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Prevalence and Intensity of Parasitic Infestation on Developmental Stages of *Clarias gariepinus* Reared in Different Water Renewal Culture Systems

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Abstract

Fish disease is a significant factor in aquaculture that causes negative impact. Therefore regular updates of epidemiological data must be ensured indicating the level of exposure to infections which prompted this study. 487 *Clarias gariepinus* comprising different developmental stages were collected from the water renewal systems; daily (DWR), weekly (WWR) and bi-weekly (BWR). The prevalence and mean intensity of infection were determined using standard parasitological methods. Water parameters were measured using recommended methods. Descriptive statistic (percentages and mean) was used for analysis. The parasites observed were protozoans - *Trichodina spp., Vorticella spp., Tetrahymena spp Chilodonella spp., Ichthyobodo spp., Piscinoodinium spp.*, and *Ambiphyra spp.*; monogenean trematodes - *Dactylogyrus spp., Gyrodactylus spp.*, and suspected *Salmonichus spp.*; crustacean parasites – *Argulus spp.* and unidentified Nematode. The highest prevalence and intensity of 80% and 55.50 ± 18.63 respectively were recorded in *Trichodina spp* infection in fingerlings, under the BWR. With *Trichodina spp* and *Dactylogyrus spp* prevalence of 80% and 40% on the gills respectively and 60% prevalence of *Trichodina spp* on the skin, the gills and the skin are the most preferred predilection sites for *Trichodina spp*, while *Dactylogyrus spp* has the gills as its main predilection site. The rate of single infection was higher than co-infection in all the culture systems for all developmental stages of *C. gariepinus*.

Key Words: indices of infection, *Clarias gariepinus*, predilection sites, culture systems, co-infection.

Introduction

Fish disease is an abnormality revealed in the behavior, texture and physiological functions of living aquatic organisms with specific or non-specific symptoms which are caused by infectious disease agents (parasites, bacteria, fungi and viruses), poor management practices and environmental imbalance. It causes economic loss due to poor quality at harvest which invariably affects other value chain products (SEAFDC, 2001). Globally, fish diseases are one of the significant factors inhibiting aquaculture productivity and sustainability due to the negative impact on food security, food safety, economic growth, job stability, and the health status of consumers (Ali *et al.*, 2020). The annual loss of revenues on fish production through disease outbreaks was estimated as 6 billion dollars (Hien *et al.*, 2020). The persistence of fish disease in farms can be responsible for product rejection by customers/consumers, loss of product, loss of jobs and eventual collapse of business

(SEAFDC, 2001). The ability of parasites to cause disease (virulence) depends on various factors including the strain, genotype, biotype and serotype of the agent (Engleking *et al*. 1991), a single alteration of amino acid in vital protein (Kim *et al*. 1994), number of pathogens, portal of entry and duration of exposure (LaPatra *et al*. 1989).

Invasion of parasites can be a sole infection or multiple infections on host at the same time. Co-infection occurred when two or more genetically different parasites infringe individual pathogenic impact in coincidence with other pathogens on the fish host (Bakaletz, 2004; Cox, 2001) with different relationships ensuing such as increase in the loads of one or both pathogen(s), increase in one while the other is suppressed, one or both pathogen(s) suppressed (Cox, 2001). The co-existence may either be to compete for resources or the site of infection on the same host, whereas such interaction may cause one pathogen to suppress the immune response of the host against the subsequent infections by other pathogens (Telfer *et al.*, 2008). The co-infections of parasites can influence disease epidemiology (Susi *et al*., 2015) either synergistic or antagonistic (Bradley and Jackson, 2008). The synergistic effects caused severe infection and mortality due to combined contributions of pathogens to immunity breakdown of the host (Bradley and Jackson, 2008) while antagonistic effect of co-infection shows the ability and impact of one pathogen on the immune response of the host as well as hindering the other pathogens (Chen *et al.*, 2013).

Pathogenic infections (single or multiple) have been reported on many cultured fish but African catfish being a well acceptable cultured fish in Nigeria (Awe, 2017) and one of the highly cultured fish susceptible to ectoparasites and endoparasites (Subashinghe, 1995) prompted the essence of the study to provide vital information for farmers on the awareness of the status of parasitic infections and intensity on developmental stages of *Clarias gariepinus* in different water renewal system to beef up their hygiene to avoid or minimized primary causative agents (parasites) to secondary infections (bacteria) in farms.

