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Occurrence of Infectious Aeromonas and Pseudomonas Bacteria in *Clarias Gariepinus* from Adamawa State, Nigeria

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Abstract

In the recent time, the production of fish and fishery products in the country is witnessing more involvement both from the government and the people although bacterial infection has been one of the major constraints to achieving the sustainable production from aquaculture. Based on this fact, this study was conducted to evaluate the occurrence of infectious aeromonads and pseudomonads in *Clarias gariepinus* from Adamawa state, Nigeria. *C. gariepinus* samples were collected from three lakes and three fish farms within the Upper Benue Valley Area of Adamawa State during dry and wet season. Tissue samples were taken from the fish samples for bacteriological examinations. Data collected were analyzed using descriptive statistics and Chi-square. The results showed that 42.86% of the sampled *C. gariepinus* with bacterial occurrence were positive for *A. hydrophila*, 28.57% for *A. sobria* and 28.57% were positive for *Ps. fluorescens*. The present study revealed that seasons and collection sites played a significant role in determining the occurrence of bacteria in fish and that pathogenic bacteria are present in *C. gariepinus* without causing any symptomatic effect on the fish.

Keywords: Bacteria, Aeromonads, Pseudomonads, Occurrence, *Clarias gariepinus*

Introduction

Fish represents an important source of protein in human diet (Idowu *et al*., 2017). The total annual demand for fish and fishery products is projected to expand by over 50 million metric tons from year 2015 (FAO 2014). *C. gariepinus* represents one of the preferred food fish in Nigeria, Adamawa State inclusive (Abiodun and Miller, 2007). *C. gariepinus* for consumption in Nigeria is sourced from both the wild and fish farms (Akinrotimi *et al.*, 2011). The demand and supply of the fish, *C. gariepinus* through both the capture and culture fisheries provide a major source of livelihood to the people of Adamawa State (Ekundayo *et al*., 2014; Mallum, 2016).

Both capture and culture fisheries productivity are liable to substantial constraint by bacterial infections, especially those of *Aeromonas* spp and *Pseudomonas* spp (Ali *et al*., 2014; Idowu *et al*., 2016). The outbreaks of these bacteria in fish can result in enormous loss through mass mortalities of the affected fish, and reduced quality and quantity of harvest (Hossian *et al*., 2011). Besides, these pathogenic bacteria may persist in fish and fishery products and eventually end up as pathogens in humans, who consume them (Das and Pattnaik, 2009; Karunasagar, 2012).

There is a growing awareness and concern in the world today on food safety and impact of their production on the environment and Nigeria is not excluded. Consumers of food products, food fish inclusive are becoming more health conscious, paying more attention to the safety of the food they eat. (INFOFISH, 2011).

In the recent time, the production of fish and fishery products in the country are witnessing more involvement both from the government and the people. Therefore, *C. gariepinus*, a preferred culturable fish species and one of the most commonly captured fish species in the Upper Benue Valley Area of Adamawa State (Abubakar *et al*., 2005; Ekundayo *et al*., 2014) is a major alternative for the production of food fish needed for immediate consumption and a

major investment choice for both the fish farmers and the fishers of the area.

Adamawa State is endowed with many rivers; hence, it is an important area of fishing and fish farming (Mallum, 2016). A number of studies have been carried out and well documented on the prevalence of bacterial pathogens in several wild and cultured freshwater fishes (Ibrahem *et al*., 2008; Adedeji *et al*., 2011; Omeje and Chukwu, 2012), however, there are dearth of information on the bacteriological surveys of aeromonas and pseudomonas bacteria in *C. gariepinus* from the Upper Benue Valley Area of Adamawa State.

The present study is therefore aimed at evaluating the occurrence of Aeromonas and Pseudomonas bacteria in *C. gariepinus* from the Upper Benue Valley Area of Adamawa State.

Materials and Methods

Study area

The Upper Benue Valley Area of Adamawa State, within which the selected three (3) fish farms and three (3) lakes for this study are situated, is located between latitudes 09˚09'00"N and 09˚33'00"N of the equator and between longitudes 12˚21'00"E and 12˚54'00E of the prime (Greenwich) meridian (Yonnana *et al*., 2015). The selected lakes are Lake Gwakra (09˚24'26"N, 12˚23'38"E), Lake Njuwa (09˚13'15"N, 12˚30'12"E), and Lake Pariya (09˚21'17"N, 12˚43'27"E), as shown in Figure 1. The three selected commercial fish farms (represented as; Farm A, Farm B, and Farm C for ethical purpose) were also within the Upper Benue Valley Area of Adamawa State.

