise disease occurrence during fish culture and to prolong the shelf life of the fish product. Moreover, since not all bacteria are harmful to fish, the roles of each of these bacterial isolates should be verified to determine their spoilage, pathogenic or beneficial effects on *C. gariepinus*. Further research should be conducted to know the roles each of these bacteria play in digestive activities, metabolic growth and development of living fish. This will help in preventing the use of antibiotics that can retard their growth and preservation after harvest. In conclusion, the use of probiotics in controlling pathogenic bacteria should be encouraged. Fish consumption can contribute significantly to the human dietary exposure to many antibiotic residues; therefore, there is the need to determine risk assessment of the potent antibiotics to the end users (human beings).

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