Materials and Methods

Study Area

The experiment was carried out in Lagos State being one of the states in Nigeria with high rate of fish farming activities (Miller and Atanda, 2011). The study covered the 3 stratified Agricultural zones (Lagos East, Lagos West and Lagos Far – East) according to Lagos State Agricultural Development Authority (LSADA).

Samples Collection

A total number of 487 *Clarias gariepinus* were collected bi–monthly from the sampling areas and five live fish samples each were randomly collected from selected farms into suitable plastic containers filled with the required quantity of water and transported to the Veterinary Medicine Laboratory of the University of Ibadan, Ibadan, Oyo State for parasitological examinations. The fish was identified according to Teugels (1986). Fry and fingerlings were collected with scoop nets while juveniles and adults were collected with drag net to avoid stress. The source of water used by farmers varied including boreholes, wells, streams/rivers and stagnant ponds.

Clinical Examination

Physical examination was carried out according to Noga (2010) to observe abnormal behavior, depigmentation, gills abnormalities, petechial haemorrhage, skin ulceration and mucus loads.

Parasitological examination

Fish were killed by severing the spinal cord behind the head. The organs harvested for parasitological examinations were skin, gills, intestine, liver, trunk kidney and blood samples. Examination of organs and tissues was performed according to Adams *et al.* (1993). Wet mount specimens were prepared for the skin by scrapping the surface from the

head to the tail region and placed on a clean glass slide likewise the small portion of gill was incised on a clean slide and viewed for ectoparasites, The fish were slit opened to expose the internal organs for endoparasites observation. The intestine was dissected and the food contents were carefully removed and the intestinal wall content was scrapped with the coverslip and placed on a clean slide. The small quantum of liver and trunk kidney was eviscerated and squashed between two clean glass slides. The thin smear of blood was prepared for haemoparasites. All the specimens were viewed under Olympus binocular microscope connected to DCM 35E – 350pixel scope photo and computer device. The wet mounts were observed for parasites using x10 and x40 objective magnification (Goselle *et al..*, 2008). The parasites observed were identified according to Noga (2010) and Smith and Noga, (1993).

Determination of parasitic parameters

Each organ was examined for corresponding endoparasites or ectoparasites. The following parameters were deduced using the equations according to Ukoli (1990) and Mamani *et al*. (2004)

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

$$\text{Intensity of infection} = \frac{\text{Total No. of parasites collected in a sample}}{\text{No of infected host}}$$

Single infection and Co-infections of parasites were obtained by calculating the rate of occurrence of single and multiple parasites in each host in relation to the total numbers of samples examined using the expression:

$$\text{Prevalence (Co-infection \%)} = \frac{\text{Aggregate of samples with coexistence parasites}}{\text{Total numbers of fish examined}}$$

Statistical Analysis

Simple descriptive statistics including percentages and mean were used for data analysis with the aid of excel 2016spinal**lts**

Prevalence and mean intensity of parasites on developmental stages of *Clarias gariepinus* across the culture systems

The prevalence and mean intensity of parasites across the culture systems and developmental stages were shown in (Table 1a – b). The three most prevalent parasites were *Trichodina spp*, *Vorticella spp* and *Dactylogyrus spp*. On fry, the highest prevalence of *Trichodina spp* was found in WWR (14.3%), *Vorticella spp* in DWR (12%) and *Dactylogyrus spp* in DWR (26%). On fingerlings, the highest prevalence was found in *Trichodina spp* in BWR (80%), *Vorticella spp* in WWR (11.4%), and *Dactylogyrus spp* in BWR (40%). In juveniles, the highest prevalence were *Trichodina spp* (50%) and *Vorticella spp* (28.6%) in DWR while *Dactylogyrus spp* in WWR (32%). In adults fish, the highest prevalence were *Trichodina spp* in DWR (10.3%), *Vorticella spp* in WWR (15.9%) and *Dactylogyrus spp* in DWR (28.2%). No *Vorticella spp* was found in BWR. Among other parasites observed, *Gyrodactylus spp* (5.5%) and *Chilodonella spp* (5.5%) were highly prevalent on fingerlings, with 7.1% each of *Gyrodactylus spp*, *Chilodonella spp* and *Ichthyobodo spp* on juveniles and 10.3% of *Gyrodactylus spp* on adults in DWR. In WWR, *Piscinoodinium spp* and *Vorticella spp* had the highest prevalence of 15.9% each on adult and the least of 0.7% each (*Tetrahymena spp*, *Chilodonella spp*, *Piscinoodinium spp* and *Ichthyobodo spp*) on juveniles while 2.9% each of *Tetrahymena spp* and *Argulus spp* on fingerlings. In BWR, *Chilodonella spp* (20%) was only prevalent. The intensity of infection on fingerlings; unidentified nematodes was 5.9% followed by