There are two marked seasons: the wet season, between April and October and the dry season, between November and March (Adebayo *et al*., 2012). The average maximum and minimum temperatures range between 40°C and 26°C respectively and a total annual rainfall of about 600 – 1600 mm (Bindol and Zemba, 2007).

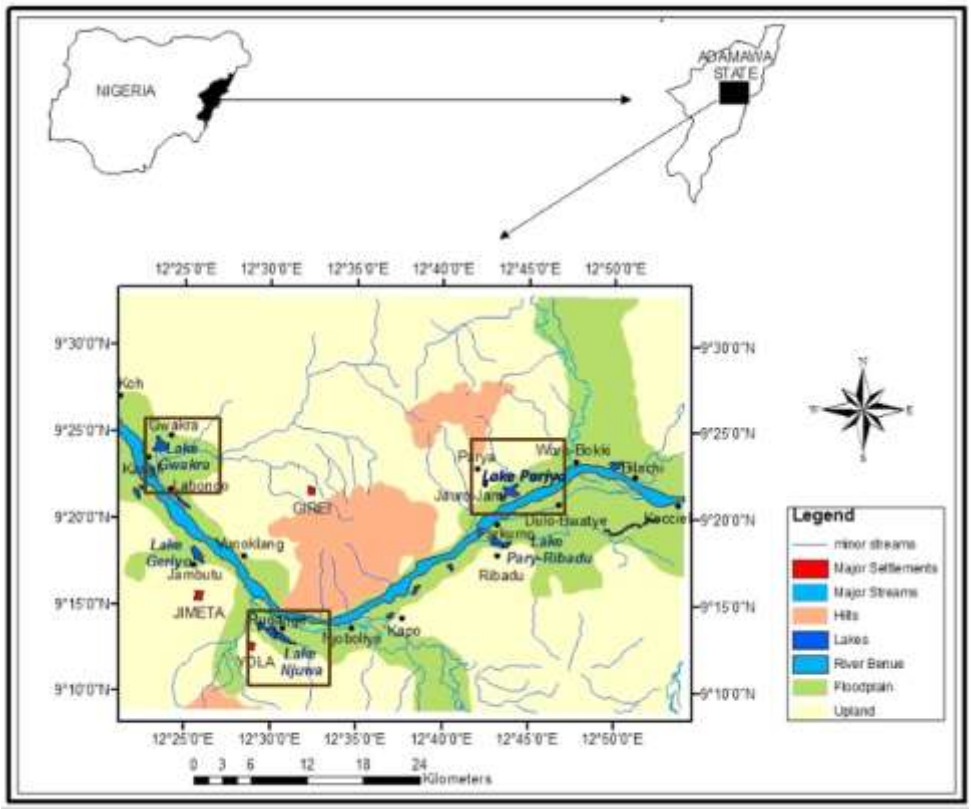


Figure 1: Study area and lakes (Yonnana *et al*., 2015)

Fish sampling

A total of one hundred and eighty (180) *C. gariepinus* specimen (Plate 1) were sampled alive; 90 were collected from the three selected commercial fish farms and 90 from the three selected lakes during the dry and wet seasons of the year. The fish were sampled with cast net. Three samples consisting of 5 *C. gariepinus* each were collected between 8am and 10 am from each fish farm and lake in each season, wet and dry. The dry season sampling was done from January – March, 2017 and the wet season sampling was done from May – July, 2017. The average weights of *C. gariepinus* sampled in the dry and wet seasons were 125±18g and 111±25g respectively. Fish were transported in a sterile plastic containers supplied with the water they were sampled from to the Bacteriological Laboratory of the Department of Microbiology, Modibbo Adama University of Technology, Yola, Nigeria.

