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Parasitic incidence in cultured and wild Nile tilapia (*Oreochromis niloticus*) in Makurdi, Benue State, Nigeria

Omeji, S.[1]*, Adadu, M. O.[2] and Kolndadacha, O. D.[3]

[1]Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, P.M.B. 2373, Makurdi, Benue State, Nigeria.
[2]Federal College of Freshwater Fisheries Technology Baga, P.M.B. 1060, Maiduguri, Borno State, Nigeria.
[3]Department of Animal Health and Production, College of Veterinary Medicine, Joseph Sarwuan Tarka University, P.M.B. 2373, Makurdi, Benue State, Nigeria.

*Corresponding author. Email: dromejisam@gmail.com; Tel: +234 8034111161.

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ABSTRACT: Parasitic incidence in cultured and wild Nile tilapia (*Oreochromis niloticus*) in Makurdi, Benue State, Nigeria was investigated by standard parasitological techniques using 305 samples comprising 146 and 159 *Oreochromis niloticus* randomly purchased from the cultured (Ponds) and wild (Lower River Benue) environments, respectively. Nine (9) parasite species belonging to two (2) species each of crustacean (*Argulus spp*. and *Ergasilus spp*.), protozoa (*Trichodina spp*. and *Ichyophthyirius multifilis*), cestode (*Ligula intestinalis* and *Bothriocephalus spp*.) and a species of monogenea (*Cichlidogyrus spp*.), digenea (*Clinostomum spp*.) and nematode (*Camallanus spp*.) were recovered from the examined fish. All the parasites were present in both environments with the exception of *I. multifilis* that was recovered from the wild *O. niloticus*. Out of the 146 and 159 samples of cultured and wild *O. niloticus*, 81 and 62 samples each were infested with 128 and 93 ectoparasites and endoparasites, respectively. The overall prevalence (55.48%), mean intensity (1.58) and abundance (0.88) were higher for cultured *O. niloticus* compared to the overall prevalence (38.99%), mean intensity (1.50) and abundance (0.58) recorded for the wild *O. niloticus*. The prevalence and intensity of infection in most of the parasite species were higher (9.59 and 1.50, 7.53 and 1.36, 2.74 and 1.25, 2.05 and 3.33, 5.48 and 1.88, 2.05 and 2.33, respectively from the cultured environment; 6.92 and 1.45, 6.29 and 1.30, 1.26 and 0.50, 0.63 and 2.00, 2.52 and 1.25, 1.26 and 4.00, 3.14 and 1.60, 1.26 and 2.50, respectively from the wild) in females than the males (7.53 and 1.18, 5.48 and 1.13, 1.37 and 1.50, 1.37 and 3.00, 3.42 and 1.60, 0.68 and 2.00, respectively from the cultured environment; 6.29 and 1.20, 4.40 and 1.29, 0.63 and 3.00, 0.00 and 0.00, 0.00 and 0.00, 0.63 and 3.00, 2.52 and 1.25, 0.00 and 0.00, respectively from the wild). Ectoparasites of cultured and wild *O. niloticus* were more in the gills (114) compared to the skin (25) while endoparasites of cultured and wild samples of *O. niloticus* were more in the intestine (48) compared to the stomach (40). Parasite prevalence was higher in the bigger fish samples compared to the smaller ones.

Keywords: Abundance, ectoparasites, endoparasites, parasite intensity, prevalence, sexual diversity.

INTRODUCTION

The importance of fish as a source of nutrients of animal origin for varying healthy diets and a cheap source of animal protein within the reach of the average citizen of any nation cannot be overemphasized (Mohanty, 2015). The continuous demand for fish is a function of several factors among which are ever increasing human population, high cost of other sources of animal protein, depletion of fish at an alarming rate due to overfishing as well as environmental alteration and pollution, issues of diseases and infections associated with the consumption of other sources of animal protein as well as the association of parasites and diseases with the fish which in the majority of cases results in reduced immunity of fish and higher susceptibility to parasites and diseases

(Tavares -Dias and Martins, 2017; Ayanda, 2009; Murray and Peeler 2005). Change in aquatic habitat has resulted to conditions suitable for the spread of trematodes (Lafferty and Kuris 2005).

More so, the ever increasing population coupled with urbanization and poor management practices have resulted to the problem of aquatic pollution and the corresponding prevalence of parasites and diseases in wild and cultured fish populations. Increasing aquatic environmental dynamics play a key role in determining where the fish and other aquatic organisms including parasites and other microbial pathogens exist (Zarlenga *et al.,* 2014).

Several studies have been carried out in Nigeria on parasitic fauna/parasite prevalence in different fish species (Okoye *et al.,* 2014; Biu *et al.,* 2014; Ejere *et al.,* 2014; Uruku and Adikwu, 2017; Ani *et al.,* 2017; Abba *et al.,* 2018; Oghenochuko, *et al.,* 2020; Omeji *et al.,* 2022). Due to the paucity of information on the parasitic incidence in cultured and wild Nile tilapia (*Oreochromis niloticus*) from Makurdi, Benue State, this study therefore aimed at investigating and providing documented evidence on the parasitic incidence in cultured and wild Nile tilapia (*Oreochromis niloticus*) from Makurdi, Benue State, with the specific objectives of comparing the parasite population of cultured and wild*O. niloticus*, comparing the parasite prevalence and intensity in cultured and wild *O. niloticus* and to relate the role of host age (body length) and host sex in structuring parasite community of *O. niloticus*.