Chilodonella spp. (2.9%) on juveniles while *Gyrodactylus spp.* (28.6%) followed by *Ichthyobodo spp* (14.3%) on adults.

Therefore the highest prevalence and mean intensity in DWR were *Trichodina spp* (50%, 28.86 ± 34.83) in juvenile followed by fingerlings (40%, 24.73 ± 33.90) respectively while the highest prevalence and intensity in WWR were *Dactylogyrus spp* in juveniles (32%) and *Vorticella spp* in fingerling (42.00 ± 13.88) respectively followed by *Trichodina spp* in fingerlings (25.7%) and fry (33.40 ± 19.40) accordingly whereas in BWR, the highest prevalence and mean intensity were *Trichodina spp* (80%, 55.50 ± 18.63) in fingerlings followed by *Dactylogyrus spp* in fingerlings (40%) and *Ichthyobodo spp* in adults (25.00 ± 0.00) respectively.

Prevalence of parasites on predilection site of developmental stages of *Clarias gariepinus* reared in different culture systems.

The prevalence of parasites on 6 selected organs (skin, gills, intestine, liver, trunk kidney and blood) of different developmental stages reared in different culture systems was reported accordingly (Table 2). No parasite was observed in the liver, trunk kidney and blood. On the skin, the fry recorded the highest prevalence of *Trichodina spp* in WWR (11.4%), *Vorticella spp* in DWR (12%), *Dactylogyrus spp* in DWR (4%) and other parasites in DWR (2%); the fingerlings had the highest prevalence of *Trichodina spp* in BWR (60%), *Vorticella spp* in WWR (11.4%) and other parasites in BWR (20%); the juveniles with the highest prevalence of *Trichodina spp* in WWR (21.8%), *Vorticella spp* in DWR (28.6%) and other parasites in DWR (21.4%) while the skin of the adult fish had the highest prevalence of *Trichodina spp* in DWR (2.6%), *Vorticella spp* in WWR and BWR (15.9% each), *Dactylogyrus spp* in DWR (2.6%) and other parasites in DWR (10.3%). On the gills examined in developmental stages, the fry gills had the highest prevalence of *Trichodina spp* (11.4%) and *Dactylogyrus spp* (14.3%) in WWR. On fingerlings, the highest prevalence of *Trichodina spp* (80%), *Dactylogyrus spp* (40%) and other parasites (2.9%) were recorded in WWR while on juvenile gills the highest prevalence of *Trichodina spp* (50%) in DWR, *Dactylogyrus spp* (32%) in WWR and 0.7% of other parasites was found in WWR and BWR whereas the adult gill of fish reared in DWR had highest prevalence of *Trichodina spp* (10.3%) and *Dactylogyrus spp* (28.2%). No *Vorticella spp* was recorded in the gills in all developmental stages likewise the absence of members of other parasites on the gills of adult fish. In the intestine of *C. gariepinus* developmental stages, no parasite was observed in the fry intestine while the highest prevalence of 1.8% each for *Trichodina spp* and *Vorticella spp* in fingerlings reared in DWR. *Vorticella spp* was highly prevalent in juveniles reared in DWR (7.1%) while other parasites were prevalent in BWR (5.9%). The adult intestine had only *Vorticella spp* in WWR (4.8%).