Processing of tissue samples

Individual fish was dissected and tissues samples from gill, intestine, kidney, liver, and skin (about 1 cm^2) were collected aseptically for bacteriological examinations as describe by Onwenefah and Adedeji (2013). Peptone water (Microxpress®) already prepared according to the manufacturer's instructions was distributed at 9ml into Bijou bottles and sterilized at 121^oC for 15 minutes. Each tissue sample was inoculated separately into the peptone water and incubated for 24 hours at 37^oC in the laboratory. Two folds serial dilution of each incubated sample of the fish tissue was carried out. Aliquots from the incubated peptone water samples were sub-cultured onto general media, Nutrient agar (Microxpress®) and selective media, Aeromonas agar (LabM, UK) and Pseudomonas agar (TM Media). All the inoculated media were incubated at 37^oC for 24 hours.

Identification of the isolates

Presumptive identification tests (Kumar and Ramulu, 2013; Kumar and Ramulu, 2014) including Grams staining, Glucose fermentation, Motility test, Oxidase test, and Catalase test were carried out, as described by Woodland (2009) in Heil (2009) and in Talalekhozani *et al*. (2015) to categorize the bacterial isolates into respective *Aeromonas* spp and *Pseudomonas* spp colonies. Followed by definitive identification test**s** (Kumar and Ramulu, 2013; Kumar and Ramulu, 2014) involving a set of biochemical tests as related to Carbohydrate metabolism: Sugar fermentation, Methyl red test (MR), Voges proskauer test (VP), Triple Sugar Iron (TSI); Amino acid and protein metabolism: Indole test; and Fluorescent pigment tests (*Pseudomonas* spp) as described by Woodland (2009) in Heil (2009) and in Talalekhozani *et al*. (2015). Nitrate reduction test were carried out as described in Talalekhozani *et al*. (2015). National Wild Fish Health Survey – Laboratory Procedures Manual (Heil, 2009), Practical Identification Manual for Bacteria and Fungi from Fish and Other Aquatic Animals (Buller, 2014) and Guidelines for Quick Application of Biochemical Test to Identify Unknown Bacteria (Talalekhozani *et al*., 2015) were used to analyze the biochemical reactions in order to classify the *Aeromonas* and *Pseudomonas* isolates to species levels.

Results

The presumptive and definitive identification tests characteristics of the *Aeromonas* spp and *Pseudomonas* spp isolated from the tissue samples of the examined fish are shown in Table 1 and 2 respectively.

The presumptive identification tests results indicated the occurrence of *Aeromonas* spp and *Pseudomonas* spp in twenty-one (21) *C. gariepinus* samples out of the one hundred and eighty (180) samples collected from the selected fish farms and lakes. The fish farm results demonstrated that *Aeromonas* spp were found in nine (9) fish samples and two (2) fish samples indicated the occurrence of *Pseudomonas* spp. The total occurrence of *Aeromonas* spp and *Pseudomonas* spp is shown in Table 3.

The definitive identification tests results demonstrated that the bacterial species isolated from the twenty-one (21) fish samples with the bacterial occurrence were found to be *Aeromonas hydrophila*, *Aeromonas sobria* and *Pseudomonas fluorescens*. The prevalence of the bacterial isolates (Figure 2) indicated that 42.86% of the fish samples with bacterial occurrence were positive for *A. hydrophila*,

28.57% for *A. sobria* and 28.57% were positive for *Ps. fluorescens*.

The prevalence of bacterial species occurrence for fish samples collected from the selected collection sites is illustrated in Table 4. The results indicated that the total prevalence of the occurrence of *A. hydrophila*, *A. sobria* and *Ps. fluorescens* to be 33.33%, 9.52% and 9.52% respectively for fish collected from the fish farms and 9.52%, 19.05% and 19.05% respectively for those collected from the lakes. The highest occurrence of bacterial species was reported for *A. hydrophila* (33.33%), whereby Farm B indicated the highest occurrence of 19.05%. The χ^2 =4.184; df=2 with p=0.1234 shows insignificant association. Even t-test has a value of t=0.2325; df=4 and the two tailed p=0.8276 are all considered insignificantly different.

Results of seasonal prevalence of bacterial occurrence for the examined *C. gariepinus* samples (Table 5) indicated *A. hydrophila* as the bacteria species with highest prevalence of 33.33% in dry. *Ps. fluorescens* had seasonal prevalence of 14.29% in both the dry and the wet seasons respectively.