METHODOLOGY

Sample collection, identification, measurement and sex determination

A total of 323 comprising of 168 and 155 samples of *Oreochromis niloticus* were collected from the cultured and wild (Lower River Benue) environments, respectively for a period of 4 months. The samples were transported in different individual holding bags to the Department of Fisheries and Aquaculture laboratory, Joseph Sarwuan Tarka University, Makurdi, based on their origins to prevent the parasite releasing and parasite hosts's witching. Sex determination, as well as length and weight measurements, were done in line with the methods described by Idodo-Umeh (2003); the sexes of the fish were determined by examination of their external genitalia, and total length and standard length were measured to the nearest 0.1 centimetres (cm) using a meter rule mounted on a dissecting board while the weight was measured to the nearest 0.1 gram (g) using an electronic weighing balance (Golden Mettler, Model: GW: 1.3kg, NW; 1kg - US).

Parasitological studies

Fish samples were gently immobilized and killed for parasitological examination. Samples of the killed fish were thoroughly examined for both ectoparasites and endoparasites. The external surface of the fish was grossly examined using a hand lens for ectoparasitic species. Thereafter, the gills were cut with the help of a pair of sharp scissors and removed with forceps and examined entirely under the dissecting microscope at a magnification of 40x - 100x. Gill smears were also prepared and observed under a light microscope according to Aloo *et al.* (2004). A wet mount of mucus from skin scrapings was placed on a clean glass slide and examined under a light microscope. The buccal cavity and the eyes of the fish samples were washed into separate Petri dishes and examined under a dissecting microscope. The large bony plate (operculum) was removed and observed under the dissecting microscope.

For endoparasites, each sample was dissected for examination of parasites within its internal organs. The gut was removed and divided into 2 sections (intestine and stomach) with each divided section being opened and contents washed into separate Petri dishes containing physiological saline solution (Aloo *et al.,* 2004). The lining of the gut lumen was also scrapped out and placed in the saline solution. One to two drops of the preparation were placed on a slide covered with slips and observed using a light binocular microscope. Different methods of fixation for observing fish parasites in this study followed the procedure illustrated by Stewart and Bernier (1999) since different parasites require different methods of fixation. For each group of the parasites, the site(s) of infection or attachment on the fish were noted and recorded with their corresponding parasites species/number.

Parasites identification

The observed parasites were sketched and observed on the binocular microscope. The identification of parasites recovered from the infested fish was done based on the distinctive body shapes, the morphological features of the specimen recovered, predilection sites in the fish host and those provided by Florio *et al*. (2009). In addition, sketches made were compared with the pictorial guide on fish parasites by Pouder *et al*. (2005) and the identification key by Paperna (1996).

Data analysis

The prevalence, abundance and intensity of infection of various parasite groups were calculated using formulae by Das *et al.* (2014) as follows:

$$\text{Prevalence} = \frac{\text{Total number of infected fish}}{\text{Total number of fish examined}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of species/parasites recovered}}{\text{Number of fish examined}}$$

$$\text{Mean intensity} = \frac{\text{Total Number of Parasites}}{\text{Number of fish infested}}$$

The relationships between factors such as fish sex, weight, total length, and parasitic infection were obtained from pooled data using analysis of variance (ANOVA). All statistical analysis was performed using Statistical Package for the Social Science (SPSS) version 21.0

RESULTS

The parasite groups and species of cultured and wild Nile tilapia (*Oreochromis niloticus*) encountered during the study period are shown in Table 1 while Table 2 shows the total prevalence, mean intensity and abundance of parasite species infesting cultured and wild *O. niloticus*.

In Table 1, nine (9) parasite species belonging to five (5) parasitic groups; two (2) species each of crustacean (*Argulus spp*. and *Ergasilus spp*.), protozoa (*Trichodina spp*. and *Ichyophthyirius multifilis*), cestode (*Ligula intestinalis* and *Bothriocephalus spp*.) and a species of monogenea (*Cichlidogyrus spp*.), digenea (*Clinostomum spp*.) and nematode (*Camallanus spp*.) were recovered. All the identified parasites were recovered from both environments with the exception of *I. multifilis* which was recovered from the wild *O. niloticus*.

In Table 2, a total of 305 samples comprising 146 and 159 samples each of cultured and wild *O. niloticus* were randomly purchased for parasitological examination during the study period (for a period of 4 months). Out of the 146 and 159 samples of cultured and wild *O. niloticus*, 81 and 62 samples each was infested with 128 and 93 different parasites ranging from ectoparasites to endoparasites, respectively. The overall prevalence (55.48%), mean intensity (1.58) and abundance (0.88) were higher ($p<0.05$) for cultured *O. niloticus* compared to the overall prevalence (38.99%), mean intensity (1.50) and abundance (0.58) recorded for the wild *O. niloticus*.

