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# Comparative study of African catfish parasites from cultured and natural habitats



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## Abstract

**Background:** The study was conducted to compare parasitic loads of *Clarias gariepinus* from cultured and natural habitats. A total number of 80 live adults (200–799 g) *C. gariepinus* comprising of 20 each were randomly obtained from two cultured habitats (ponds) and two natural habitats (rivers). In the laboratory, these fish were all examined for the presence of parasites. Their sexes were identified while the lengths and weights were measured and recorded prior to dissection. The parasites observed were also identified using morphological characteristics.

**Results:** Out of the 80 *C. gariepinus* sampled, 43 (53.75%) were infected and a total of 409 parasites comprising of 141 (34.47%) ectoparasites and 268 (65.53%) endoparasites were observed from the infected fish. The prevalence of parasitic infection in cultured and natural habitats was 20% and 33.75%, respectively. The results showed that there was a significant difference ( $P < 0.05$ ) in parasitic infection of *C. gariepinus* obtained from cultured and natural habitats. Parasitic loads were observed to be significantly higher in natural habitat (33.74% and 26.16% for river A and river B, respectively) compared to cultured habitat (20.54% and 19.55% for pond A and pond B, respectively). The prevalence of parasites in relation to sexes of *C. gariepinus* was not significantly different ( $P > 0.05$ ) for both habitats. It was also noted that catfishes with body weight 500–599 g had the highest prevalence (100%) both in cultured and natural habitats.

**Conclusions:** The study showed that the parasite loads were more in *C. gariepinus* obtained from natural habitat compared to those obtained from cultured habitat. It is therefore recommended that the sanitary conditions under which fishes are reared in fish pond should be improved and fish stocked from natural habitats or unscreened ponds should be quarantined to eliminate and treat possible parasitic infection before introducing them into other fish ponds.

**Keywords:** *Clarias gariepinus*, Ectoparasites, Endoparasites, Fish ponds, Rivers

## Background

Fish is a food commodity that is distributed worldwide and regarded as an important source of animal protein (Osugwe and Obiekezie 2007) and other essential elements that are necessary for the maintenance of healthy body to the human especially in the developing countries. Fish on the average generally appear cheaper, and the protein contents of fish and its products are higher

than those of other similar food items such as meat and eggs (Aihonsu et al. 2006). Fish is also an important source of income for fishermen and fish farmers especially in Nigeria and other developing countries (FAO 1996). It contributes significantly to the economic development of countries that involve in aquaculture and fisheries' programs.

The African catfish (*Clarias gariepinus*) has been reported to be a suitable aquaculture species in Nigeria and other countries in Africa (Eyo et al. 2015) due to several favorable characteristics which include its ability

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to tolerate a wide range of environmental conditions and high stocking densities under culture conditions, fast growth rate, acceptability of artificial feed, and high fecundity rate among others (Eyo et al. 2015). It is also popular with consumers in Nigeria for its highly nutritive values (Udeze et al. 2012).

Fish consumption is however not devoid of risks due to the possibility of them harboring infectious or pathogenic parasites particularly if such organisms are of zoonotic importance (Leal et al. 2008) owing to the fact that fish are sometimes cultured under potentially stressful conditions which may proliferate existing infections to become more severe and precipitate disease outbreaks, and these may compromise the fitness of such fish for human consumption (Danba et al. 2015). Therefore, this study sought to provide information on the parasitic loads of African catfish (*C. gariepinus*) from cultured and natural habitats.

## Methods

### Study sites

The study sites for this research were two fish-cultured ponds and two natural ponds. The fish-cultured ponds selected for this study were Ayodele fish pond (pond A) (latitude 7° 17' 50'' N, longitude 5° 9' 0'' E) and Abbey fish pond (pond B) (latitude 7° 16' 59'' N, longitude 5° 9' 32'' E). Both are located within Akure, a major city in Ondo State in South-western, Nigeria. The two natural habitats used were Owena reservoir (river A) (between latitude 7° 15' N, longitude 5° 5' E, and latitude 7° 4' N, longitude 4° 47' E) which is situated across Owena River located in the suburb of Owena town in Ifedore Local Government Area of Ondo-State and Igbokoda River (river B) (latitude 6° 21' N and longitude 4° 48' E) situated in Igbokoda town in Ilaje-Ese Odo, Ondo State.