Table 1: Presumptive Identification of Bacterial Isolates from the Examined Fish Species

Tests		**Bacterial isolates**	
		***Aeromonas* spp.**	***Pseudomonas* spp.**
Colony Characteristics	Aeromonas agar (LabM, UK)	Convex, glossy; Translucent, tangy green colonies	Convex, glossy; Translucent, tangy green colonies
	Pseudomonas agar (TM Media)	No growth	Convex, yellowish colonies
Staining		-ve	-ve
Glucose fermentation		+ve	-ve
Motility test		+ve	+ve
Oxidase test		+ve	+ve
Catalase test		V	V

V: variable result

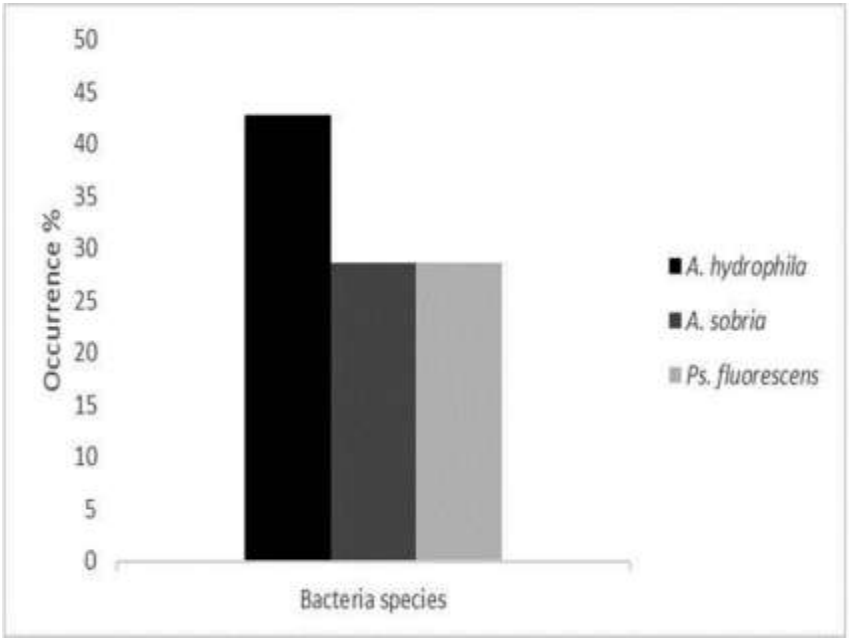
Table 2: Definitive Identification of Bacterial Isolates from the Examined Fish

Biochemical test	***A. hydrophila***	***A. sobria***	***Ps. fluorescens***
Gas production from Dextrose	+	-	+
Methyl red test (MR)	+	+	-
Voges proskauer test (VP)	+	+	V
Acid from glucose	+	+	V
Acid from sucrose	+	+	-
H_2S production	+	+	-
Indole test	+	+	-
Fluorescent pigment test	NA	NA	+
Nitrate reduction test	+	+	+

NA: Not applicable, V: variable result

Table 3: Occurrence of *Aeromonas* spp and *Pseudomonas* spp in the examined *C. gariepinus*

Fish species	Site	No. of Exam fish	No. of Inf. Fish	*Aeromonas* spp			*Pseudomonas* spp		
				Season			Season		
				Dry	Wet	Total	Dry	Wet	Total
				No inf.	No inf.		No inf.	No inf.	
Fish farm	Farm A	30	2	2	-	**2**	-	-	-
	Farm B	30	5	3	1	**4**	1	-	**1**
	Farm C	30	4	1	2	**3**	-	1	**1**
	Total	**90**	**11**	**6**	**3**	**9**	**1**	**1**	**2**
Wild	Lake Gwakra	30	2	-	1	**1**	1	-	**1**
	Lake Njuwa	30	5	1	2	**3**	-	2	**2**
	Lake Parya	30	3	1	1	**2**	1	-	**1**
	Total	**90**	**10**	**2**	**4**	**6**	**2**	**2**	**4**
Total		**180**	**21**	**8**	**7**	**15**	**3**	**3**	**6**



*Percentage was calculated according to the total number of fish with bacterial occurrence