Prevalence of single and co-infections of parasites in developmental stages under culture systems

The prevalence of individual and multiple parasites on developmental stages under culture systems was presented in Table 3. In DWR, a single infection of parasites was higher on fry (26%) and adults (34.2%) compared to multiple parasites with prevalence of 8% and 13.2% respectively whereas both single and multiple infections were exhibited on fingerlings (23.6%, 21.8%) and juveniles (21.4%, 28.6%). In WWR, single infections had higher prevalence on fry (14.3%), fingerlings (34.3%) and juveniles (29.3%) while adults had more multiple parasitic infections (11.1%) but the highest co-infection was also recorded in juveniles (16.3%). In BWR, single infection was found only on adult (42.9%) whereas multiple infection was harvested on fingerlings (60%) but equal prevalence of 14.7% each was recorded for single and multiple infections on juveniles. However, the rate of single infection was higher in all the culture systems compared to multiple infections.

Water parameters measured across the culture systems for community of parasites

The mean water parameters measured for the community of parasites ranged accordingly for pH (6.90 ± 0.49 - 7.45 ± 1.49), water temperature (30.67 ± 2.40 - 32.36 ± 2.72^{o}C), DO (4.99 ± 5.16 - 18.62 ± 3.02mgl^{-1}), ammonia (2.16 ± 0.28 - 2.48 ± 0.74mgl^{-1}), nitrite (0.54 ± 0.06 - 0.80 ± 0.87mgl^{-1}), iron (0.30 ± 0.14 – 0.93 ± 1.15mgl^{-1}), alkalinity (66.67 ± 70.71 – 304.38 ± 391.27mgl^{-1}), hardness (390 ± 250.57 – 933 ± 866.18mgl^{-1}) and turbidity (17.05 ± 7.90 - 40.67 ± 9.62cm) across the culture systems (Table 4).

Table 1a: Prevalence and mean intensity of infection on fry and fingerlings stages of *Clarias gariepinus* reared across different culture systems

Developmental Stages	Parasites	DWR		WWR		BWR	
		Prevalence (%)	MII	Prevalence (%)	MII	Prevalence (%)	MII
Fry	Trichodina *spp*	4	6.50 ± 6.36	14.3	33.40 ± 19.40	0	0.00 ± 0.00
	Vorticella spp	12	5.00 ± 3.22	5.7	22.00 ± 0.00	0	0.00 ± 0.00
	Dactylogyrus spp	26	9.62 ± 7.65	11.4	2.50 ± 1.91	0	0.00 ± 0.00
	Susppected *Salmonichus spp*	2	1.00 ± 0.00	0	0.00 ± 0.00	0	0.00 ± 0.00
Fingerlings	Trichodina *spp*	40	24.73 ± 33.90	25.7	16.22 ± 21.31	80	55.50 ± 18.63
	Vorticella spp	7.3	7.50 ± 7.14	11.4	42.00 ± 13.88	0	0.00 ± 0.00
	Dactylogyrus spp	16.4	6.67 ± 3.67	20	5.14 ± 2.79	40	1.50 ± 0.71
	Gyrodactylus spp	5.5	9.33 ± 6.81	0	0.00 ± 0.00	0	0.00 ± 0.00
	Tetrahymena spp	3.6	4.50 ± 2.12	2.9	3.00 ± 0.00	0	0.00 ± 0.00
	Chilodonella spp	5.5	20.00 ± 12.77	0	0.00 ± 0.00	20	6.00 ± 0.00
	Ambiphyra spp	1.8	22.00 ± 0.00	0	0.00 ± 0.00	0	0.00 ± 0.00
	Piscinoodinium spp	1.8	1.00 ± 0.00	0	0.00 ± 0.00	0	0.00 ± 0.00
	Ichthyobodo spp	1.8	5.00 ± 0.00	0	0.00 ± 0.00	0	0.00 ± 0.00
	Argulus spp	0	0.00 ± 0.00	2.9	2.00 ± 0.00	0	0.00 ± 0.00

MII – Mean Intensity of Infection

Table 1b: Prevalence and mean intensity of infection on juveniles and adults stages of *Clarias gariepinus* reared across different culture systems

Developmental Stages	Parasites	DWR		WWR		BWR	
		Prevalence (%)	MI	Prevalence (%)	MI	Prevalence (%)	MI
Juveniles	Trichodina *spp*	50	28.86 ± 34.83	25.2	26.30 ± 34.64	20.6	11.57 ± 10.15