### Ethics and consent

The ethic and consent concerning the use of fish for this research were deemed unnecessary according to the Federal Institute of Industrial Research. Meanwhile, the experimental protocol including the number of fishes used for this research was approved and regulated by the Institute. In addition, all the methods were carried out in accordance with relevant guidelines.

### Sample collection and preparation

A total number of 80 live adult African Catfish (*C. gariepinus*) of different weight range were purchased randomly from the above locations comprising of 20 samples from each of the locations, and they were transported live in a clean plastic keg containing water to the Biology Research Laboratory for further examinations. They were identified based on external features as described by Edeh and Solomon (2016).

### Sex determination

Sexes of fish were identified by physical observation of the urogenital papillae located behind the anus which is long or distended in male, while in the female, it is round and reddish in the matured ones as described by Lagrue et al. (2011). These were later confirmed after dissection by visual observation of the testes in male and ovaries in the female. Prior to this, the fish were rendered inactive for easy handling.

### Measurements of length and weight

The total length of the fish samples was taken from the tip of the snout to the extreme end of the caudal fin using a calibrated meter rule to the nearest centimeter (cm) and recorded. Fish samples were also weighed to the nearest gram (g) using a manual weighing balance and recorded.

### Ectoparasite examination

For the ectoparasites, external examination of the fish surface was first carried out by using hand lens for the detection of parasitic manifestation as described by Tachia et al. (2010). Subsequently, a sterile scalpel blade was used to scrape the skin from the head to the tail to obtain skin smear (mucus mixed with epidermal cells) which was placed in a sample plate containing 10 ml of 0.9% saline solution and stirred using a mounted pin (Adeyemo and Falaye 2007; Ekanem et al. 2014). Drops of the mixed solution were collected using a dropper, placed on a clean slide, and examined under the ×10 and ×40 lenses of the binocular microscope (Olympus CX40). Detection of parasites from the gills of the sampled fish was made by using the methods described by Adeyemo and Falaye 2007, and Ekanem et al. 2014. The operculum was cut opened to expose the gills by using dissecting scissors, the exposed gills were detached, and the gill filaments and the gill arches were examined under the microscope.

### Endoparasite examination

A cut was made on the ventral side of the fish from the anal opening to the lower jaw using a dissecting scissors to expose the body cavity and most of the internal organs. The stomach and intestine were separated and kept in different sample plates containing 0.9% saline solution. The contents of the stomach and intestine were washed in this normal saline solution for sedimentation and floatation. A drop of the residue was placed on the slide and the wet mount was examined for parasites under the microscope (Olympus CX40) using the ×10 and ×40 objectives for various parasites. The parasites were identified using a standard text by Ajala and Fawole (2014) and Kawe et al. 2016. The prevalence and intensity were calculated using the formulae below:

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

$$\text{Intensity} = \frac{\text{Number of parasite}}{\text{Number of fish infected}}$$

### Statistical analysis

One sample *T* test was used to calculate the significant difference between levels of infection in the two habitats while Carl Pearson chi-square test was used to determine the significant difference in parasite prevalence between the sexes and significance was taken at  $P < 0.05$ . All analyses were done using Statistical Package for the Social Science (SPSS).

## Results

### Prevalence of infection and intensity of parasites from the studied habitats

The result presented in Table 1 showed that of the total 80 *C. gariepinus* examined, and a total of 43 (53.75%) harbored different parasites. The prevalence of parasitic infection in river A (60%) and river B (75%) was significantly higher than that of pond A (45%) and pond B (35%) ( $P < 0.05$ ). Generally, the total prevalence was higher in natural habitat (33.75%) than the cultured habitat (20%). However, the parasitic load (intensity) was slightly more in the cultured habitat (20.76) than the natural habitat (18.63%).

### Parasitic loads from infected *C. gariepinus*

The parasitic loads from infected *C. gariepinus* as presented in Table 2 showed that of the 409 parasites recovered from the infected catfishes, 141 (34.47%) were ectoparasites while 268 (65.53%) were endoparasites. Parasitic loads were observed to be significantly higher in natural habitat (33.74% and 26.16% from river A and river B, respectively) compared to cultured habitat (20.54% and 19.55% from pond A and pond B, respectively). Similarly, the percentage ratio of endoparasite to ectoparasite was significantly higher in the natural

habitat (40.83: 19.07) than the cultured habitat (24.69: 15.40). Generally, 65.53% ( $n = 268$ ) of the parasites recovered from the catfishes were endoparasites while 34.47% ( $n = 141$ ) were ectoparasites (Table 2).