Figure 2. Prevalence of bacterial occurrence in the examined *C. gariepinus*

Table 4: Prevalence of bacterial species in the collection sites

Bacteria Species	Fish farm								Wild								Total %
	Farm A		Farm B		Farm C		**Total**		Lake Gwakra		Lake Njuwa		Lake Parya		**Total**		
	No. inf.	%	No. inf.	%	No. inf.	%	**No. inf.**	**%**	No. inf.	%	No. inf.	%	No. inf.	%	**No. inf.**	**%**	
A. hydrophila	2	9.52	4	19.05	1	4.76	**7**	**33.33**	1	4.76	1	4.76	-	-	**2**	**9.52**	**42.85**
A. sobria	-	-	-	-	2	9.52	**2**	**9.52**	-	-	2	9.52	2	9.52	**4**	**19.05**	**28.57**
Ps. fluorescens	-	-	1	4.76	1	4.76	**2**	**9.52**	1	4.76	2	9.52	1	4.76	**4**	**19.05**	**28.57**
Total	**2**	**9.52**	**5**	**23.81**	**4**	**19.05**	**11**	**52.38**	**2**	**9.52**	**5**	**23.81**	**3**	**14.28**	**10**	**47.62**	

*Percentage was calculated according to the total number of infected fish

Table 5: Seasonal prevalence of bacterial occurrence in the examined fish

Season	No. of Exam fish	No. of inf. fish	***A. hydrophila***		***A. Sobria***		***Ps. fluorescens***		Total %
			No. of fish	%	No. of fish	%	No. of fish	%	
Dry	90	15	7	33.33	5	23.81	3	14.29	**71.43**
Wet	90	6	2	9.52	1	4.76	3	14.29	**28.57**

Discussion

The bacteria, *A. hydrophila*, *A. sobria* and *Ps. fluorescens* identified in the present study are both opportunistic and pathogenic in nature and has been identified as disease causing organisms in *C. gariepinus* (Olufemi *et al*., 1991; Efuntoye *et al*., 2012). However, in this study they were isolated from apparently healthy *C. gariepinus*. The fish (host) defense response coupled with the tolerable environmental conditions of the collection sites might be the enabling factor for the fish ability to suppress the bacteria's pathogenic activities (Efuntoye *et al*., 2012; Danba *et al*., 2014). Nonetheless, the examined fish farms and lakes are not invulnerable to disease outbreaks from the activities of these isolated bacteria, *A. hydrophila*, *A. sobria* and *Ps. fluorescens* (Hossian *et al*., 2011; Anyanwu *et al*., 2014). Stress is an indispensable factor of disease development in fish. Symptomatic manifestation of disease in fish largely depends on the degree of stress and when the stress is introduced (Lio-Po and Lim, 2014; Idowu *et al*., 2016).

In regard to the prevalence of bacterial occurrence, *Aeromonas spp* was indicated as the predominant bacterial isolates, with *A. hydrophila* (42.86%) and *A. sobria* (28. 57%). This is in accordance with the work of Wamala *et al*. (2018), who reported *Aeromonas spp* to be the predominant bacteria isolates with *A. hydrophila* (43.8%) and *A. sobria* (20.1%). Similar findings have also been documented by Moustafa *et al*. (2010) and Walakiri *et al*. (2014). The related results reported in the different studies could be due to the ubiquitous nature of *Aeromonas spp*. in aquatic environment, similarity of the fish collection sites and the fish species examined (Hatha *et al*., 2005).

Fish farms had higher occurrence of *A. hydrophila*, as compared to lakes with Farm B indicating the highest occurrence. The characteristic features of fish culture systems (especially earthen ponds) such as high density of fish, low water quality, increased human activity, water re-circulation, stock movement and high organic matter could be responsible for this observed bacterial occurrence (Penders and Stobberingh, 2008). Moreover, *A. hydrophila* has been reported to be of more pathogenic importance in cultured system than in the wild (Topic-Popovie *et al*., 2000; Ibrahem *et al*., 2008). *Ps. fluorescens* indicated higher number of occurrence for the wild collection sites. This could be attributed to the direct contamination of lake water by bacteria from surrounding soils and runoff water (Wamala *et al*., 2018).