	Vorticella spp	28.6	17.25 ± 7.68		2	20.33 ± 19.63		0	0.00 ± 0.00				
	Dactylogyrus spp	28.6	4.00 ± 2.94		32	5.92 ± 5.61		20.6	6.50 ± 3.73				
	Gyrodactylus spp	7.1	1.00 ± 0.00		2	11.00 ± 4.56		0	0.00 ± 0.00				
	Tetrahymena spp	0	0.00 ± 0.00		0.7	11 ± 0.00		0	0.00 ± 0.00				
	Chilodonella spp	7.1	5.00 ± 0.00		0.7	1.00 ± 0.00		2.9	1.00 ± 0.00				
	Piscinoodinium spp	0	0.00 ± 0.00		0	6.00 ± 0.00		0	0.00 ± 0.00				
	Ichthyobodo spp	7.1	10.00 ± 0.00		0.7	53.00 ± 0.00		0	0.00 ± 0.00				
	Unidentified Nematode *spp*	0	0.00 ± 0.00		0	0.00 ± 0.00		5.9	1.00 ± 0.71				
Adults	Trichodina *spp*	10.3	20.75 ± 33.53		4.8	33.33 ± 40.45		0	0.00 ± 0.00				
	Vorticella spp	10.3	13.00 ± 6.98		15.9	12.20 ± 11.16		0	0.00 ± 0.00				
	Dactylogyrus spp	28.2	7.64 ± 6.93		9.5	1.83 ± 0.75		0	0.00 ± 0.00				
	Gyrodactylus spp	10.3	3.00 ± 3.37		0	0.00 ± 0.00		28.6	1.50 ± 0.71				
	Piscinoodinium spp	0	0.00 ± 0.00		15.9	21.00 ± 0.00		0	0.00 ± 0.00				
	Ichthyobodo spp	0	0.00 ± 0.00		0	0.00 ± 0.00		14.3	25.00 ± 0.00				

Table 2: Prevalence of parasites on predilection of developmental stages reared across the culture systems

Culture Systems	Developmental Stages	*Trichodina spp*			*Vorticella spp*			*Dactylogyrus spp*			Other *spp*		
		Skin	Gills	Intestine	Skin	Gills	Intestine	Skin	Gills	Intestine	Skin	Gills	Intestine
DWR	Fry	2.0	4.0	0.0	12.0	0.0	0.0	4.0	8.0	0.0	2.0	0.0	0.0
	Fingerlings	36.4	16.4	1.8	7.3	0.0	1.8	0.0	16.4	0.0	18.2	1.8	0.0
	Juveniles	21.4	50.0	0.0	28.6	0.0	7.1	0.0	28.6	0.0	21.4	0.0	0.0
	Adults	2.6	10.3	0.0	10.3	0.0	0.0	2.6	28.2	0.0	10.3	0.0	0.0
WWR	Fry	11.4	11.4	0.0	5.7	0.0	0.0	2.9	14.3	0.0	0.0	0.0	0.0
	Fingerlings	20.0	20.0	0.0	11.4	0.0	0.0	0.0	20.0	0.0	2.9	2.9	0.0
	Juveniles	21.8	14.4	0.0	2.0	0.0	0.7	0.0	32.0	0.0	4.1	0.7	0.0
	Adults	1.6	4.8	0.0	15.9	0.0	4.8	0.0	9.5	0.0	1.6	0.0	0.0

BWR	Fry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fingerlings	60.0	80.0	0.0	0.0	0.0	0.0	0.0	40.0	0.0	20.0	0.0	0.0
	Juveniles	17.6	8.8	0.0	0.0	0.0	0.0	0.0	20.6	0.0	2.9	0.7	5.9
	Adults	1.6	0.0	0.0	15.9	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0

Table 3: Prevalence of single and co-infection of parasites on developmental stages under different culture systems

Culture Systems	Developmental Stages	Prevalence (%)	
		Single Infection	Co - infection
DWR	Fry	26	8
	Fingerlings	23.6	21.8
	Juveniles	21.4	28.6
	Adults	34.2	13.2
WWR	Fry	14.3	8.6
	Fingerlings	34.3	11.4
	Juveniles	29.3	16.3
	Adults	7.9	11.1
BWR	Fry	0	0
	Fingerlings	20	60
	Juveniles	14.7	14.7
	Adults	42.9	0

Table 4: Mean water parameter for community of parasites in different culture systems