### Taxonomic classification of catfish parasites in cultured and natural habitats

All the parasites obtained from this study (409) were observed to be distributed among five taxonomic groups of parasites namely nematoda, cestoda, trematoda, protozoa, and hirudinea (Table 3). The endoparasites obtained from catfishes include 4 nematodes (*Caenorhabditis elegans*, *Philometroides africanus*, *Procamallanus* spp., and *Camallanus* spp.), 3 cestodes (*Monobothriodes woodlandi*, *Lytocestes marcuseni*, and *Spirometra reinacei*), 3 trematodes (*Clinostomum complanatum*, *Nesolecithus africanus*, and *Otodistomum* spp), and 1 protozoon (*Protoopalina symphysodonis*). The catfish ectoparasites recovered include 1 hirudinean (*Piscicola geometra*), 2 trematodes (*Gyrodactylus* spp. and *Dactylogyrus* sp.), and 3 protozoans (*Ichthyophthirius multiifiliis*, *Ichthyophthous hoferi*, and *Epistylis* spp). In addition, *Otodistomum* spp. and *M. woodlandi* were noted to be absent in pond A while *Camallanus* spp., *N. africanus*, *S. reinacei*, and *P. geometra* were absent in pond B (Table 3). Among the catfish parasites obtained from cultured habitat, *Piscicola geometra* had the highest species prevalence (20%).

General overview of the catfish parasites in natural habitat showed that *C. elegans*, *P. africanus*, *S. reinacei*, and *L. marcuseni* were absent in river A but present in river B. Meanwhile, *I. multiifiliis* and *I. hoferi* were not encountered in catfishes obtained from river B. Of all the catfish parasites obtained in natural habitat, *P. symphysodonis* (25%) and *I. hoferi* (20%) had a higher prevalence compared to other catfish parasites obtained from natural habitat (Table 4).

Comparatively, *Procamallanus* spp., *Camallanus* spp., *Dactylogyrus* spp., *Gyrodactylus* spp., *Otodistomum* spp., *S. reinacei*, and *L. marcuseni* were catfish parasites that are common to both cultured and natural habitats (Table 3). In contrast, *N. africanus*, *Epistylis* spp, *M. woodlandi*, and *P. geometra* are catfish parasites associated with cultured

**Table 1** Prevalence and intensity of parasites from the cultured and natural habitats

Habitats	Locations	No. of fish examined	No. of fish infected	Prevalence (%)	No. of parasite recovered	Intensity
Cultured	Pond A	20	9	45.00	84	9.33
	Pond B	20	7	35.00	80	11.43
Subtotal		40	16	20.00	164	20.76
Natural	River A	20	12	60.00	138	11.50
	River B	20	15	75.00	107	7.13
Subtotal		40	27	33.75	245	18.63
Total		80	43	53.75	409	9.51

$t = 6.131$ ,  $P = 0.009$ ,  $df = 3$

**Table 2** Comparison of the catfish parasites in natural and cultured habitats

Habitats	Locations	Parasites recovered		Total (%)
		Ectoparasites (%)	Endoparasites (%)	
Cultured	Pond A	28 (33.30)	56 (66.70)	84 (20.54)
	Pond B	35 (43.80)	45 (56.30)	80 (19.55)
Subtotal		63 (15.40)	101 (24.69)	164 (40.09)
Natural	River A	56 (40.60)	82 (59.40)	138 (33.74)
	River B	22 (20.60)	85 (79.40)	107 (26.16)
Subtotal		78 (19.07)	167 (40.83)	245 (59.90)
Total		141 (34.47)	268 (65.53)	409 (100.0)

$t = 7.669, P = 0.005, df = 3$

habitat, while *C. elegans*, *P. africanus*, *C. complanatum*, *P. symphysodonis*, *I. multiifillis*, and *I. hoferi* were only found in natural habitat (Table 4).

**Prevalence of parasites in relation to the sex of *C. gariepinus***

Table 5 showed the prevalence of parasites in both male and female *C. gariepinus* sampled from cultured and natural habitat. The obtained results showed that the prevalence was higher in female compared to male except in pond A which the prevalence recorded was higher in male *C. gariepinus* (55.56%) than female (36.37%). Meanwhile, chi-square analysis of the data on sex showed no significant difference in prevalent rates between male and female *C. gariepinus* ( $P > 0.05$ ).