The present study revealed *A. hydrophila* and *A. sobria* to have higher occurrences during the dry season as compared to the wet season, though, with *A. hydrophila* having the highest occurrence. Seasonality in the prevalence of *A. hydrophila* had been reported in different research works including Topic-Popovie *et al*. (2000), Ibrahem *et al*. (2008), Moustafa *et al*. (2010) and Omeje and Chukwu (2012). However, while the present study results corresponded with those of Ibrahem *et al*. (2008) and Omeje and Chukwu (2012) who also indicated the prevalence of *A. hydrophila* to be higher during the warmer periods of their study. The results were not so with Topic-Popovie *et al*. (2000) and Moustafa *et al*. (2010) who on the contrary observed higher prevalence of *A. hydrophila* during colder periods of their study as compared to warmer periods. This might be an indication that the survival of *A. hydrophila* is not necessarily a function of whether it is warm or cold season (Omeje and Chukwu, 2012) rather of the ubiquitous nature of the bacterium in aquatic environment.

In the present study, considerable correspondences were yet to be inferred with regards to the seasonal prevalence of *Ps. fluorescens* as the bacterium indicated similar number of occurrence both in the dry and wet season. However, *Ps. fluorescens* had been demonstrated to take advantage of colder seasons for propagation and infection transmission (El-Moghazy, 2004; Moustafa *et al*., 2010). Although, Hoda *et al*. (1999) demonstrated the highest prevalence of *Pseudomonas* to occur during the warmer period of their study.

The present study revealed that, pathogenic bacteria are present in *C. gariepinus* without causing any symptomatic effect. Also, season and collection site play a significant role in determining the occurrence of bacteria in fish.

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References

Abiodun, J.A. and Miller. J.W. (2007): Assessment of Gerio lake fishery for enhanced management and improved fish production. *Journal of Applied Science and Environment Management* 11(4): 11 – 14.

Abubakar, K.A., Haruna, A.B. and Ladu, B.M.B. (2005): Studies on fish yield, diversity and abundance in Lake Gerio, Yola, Adamawa state, Nigeria. *Nigeria Journal of Tropical Agriculture*. **7**: 35-41.

Adebayo, A.A., Zemba, A.A., Ray, H.H. and Dayya, S.V. (2012): Climate change in Adamawa state, Nigeria: Evidence from agro climatic parameters. *Adamawa State University Journal of Scientific Research*. 2(2): 18p

Adedeji, O.B., Emikpe, B.O. and Adebisi, T. (2011): Bacterial load on the skin and stomach of *C. gariepinus* and *O. niloticus* from Ibadan, Southwest Nigeria: Public health implications. *Journal of Microbiology and Biotechnology Research*. **1**(1): 52-59.

Akinrotimi, O.A., Abu, O.M.G. and Aranyo, A.A. (2011): Environmental Friendly Aquaculture Key to Sustainable Fish Farming Development in Nigeria. *Continental Journal Fisheries and Aquatic Science*. **5**(2): 17-31.

Ali, M.H., Chowdhury, F.S., Ashrafuzzaman, M., Chowdhury, M.A., Ul-Haque, M.R., Zinnah, K.M.A. and Rahman, M.M. (2014): Identification, pathogenicity, antibiotic and herbal sensitivity of *Edwardsiella tarda* causing fish disease in Bangladesh. *Current Research in Microbiology and Biotechnology*. **2**(1): 292-297.

Anyanwu, M.U., Chah, K.F. and Shoyinka, V.S. (2014): Antibiogram of aerobic bacteria isolated from skin lesions of African catfish cultured in Southeast, Nigeria. *International Journal of Fisheries and Aquatic Studies*. 2(1): 134 – 141

Bindol, N.I. and Zemba, A.A. (2007): Analysis of rainfall data for effective agricultural production in Adamawa state, Nigeria. *Multidisciplinary Journal of Empirical Research*. **4**(1): 169 - 175

Buller, N.B. (2014): *Bacteria and fungi from fish and other aquatic animals: A practical identification manual*. 2nd edition, CABI Publishing, Cambridge.

Danba, E.P., Bichi, A.H., Ishaku, S., Ahmad, M.K., Buba, U., Bingari, M.S., Barau, B.W. and Fidelis, U. F. (2014): Occurrence of pathogenic bacteria associated with *Clarias gariepinus* in selected fish farms of kumbotso local government area of Kano state, Nigeria. *Bayero Journal of Pure and Applied Sciences*. 7(2): 145 – 149.