Water Parameters	Culture Systems	Water Parameters	Culture Systems
pH	7.06 ± 0.95	6.90 ± 0.49	7.45 ± 1.49
Water Temp. (oC)	30.67 ± 2.40	30.68 ± 2.69	32.36 ± 2.72
Air Temp. (oC)	38.24 ± 5.09	33.47 ± 3.83	35.44 ± 3.66
DO (mgl-1)	18.62 ± 3.02	4.99 ± 5.16	11.37 ± 9.02
NH3 (mgl-1)	2.16 ± 0.28	2.48 ± 0.74	2.46 ± 0.59
NO2 (mg/l)	0.72 ± 0.07	0.80 ± 0.87	0.54 ± 0.06
Iron (mgl-1)	0.30 ± 0.14	0.93 ± 1.15	0.86 ± 0.81
Alkalinity (mgl-1)	66.67 ± 70.71	74.70 ± 52.04	304.38 ± 391.27
Hardness (mgl-1)	390 ± 250.57	440 ± 314.54	933 ± 866.18
Turbidity (cm)	40.67 ± 9.62	28.65 ± 15.19	17.05 ± 7.90

Discussion

Across the culture systems, *Trichodina spp* dominated the prevalence trend among the major parasites in developmental stages which possibly supports the evidence that *Trichodina spp* are true parasites foraging on fish tissues (Paperna, 1980). Trichodinids infestations are very important in aquaculture being able to reduce growth rate (Ekanem and Obiekezie

1996), cause chronic mortality (Valladão *et al.* 2013); impair the vision and buoyancy of fish seeds which may lead to mortality (Valladão *et al.,* 2014) though usually cause limited problems to fish at mild infection (Lom 1995). They are generally considered as opportunistic and sometimes associated with other pathogens mostly bacteria (Alvarez-Pellitero, 2004). The highest prevalence of *Vorticella spp* in different developmental stages implied that *Vorticella spp* could habit any developmental stage of *Clarias gariepinus* as a transport medium to reach its suitable source of food since they are ectocomensal parasites. They are sessile peritrichs, commonly found in several cultured fishes (Abdel – Baki *et al*., 2014; Woo and Leatherland, 2006) but is reported for the first time in cultured *Clarias gariepinus* in this study. The prevalence of *Dactylogyrus spp* was were reportedly high at different developmental stages across the culture systems, this agreed with the report on *C. gariepinus* (Okunade *et al.,* 2018) and *Piaractus mesopotamicus (*Jeronimo *et al*., 2014) showing that monogenean trematodes may occur in any developmental stage of the fish (Lizama *et al*., 2007). Moreover, *Dactylogyrus* was not recorded on fry in culture systems studied contrary to the infected *Oreochromis niloticus* reared in hatcheries by *Dactylogyrus spp* (Ahmed and Shoreit, 2001). *Gyrodactylus spp* had the highest prevalence in adults in BWR followed by DWR which indicated that monogeneans can parasitise other developmental stages contrary to moderate or heavy infections of monogeneans reported in juvenile fish causing severe mortality (Alvarez-Pellitero, 2004). These findings conformed to the fact that fish are susceptible to pathogenic infections even in an environment suitable for growth and reproduction as well as supporting a positive correlation between bigger-sized fish and infection with an explanation of having a larger surface area for parasite multiplication (Roberts, 1978; Blackburn and Lawton, 1994; Blackburn and Gatson, 1997). Chillodonella infections are temperature dependent with *Chilodonella hexasticha* possibly being highly pathogenic at low temperature particularly on carp fish (Bauer *et al*., 1973) while *Chilodonella piscicola* mostly infects cyprinids at high temperatures (Hoffmann *et al.,* 1979). Fingerlings were reported to be highly susceptible to Chilodonella infection (Rintamäki *et al*., 1994, Urawa and Yamao 1992). The prevalence of *Argulus spp* was very low in this study and may not possibly cause a major impact on *Clarias gariepinus* examined unlike *Argulus foliaceus* L. 1758 that reportedly caused severe threat in tilapia culture (Roberts and Sommerville 1982), rainbow trout (Menezes *et al.,* 1990, Ruane *et al.* 1995), and common carp (Jafri and Ahmed 1994) with high mortality probably because they are potential vectors for bacteria (Shimura 1983), fungi (Bower-Shore 1940), viruses (Ahne 1985) and nematodes (Moravec 1994).