**Distribution of ectoparasites in relation to sites of infection in infected *C. gariepinus***

Distributions of ectoparasites in relation to the site of infection in *C. gariepinus* were presented in Table 6. The

results showed that more ectoparasites were observed on the skin ( $n = 93$ ) compared to the gills ( $n = 48$ ) of infected *C. gariepinus* (Table 6). Three ectoparasites were recovered from the gills (*Ichthyophthnous hoferi*, *Dactylogyrus* spp., and *Gyrodactylus* spp.) while six ectoparasites which include *Ichthyophthirus multiifillis*, *I. hoferi*, *Piscicola geometra*, *Dactylogyrus* spp, *Epistylis* spp., and *Gyrodactylus* spp. were recovered from the skin of the fish.

**Distribution of endoparasites in relation to sites of infection in infected *C. gariepinus*.**

Distributions of endoparasites in relation to sites of infection in *C. gariepinus* were presented in Table 7. The results showed that 268 endoparasites were recovered from the stomach and intestines of infected catfishes. The result further showed that the catfish intestines ( $n = 140$ ) were more infected than the stomach ( $n = 128$ ). Out of the 11 species of endoparasites observed in catfishes, *N. africanus* was absent in the fish intestine while

**Table 3** Catfish parasites in cultured habitat

Group	Parasite Species	Pond A			Pond B		
		No. of fish infected	Species prevalence (%)	No. of parasite recovered	No. of fish infected	Species prevalence (%)	No. of parasite recovered
Nematoda	<i>Procamallanus spp</i>	3	15	9	2	10	18
	<i>Camallanus</i> spp	2	10	23	0	0	0
Trematoda	<i>N. africanus</i>	2	10	16	0	0	0
	<i>Otodistomum</i> spp	0	0	0	2	10	7
	<i>Dactylogyrus</i> spp	1	5	4	2	10	6
	<i>Gyrodactylus</i> spp	2	10	5	2	10	7
Protozoan	<i>Epistylis</i> spp	1	5	6	3	15	22
Cestoda	<i>M. woodlandi</i>	0	0	0	2	10	14
	<i>S. reinacei</i>	1	5	3	0	0	0
	<i>L. marcusei</i>	1	5	5	1	5	6
Hirudinea	<i>P. geometra</i>	4	20	13	0	0	0

**Table 4** Catfish parasites in natural habitat

Taxonomic group	Parasite species	River A			River B		
		No. of fish infected	Species prevalence (%)	No. of parasite recovered	No. of fish infected	Species prevalence (%)	No. of parasite recovered
Nematoda	<i>C. elegans</i>	0	0	0	4	20	19
	<i>P. africanus</i>	0	0	0	2	10	8
	<i>Procamallanus</i> spp	2	10	10	4	20	12
	<i>Camallanus</i> spp	3	15	15	2	10	5
Trematoda	<i>C. complanatum</i>	2	10	12	2	10	16
	<i>Otodistomum</i> spp	0	0	0	1	5	3
	<i>Dactylogyrus</i> spp	2	10	7	4	20	15
	<i>Gyrodactylus</i> spp	3	15	12	2	10	7
Protozoa	<i>P. symphysodonis</i>	5	25	38	2	10	6
	<i>I. multiifilis</i>	2	10	13	0	0	0
	<i>I. hoferi</i>	4	20	24	0	0	0
Cestoda	<i>M. woodlandi</i>	2	10	7	2	10	11
	<i>S. reinacei</i>	0	0	0	1	5	2
	<i>L. marcuseni</i>	0	0	0	1	5	3

*Otodistomum* spp. was absent in the fish stomach (Table 7). In terms of the total number of parasites recovered, *Procamallanus* spp. ( $n = 49$ ), *P. symphysodonis* ( $n = 44$ ), and *Camallanus* spp. ( $n = 43$ ) were the most abundant endoparasites in *C. gariepinus* (Table 7). Similarly, of the 52 infected catfishes, 10 of them were infected with *Procamallanus* spp., 6 catfishes were infected with *M. woodlandi*, *P. symphysodonis* and *Camallanus* spp., 2 catfishes were infected with *P. africanus*, *S. reinacei*, and *N. africanus* (Table 7).