Das, B.K. and Pattnaik, P. (2009): Good aquaculture practices. *In: Proceedings of the Workshop on Concepts of HACCP and its Application in Aquaculture*, pp.44-57. CIFA Central Institute of Freshwater Aquaculture (Indian Council of Agricultural Research) Odisha, India CIFA. 105p.

Efuntoye, M.O., Olurin, K.B. and Jegede, G.C. (2012): Bacterial Flora from Healthy *Clarias gariepinus* and their Antimicrobial Resistance Pattern. *Advance Journal of Food Science and Technology* 4(3): 121 – 125.

Ekundayo, T.M., Sogbesan, O.A. and Haruna, A.B: (2014) Study of fish exploitation pattern of Lake Gerio, Yola, Adamawa State, *Nigeria. Journal of Survey in Fisheries Sciences* 1(3): 9-20.

El-Moghazy, D.F. (2004): Studies on pseudomonas septicemia in cultured *Oreochromis niloticus* fish. Thesis, M.V.Sc., Fish Disease and Management, Faculty of Veterinary Medicine. Suez Canal University

FAO, (2014): Food and Agricultural Organization of the United Nations. The state of world fisheries and aquaculture 2014. FAO Fisheries Department, Rome Italy, 30p.

Hatha, M., Vivekanandhan, A.A., Joice, G.J. and Christol, A. (2005): Antibiotic resistance pattern of motile aeromonads from farm

raised freshwater fish. *International Journal of Food Microbiology* **98**: 131 – 134.

Heil, N. (2009): *National Wild Fish Health Survey – Laboratory Procedures Manual* 5th Edition, U. S. Fish and Wildlife Service, Warm Springs, GA.

Hoda. H., Yusef, H., Abd-EL-Kader, M. and Abd-EL-Latif, H.H. (1999): Quantitave and qualitative studies on bacterial Microflora of Fish reared in fresh water fish farm in Alexandiria. *Journal of Egypt Microbiology*. 34: 315 – 330.

Hossian, M.M.M., Rahman, M.A., Monda, S., Shadat-Mondal, A.S.M. and Chowdhury, M.B.R. (2011): Isolation of some emergent bacteria pathogens recovered from capture and culture fisheries in Bangladesh. *Bangladesh Research Publications Journal*. **6**(1): 77-90.

Ibrahem, M.D., Mostafa¸ M.M., Arab, R.M.H. and Rezk, M.A. (2008): Prevalence of *Aeromonas hydrophila* infection in wild and cultured tilapia nilotica *(O.niloticus)* in Egypt. *8th International Symposium on Tilapia in Aquaculture* 2008 Cairo, Egypt. 1257-1270.

Idowu, T.A., Onyia, L.U. and Kefas. M. (2016): Fish diseases and health management. *In: Contextual aquaculture and fisheries digest*. Maiden Edition, Paraclete Publisher, Yola, Nigeria. 155-171p.

Idowu, T.A., Umar, A.B., Adedeji, H.A., Jidauna, S.B. and Sogbesan, O.A. (2017): Nutritional Composition of *Mormyrus Rume* and *Protopterus Annectens* from Lake Gerio, Yola, Adamawa State, Nigeria. *BAOJ Food Science and Technology* 1: 004.

INFOFISH (2011): *Handbook on organic aquaculture.* CFC/FAO/INFOFISH Project on Organic Aquaculture in Myanmar, Thailand and Malaysia. INFOFISH, Lumpur, Malaysia. 35p.

Karunasagar, I. (2012): Public health and trade impact of antimicrobial use in aquaculture. In: M.G. Bondad-Reantaso, J.R. Arthur and R.P. Subasinghe, eds. *Improving biosecurity through prudent and responsible use of veterinary medicines in aquatic food production* pp. 1-9. FAO Fisheries and Aquaculture Technical Paper No. 547. Rome, FAO. 207p.