On the skin of *Clarias gariepinus* examined, the high prevalence of *Trichodina sp* on different developmental stages was similar to the high prevalence on juvenile skin of *Oreochromis niloticus* under semi-intensive (39.2%) and extensive (97.5%) culture (Suliman and Al-Harb 2016). The prevalence of *Vorticella spp* recorded was highest in juvenile in DWR and adults in WWR conformed to the prevalence of *Vorticella spp* (10%) reported in *Symphysodon discus* (Mohammadi *et al*., 2012*)* which was reportedly found even in healthy fish though may be facultative at times on the skin of some fish species (Reda, 2011) when stressed by adverse environmental conditions (Basson and Van As, 2006; El-Tantawy and El-Sherbiny, 2010) thereby prompted the suggestion that a great number of Vorticellids congested on the skin of exhausted, moribund fish devoid of any defense reaction under adverse environmental conditions (Migala and Kazubski, 1972). No *Vorticella spp* was recorded on gills of any developmental stages in all the culture systems which were different from the reports of many researchers with records of Vorticella *spp* on gills of *Clarias gariepinus* (El-Tantawy and El-Sherbiny, 2010) and both the skin and gills of *Cyprinus carpio* and *Ctenopharyngodon idella (*Guguloth *et al*., 2013, Dash *et al*., 2015) and

*Oreochromis niloticus (*Abdel-Baki *et al*., 2014). The implication of which shows that Vorticella *spp* is not hosted or site specific *Dactylogyrus spp* had a low prevalence on fry skin (4%) in DWR and juveniles (2.9%) in WWR whereas *Gyrodactylus spp* had highest the prevalence on adults skin (10.3%) under DWR while the prevalence of 3.4% and 20% were recorded for juveniles and adults reared in WWR and BWR accordingly. The information showed that neither *Dactylogyrus spp* nor *Gyrodactylus spp* is developmental stage specific and their prevalence could either be low or high on the skin as reported by some researchers (Shinn *et al*., 2010, Okunade *et al*., 2018) depending on the prevailing factors.

On the gills, *Trichodina spp* parasitised all the developmental stages with the highest prevalence on adults in DWR and fry in WWR similar to the high prevalence in juvenile gills of *Oreochromis niloticus* under semi- intensive culture and extensive culture (Suliman and Al-Harb 2016). *Dactylogyrus spp* was found on gills of all the developmental stages with the highest prevalence on juveniles in DWR (28.6%) and WWR (31.8%) and fingerlings in BWR (40%) which contradict no *Dactylogyrus spp* on fry and fingerlings reported (Okunade *et al*., 2018). *Gyrodactylus spp* parasitised only the gills of fingerlings in DWR having 1.82% prevalence, different from the report that *Gyrodactylus spp*. infected the gills of all the stages with highest prevalence recorded in juvenile (70.37%) and least in fry (1.85%) (Okunade, *et al.*, 2018). The presence of monogeneans trematodes (*Dactylogyrus spp* and *Gyrodactylus spp*) on the gills showed that their prevalence cannot be predetermined but rather may depend on environmental factors within the culture systems and management procedures contrary to report on host specific and site specific on the host (Cone 1995). The transmission of *Gyrodactylus spp* is mostly thought to be direct host – to host contact and are short - lived in the water column if detached from their host which may suggest that the low prevalence in this study is likely to be due to deficiency of certain conditions since gyrodactylids which are viviparous (2 – 4 generations of an embryo with developed pair of anchors frequently seeing inside an adult gyrodactylid) reproduce rapidly under favourable conditions (Eissa 2002). Some dactylogyriids, *Dactylogyrus macracanthus* and *Dactylogyrus tincae* (Ergens *et al*., 1987) *Dactylogyrus triappendixis* (Wierzbicka *et al*., 1997) were reported to be non – pathogenic on trench fish despite the damage caused on the gills at low infestation unless heavily infected. The presence of monogeneans on gills may subject the fish to less tolerance of low oxygen conditions while high infestation leads to skin and gills destructions and mortality. Infections on tissues usually create pathway for secondary infection by bacteria and fungus.