#### Prevalence of parasites in relation to the body weight of infected *C. gariepinus*

The results of parasite prevalence in relation to the body weight as presented in Tables 8 and 9 showed that catfishes obtained from both cultured and natural habitats with body weight 500–599 g had the highest prevalence

(100%) while no parasite (0%) was observed in catfishes obtained from a natural habitat with body weight 200–299 g and 700–799 g. Parasite is only absent in catfishes with body weight 700–799 g obtained from pond B of the natural habitat.

#### Discussion

The results of this work reveal the presence of parasites in *C. gariepinus* from cultured and natural habitats under study. Findings indicated a higher prevalence of 33.75% of catfish parasites in natural habitat compared to a low prevalence of 20% observed in cultured habitat. Higher prevalence recorded from natural habitat may be due to many factors such as feeding habit of fish, pollution of water bodies, and availability of intermediate hosts (copepods, insects, molluscs, etc.) which harbor the infective larval stage of some of these parasites

**Table 5** Prevalence of parasites in relation to the sex of *C. gariepinus*

Habitat	Location	Sex	No. of fish examined	No. of fish infected	Prevalence (%)	$\chi^2$	<i>P</i> value
Cultured	Pond A	Male	9	5	55.56	0.74	0.39
		Female	11	4	36.37		
	Pond B	Male	11	3	27.27		
		Female	9	4	44.44		
Natural	River A	Male	7	4	57.14	0.04	0.85
		Female	13	8	61.54		
	River B	Male	12	8	66.67		
		Female	8	7	87.50		
Total			80	43	53.75		

**Table 6** Distribution of ectoparasites in relation to the site of infection on infected *C. gariepinus*

Parasite species	No. of fish infected	Prevalence (%)	Site of infection		Total no. of parasites	Intensity
			Gills	Skin		
<i>I. multiifiliis</i>	2	2.5	0	13	13	6.5
<i>I. hoferi</i>	4	5.0	18	6	24	6.0
<i>P. geometra</i>	4	5.0	0	13	13	3.3
<i>Dactylogyrus</i> spp.	10	12.5	23	10	32	3.6
<i>Epistylis</i> spp.	4	5.0	0	28	28	7.0
<i>Gyrodactylus</i> spp.	8	10.0	7	23	31	3.4
Total	32	40.0	48	93	141	4.4

making them available to fish in the water (Kawe et al. 2016). Also, Hoffman (1998) stated that wild populations of animals have greater parasite species diversity due to larger home ranges compared to domesticated ones. Meanwhile, the low prevalence recorded from cultured habitat may imply that there have been an improvement in management practices of cultured fish such as the reduction in overcrowding of fish ponds carried out by a fish farmer in these study areas (Ayanda 2009) and the use of screen net around fish ponds to guide against piscivorous birds which may serve as host to some of these parasites and can disseminate parasite eggs to fish ponds (Aliyu and Solomon 2012). The high prevalence of fish parasites recorded in the research agrees with the work of Onyedineke et al. (2010) who reported a high prevalence (59.2%) of parasites from fish obtained from the river at Illushi, Edo State, Nigeria, and with Kawe et al. (2016) who recorded high prevalence (67.5%) of gastrointestinal helminth parasites of *C. gariepinus* in Abuja, Nigeria. However, the result is in contrast to the findings

of Anosike et al. (1992) who reported heavy infection of 52% for cultured and 34.7% for wild *C. gariepinus* in Plateau State (Ayanda 2009).

However, the presence of parasites in *C. gariepinus* sampled from cultured habitat used for this study, although with low prevalence may be due the introduction of unexamined *C. gariepinus* obtained from the wild directly into fish ponds or the presence of parasites in the parent stock. Oniye et al. (2004) suggested the incorporation of antihelminthic therapy into the diet of *C. gariepinus* obtained from the wild that might be used as broodstocks. Also, Yakubu et al. (2002) suggested that when fish are to be stocked from wild, they should be kept under good hygienic conditions in quarantine ponds and treated with recommended chemicals for at least 1–2 weeks to eliminate any stage of parasites.