Kumar, M.P. and Ramulu, K.S. (2013): Presumptive and definitive identification of *Pseudomonas* from infected *Pangasius hypophthalmus* in culture ponds of West Godavari and Krishna districts of Andhra Pradesh. *Journal of Microbiology and Biotechnology Research.* **3**(3):41-45

Kumar, M.P. and Ramulu, K.S. (2014): Presumptive and definitive identification of *Aeromonas* from infected *Pangasius hypophthalmus* in culture ponds of West Godavari and Krishna districts of Andhra Pradesh. *Scholars Academic Journal of Biosciences.* **2**(7): 441 – 444

Lio-Po, G. and Lim, L. (2014): Infectious diseases of warm water fish in freshwater. *In Diseases and disorders of finfish in cage culture*. Woo, P. and Bruno D., Eds. Oxfordshire: CAB International, 193 – 253.

Mallum, S.S. (2016): Evaluation of toxicity of propanil and dichlorvos on African Catfish, *Clarias gariepinus* (Burchell, 1822) and Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758). Thesis PhD. Department of Fisheries, Modibbo Adama University of Technology, Yola, Nigeria. 154p.

Moustafa, M., Mohamed, L.A., Mahmoud, M.A., Soliman, W.S. and El-gendy, M.Y. (2010): Bacterial infections affecting marine fishes in Egypt. *Journal of American Science*. **6**(11): 603-612.

Olufemi, B.E., Akinlabi, D.A. and Agbede, S.A. (1991): Aerobic bacterial Pathogens isolated from the African Catfish *Clarias gariepinus* (Burch). *Tropical Veterinary*. 9: 177 – 180.

Omeje, V.O. and Chukwu, C.C. (2012): A relative prevalence of *Oreochromis niloticus*, *Clarias gariepinus* and *Heterotis niloticus* to *Aeromonas hydrophila* in an integrated fish farm. *Nigerian Veterinary Journal*. 33(2): 492 – 498.

Onwenefah, M. and Adedeji, O.B. (2013): Bacterial flora of cultured catfish fed with poultry hatchery waste from selected farms in

Ibadan, Southwestern Nigeria. *New York Science Journal*. **6**(7): 106 – 110.

Penders, J. and Stobberingh, E.E. (2008): Antibiotic resistance of motile aeromonads in indoor catfish and eel farms in the southern part of The Netherlands. *International Journal Anti-microbe Agents.* 31(3):261 – 265.

Roberts, R.J. (2012): *Fish Pathology*. 4th edition, Wiley-Blackwell, UK. 581p.

Talalekhozani, A., Alaee, S. and Ponraj, M (2015): Guidelines for quick application of biochemical test to identify unknown bacteria. *Account of Biotechnology Research* **2**(2): 65 – 85.

Topic-Popovie, N.E., Teskeredzic, I.E., Strunjak-Provic, R.I. and Coz-Rakovac, R. (2000): *Aeromonas hydrophila* isolated from wild freshwater fish in Croatia. *Veterinary research communications*. 24: 371 – 371.

Walakira1, J., Akoll, P., Engole1, M., Sserwadda1, M., Nkambo1, M., Namulawa1, V., Kityo1, G., Musimbi1, F., Abaho, I., Kasigwa, H., Mbabazi1, D., Kahwa, D., Naigaga, I., Birungi, D. Rutaisire, J. and Majalija, S. (2014): Common fish diseases and parasites affecting wild and farmed tilapia and catfish in central and western Uganda. *Uganda Journal of Agricultural Sciences*. 15(2): 1 – 11.

Wamala, S.P., Mugimba, K.K., Mutoloki, S., Evensen, O., Mdegela, R., Byarugaba, D.K and Sorum, H. (2018): Occurrence and antibiotic susceptibility of fish bacteria isolated from *Oreochromis niloticus* (Nile tilapia) and *Clarias gariepinus* (African catfish) in Uganda. *Fisheries and Aquatic Sciences*. 21:6

Woodland, J. (2009): Bacteriology. *In: National Wild Fish Health Survey – Laboratory Procedures Manual* 5th Edition, U. S. Fish and Wildlife Service, Warm Springs, GA. 5-1 – 5-46p.

Yonnana, E., Tukur, A.L. and Mubi, A.M. (2015): Morphometric characteristics of selected fluviatile lakes in the Upper Benue Valley Area of Adamawa State, Northeastern Nigeria. *Journal of Geography and Regional Planning*. **8**(3): 56-64.