Trichodina spp (less than 2%) in the intestine of fingerlings (DWR) and juveniles (WWR) and *Vorticella spp* with 3.64% prevalence on fingerlings in DWR and highest in adults (6.25%) in WWR agreed with the report that *Trichodina spp* could be endoparasites probably because of their direct life cycle which encourages faster reproduction and spread within short period (Lom and Dykova, 1992). No *Dactylogyrus spp* and *Gyrodactylus spp* were found in the intestine of any developmental stage of *C. gariepinus* in culture systems contrary to some endoparasitic monogeneans (Gussev and Fernando, 1973; Euzet and Combes, 1998, Domingues and Boeger, 2002, Jerônimo, *et al*., 2010). The prevalence of nematode *spp* recovered from the intestine (5.9%) in this study was low to that of *Cithariniella citharini* (10%) and *Procamallanus laeviconchus* (12.5%) recovered from wild *Citharinus citharus* (Uneke, 2015), Procamallanus *spp* (42.9%) in *Oreochromis niloticus* (Biu *et al*, 2004) and *Contracaecun spp* (23.8%) in Synodontis fish along River Niger and Benue confluence (Iyaji *et al.*, 2015).. This may be due to the influence of the environmental factors in the natural ecosystem different from the controlled management ranging from the sources of water mostly deep well, borehole and spring water, culture facilities apart from earthen ponds were either under the shed or covered occasionally with tarpaulin materials to prevent possible

invasion of other intermediates host. It could also be deduced that since the prevalence of nematode was drastically low, *Clarias gariepinus* is neither a definitive host nor paratenic host to cause the spread of the particular nematode parasites. The infection noticed might be due to an occasional introduction of dead husbandry animal since most farmers even those using earthen ponds exclusively depended on commercially produced feeds but according to Smyth (1962), the adult nematodes (except the blood sucking nematodes) seemed to eat semi-solid or numerous quantity of absorbable materials. The most common nematodes infecting cultured fish reported were *Procamallanus spp* and *Camallanus spp* (Okoye *et al.*,2014; Ekanem *et al.*, 2011; Onyedineke, *et al.*, 2010) *Procamallanus spp* and *Acanthcephala spp* (Idika *et al.*, 2017) and *Acanthcephala spp* , *Neochinorhyncus spp* and *Pomphorhychus spp* (Vincent *et al.*, 2014) while the rare ones were *Gnathostoma. spp, Oxyuroid spp, Rhabduchona congolensis, Sppinitectus guntheri* (Okoye *et al.*,2014). However, low infestation of nematodes often occurs in healthy fish, but high infestation could cause illness or death (Yanong, 2006). In this study, no helminth parasites was obtained from the skin and gill, in agreement to (Ugwuzor, 1985). Intensity of infection explained the number of a particular parasites on host at a particular period of sampling. It shows that the mean intensity is not directly related to the prevalence of parasites in the sense that low prevalence with high parasitic load will lead to high mean intensity or rather low mean intensity vice versa agreeing with (Rozsa, *et al*., 2000) that a high percentage of parasites concentrating on a few host individual may cause a wide confidence interval as observed with *Chilodonella spp* and *Ambiphyra spp* on fingerlings in DWR and *Ichthyobodo spp* on juveniles in WWR. On the other hand, the overall view of highest mean intensity recorded in WWR may due to the fact that highest number of farmers were in this category which may influence the values. The essence of examining co – infection in fish helped to assess the resultant effects (synergistic or antagonistic) on the hosts (Bordes and Morand, 2009). The single infection was higher in this study which may due to the fact that most farmers reared only *Clarias gariepinus* than polyculture which was reported to influences cross infection and inter*spp*ecies infectious diseases transmission (Eissa *et al.*, 2010). The water parameters measured complied with the acceptable requirement for culture fish.

Conclusion

The relatively low understanding of parasites by the farmers may predispose the production line to unguided management protocol especially on fish health manage perspective which often made farmers to ascribe mortality to different uncertain factors including fish diseases. The first and second highest prevalence and intensity of parasites across the culture systems ranged among the fry, fingerlings and juveniles which indicated that more attention must be given to hatchery hygiene to avoid transfer to grow –out production. Good management practices must be encouraged especially during fish seeds production to foster functional immunity response to pathogenic infections. Moreover, better understanding of immune responses of fish to single and co-infections must be studied in order to improve on strategies for health management and disease control. Therefore, the expository information on cultured fish parasites (protozoans, crustaceans and helminths) in this study may caution the farmers to pay more attention to each production cycle to minimize the possibility of the portal entry (parasitic infection) to secondary infection (bacteria, fungi and viral infections).

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