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

**Table 7** Distribution of endoparasites in relation to the site of infection in infected *C. gariepinus*

Parasite species	No. of fish infected	Prevalence (%)	Site of infection		Total no. of parasites recovered	Intensity
			Stomach	Intestines		
<i>C. elegans</i>	4	5.00	2	17	19	4.8
<i>P. africanus</i>	2	2.50	5	3	8	4.0
<i>C. complanatum</i>	4	5.00	12	16	28	7.0
<i>P. symphysodonis</i>	6	7.50	21	23	44	7.3
<i>S. reinacei</i>	2	2.50	2	3	5	1.3
<i>Procammallanus</i> spp.	10	12.50	25	26	49	4.9
<i>M. woodlandi</i>	6	7.50	18	14	32	5.3
<i>Camallanus</i> spp.	6	7.50	18	25	43	7.2
<i>L. marcuseni</i>	3	3.75	3	11	14	4.7
<i>N. africanus</i>	2	2.50	16	0	16	8.0
<i>Otodistomum</i> spp.	3	3.75	0	10	10	3.3
Total	52	65.00	128	140	268	5.0



**Table 8** Prevalence of parasites in relation to body weight of natural *C. gariepinus*

Body weight (g)	River A			River B		
	No. of fish examined	No. of fish infected	Prevalence (%)	No. of fish examined	No. of fish infected	Prevalence (%)
200–299	3	1	33.33	1	0	0.00
300–399	3	1	33.33	3	1	33.33
400–499	5	3	60.00	9	8	88.89
500–599	6	5	83.33	5	5	100.00
600–699	3	2	66.66	2	1	50.00
700–799	0	0	0.00	0	0	0.00
Total	20	12	60.00	20	15	75.00

and Adikwu 2017). In terms of the number of parasite recovered from the catfishes, *Camallanus* spp. was the most abundant in cultured habitat while *P. symphysodonis* was the most abundant in natural habitat. However, there was no single species of Acanthocephalan recorded in this study which may be majorly due to absence of suitable intermediate host required for transmission although, some earlier works such as Balarin 1979; Onwuliri and Mgbemena 1987 reported that Acanthocephalan was the commonest parasites of fresh water fish in the tropics.

In addition, Imevbore and Bakare (1970) reported that *Clarias* species are bottom dwellers, which feed on what is most available and close to them such as detritus, water invertebrates like arthropods, molluscs, and mud, and among these invertebrates, there may be intermediate hosts of various parasites which may develop into adults in the gut of fish after consumption. The recovery of these species of parasites in this study could also have serious physiological consequences as they interfere with the absorption of food nutrients in the fish intestines, similar observation was made by other authors (Biu et al. 2014; Iboh and Ajang 2016). The authors added that such interference could reduce the food intake of fishes.

The prevalence of catfish parasites in relation to sexes as reported by this study was not significant. This finding was a deviation from the study of other authors. For

instance, a higher prevalence of parasites in female *C. gariepinus* compared to male has been reported by Omeji et al. 2013 and Ogonna et al. 2017. Both authors recorded higher parasitic infections in female compared to male. Similar reports of Ayanda 2009 and Emere 2000 at different locations reported higher parasitic infections in female species than the males. In addition, Emere and Egbe (2006) also reported higher infection in females than males and suggested that it could be due to the physiological state of the females as most gravid females could have reduced resistance to infection by parasites; this is because the immune system of the females is highly compromised during pregnancy. Omeji et al. (2013) noted that female fish need increased food intake to meet their food requirements for the development of eggs and that this may have exposed them to more contact with the parasites, which subsequently increased their chance of being infected. In contrast, the report of Oniye et al. (2004) recorded a higher prevalence of infection in male (15.0%) than the female catfishes (4.17%) and Tachia et al. (2010) also recorded higher infection in males (65.12%) than the females (34.89%). Generally, feeding in catfishes is attributed to their quest for survival and differential feeding either by quantity or quality of food and not by sexes (Ogonna et al. 2017). The present study revealed that the skin and intestines harbored the highest number of ectoparasites (93) and endoparasites (140), respectively. This could be due to the

**Table 9** Prevalence of parasites in relation to the body weight of cultured *C. gariepinus*

Body weight (g)	Pond A			Pond B		
	No. of fish examined	No. of fish infected	Prevalence (%)	No. of fish examined	No. of fish infected	Prevalence (%)
200–299	3	1	33.33	3	1	33.33
300–399	2	0	0.00	6	2	33.33
400–499	3	1	33.33	6	0	0.00
500–599	4	2	50.00	3	3	100.00
600–699	4	2	50.00	2	1	50.00
700–799	4	3	75.00	0	0	0.00
Total	20	9	45.00	20	7	35.00

conducive nutritional advantage presented by the host's intestine to the parasites; this observation corroborates with the works of Aliyu and Solomon (2012) and Onyedineke et al. (2010) who reported the highest number of parasites in the intestine from *C. gariepinus* obtained from lower Usman Dam, Abuja, and River Niger at Illushi Edo State, respectively. The preference of parasites for the intestines compared to the stomach may also be due to the presence of digested food present in the intestines and greater surface area of the intestines as suggested by Dan-kishiya and Oboh (2013) while Ajala and Fawole (2014) argued that the presence of an acidic medium in the stomach may render the stomach unfavorable for these parasites. Also, the peristaltic movement of the stomach muscle during digestion may also hinder the proliferation of parasites in the stomach as opined by Akinsanya and Hassan (2008).

More ectoparasites were recorded from the skin of *C. gariepinus* than the gills. This result agrees with the report of Tachia et al. (2010), who observed more ectoparasites on the skins of *C. gariepinus* caught from the University of Agriculture Research Fish Farm. The author 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. This report is contrary to 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. Somerville (1984) also noted that the sieving ability of the gill rakers may help to trap some parasites.

A higher rate of parasitic infection was observed in the larger size of *C. gariepinus* than the smaller ones across the two habitats. An increase in size as postulated by Oniye et al. (2004) is an indication of an increase in length and weight of fish and this can also be considered as a measure of age. Therefore, this observation may be attributed to the fact that larger size *C. gariepinus* provide a larger surface area for parasitic infection than the smaller ones and the ability of larger size fish to cover wide areas in search of food, and as a result of these, they take in more food than smaller ones which may expose them to parasitic infections (Tachia et al. 2010; Omeji et al. 2013; Bichi and Dawaki 2010). Bichi and Dawaki (2010) reported that the prevalence was found to increase as the fish grows and could be attributed to the longer time of exposure to the environment by body size. In relation to this observation, Reed et al. (1987) stated that there is a change in the diet of juvenile *Clarias* spp. from weeds, seeds, phytoplankton, and zooplankton to insect larvae, snails, crustaceans, worms, and smaller fish as adulthood is attained.

## Conclusions

This study revealed the presence of parasites in the two habitats under study. The parasites recovered were found to belong to Nematoda, Cestoda, Trematoda, Protozoan, and Hirudinea taxonomic group. Both habitats were noted to be infected; however, the natural habitat was more infected than the cultured habitat. Also, *C. gariepinus* of larger size were more infected compared to a smaller size. Based on this study, it is therefore important that the sanitary conditions under which fish are reared in fish ponds should be improved through the use of quality water free of contamination. Likewise, vegetation surrounding fish ponds should be reduced in order to eliminate potential intermediate host. Fish from unscreened sources should not be introduced directly into fish ponds but rather be quarantined to eliminate possible parasitic infection especially fish from natural habitats. Also, fish farmers and sellers should be enlightened on the potential risk of parasitic infection in fish in order to avoid economic loss and most importantly, fish should be properly cooked before consumption so as to destroy parasite harbored.

## Abbreviations

*C. gariepinus*: *Clarias gariepinus*; *C. elegans*: *Caenorhabditis elegans*; *C. complanatum*: *Clinostomum complanatum*; FAO: Food and Agriculture Organization; *I. multiifiliis*: *Ichthyophthirius multiifiliis*; *I. hoferi*: *Ichthyophthirius hoferi*; *L. marcusei*: *Lytocestes marcusei*; *M. woodlandi*: *Monobothriodes woodlandi*; *N. africanus*: *Nesolecithus africanus*; *P. geometra*: *Piscicola geometra*; *P. africanus*: *Philometroides africanus*; *P. symphysodonis*: *Protoopalina symphysodonis*; *S. reinacei*: *Spirometra reinacei*

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## Authors' contributions

OJA and OOO involved in the study design. OJA and FCO involved in the field and the laboratory works. Data analysis was undertaken by the authors OJA and FCO. OJA and FCO were the major contributors in writing the manuscript. The authors read and approved the final manuscript.

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## Availability of data and materials

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

## Ethics approval and consent to participate

The ethic and consent concerning the use of fish for this research were deemed unnecessary according to the *Federal Institute of Industrial Research*.

## Consent for publication

The authors gave their consent to the Bulletin of the National Research Centre to publish this manuscript if accepted for publication in the Bulletin of National Research Centre.

## Competing interests

The authors declare that they have no competing interests.



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