Sex related prevalence and mean intensity of parasite community of cultured and wild Nile tilapia (*O. niloticus*) are presented in Table 3. Variation in prevalence of infection between the male and female cultured and wild tilapia (*O. niloticus*) existed.

For the cultured *O. niloticus*, the prevalence of infection was higher ($p<0.05$) in female *O. niloticus*infested with *Argulus spp*. (9.59%), *Ergasilus spp*. (7.53%), *Clinostomum spp*. (2.74%), *Ligula intestinalis*, (2.05%) *Bothriocephalus spp*. (5.48%) and *Camallanus spp*. (2.05%) compared to the male counterpart of (7.53%), (5.48%), (1.37%), (1.37%), (3.42%) and (0.68%) infested with *Argulus spp*., *Ergasilus spp*., *Clinostomum spp*., *Ligula intestinalis*, *Bothriocephalus spp*. and *Camallanus spp*., respectively. However, the prevalence of infestation in the male cultured *O. niloticus*infested with Trichodina spp. (2.05%) and *Cichlidogyrus spp.* (2.05%) was higher ($p<0.05$) than the female infested with *Trichodina spp*. (1.37%) and *Cichlidogyrus spp,* (0.68%).

For the wild *O. niloticus*, while the prevalence of infection with *Argulus spp*. (6.92%), *Ergasilus spp*. (6.29%), *Trichodina spp*. (1.26%), *Ichthyophthyrius multifilis* (0.63%) *Clinostomum spp*. (2.52%), *Ligula intestinalis* (1.26%), *Bothriocephalus spp*. (3.14%) and *Camallanus spp*. (1.26%) were higher($p<0.05$) for the female, male recorded prevalence of infestation of (6.29%), (4.40%), (0.63%), (0.00%), (0.00%), (0.63%), (2.52) and (0.00%) infested with Argulus spp., *Ergasilus spp*., *Trichodina spp*., *Ichthyophthyririus multifilis*, *Clinostomum spp*., *Ligula intestinalis*, *Bothriocephalus spp*. and *Camallanus spp*., respectively. However, the prevalence of infection with *Cichlidogyrus spp.* was higher for the male (1.26%) than the female (0.00%).

Host sex insignificantly affected the intensity of infection with some species of parasites of *O. niloticus* from the cultured and wild. In the cultured, intensity of infection with Argulus spp. (1.50), *Ergasilus* spp. (1.36), *Trichodina spp*. (1.50), *Ichthyophthyririus multifilis* (0.00), *Clinostomum spp*. (1.25), *Cichlidogyrus spp*. (4.00), *Ligula intestinalis* (3.33), *Bothriocephalus spp*. (1.88) and *Camallanus spp*. (2.33) was higher in the females than the males with the intensity of infection with *Argulus spp*. (1.18), *Ergasilus spp*. (1.13), *Trichodina spp*. (1.33), *Ichthyophthyririus multifilis* (0.00), *Clinostomum spp*. (1.50), *Cichlidogyrus spp*. (1.00), *Ligula intestinalis* (3.00), *Bothriocephalus spp*. (1.60) and *Camallanus spp*. (2.00)

In the wild *O. niloticus*, the intensity of infection with *Argulus spp*. (1.45), *Ergasilus spp*. (1.30), *Trichodina spp*. (3.00), *Ichthyophthyrius multifilis* (2.00), *Ligula intestinalis* (4.00), *Bothriocephalus spp*. (1.60) and *Camallanus spp*. (2.50) was higher in the females than the males with the intensity of infection with *Argulus spp*. (1.20), *Ergasilus spp*. (1.29), *Trichodina spp*. (0.50), *Ichthyophthyrius multifilis* (0.00), *Clinostomum spp*. (0.00), *Ligula intestinalis* (3.00), *Bothriocephalus spp*. (1.25) and *Camallanus spp*. (0.00).

The total number (%) of parasites, prevalence and abundance of parasite population of cultured and wild Nile tilapia (*O. niloticus*) based on the site of attachment are shown in Table 4. The recovered parasites infested both the external (skin and gills) and internal (stomach and intestine) organs of the fish samples.

Generally, out of the total number (128) of parasites recorded from the cultured *O. niloticus*, the highest number/percentage parasite, 59(46.09), prevalence (30.82), and abundance (0.40) were recorded for the infested gills while the least number/percentage parasite 14(10.94%), prevalence (6.85)and abundance (0.10) were

Table 1. Parasite groups and species of cultured and wild *O. niloticus.*

Parasitic groups	Parasite species	Culture	Wild
Crustacea	*Argulus spp.* and	+	+
	Ergasilus spp	+	+
Protozoa	*Trichodina spp.* and	+	+
	Ichtyophthirius multiphilis	-	+
Digenea	*Clinostomum spp.* and	+	+
	Cichlidogyrus spp.	+	+
Cestode	*Ligula intesinalis* and	+	+
	Bothriocephalus spp.	+	+
Nematode	*Camallanus spp*.	+	+

+ = present, - = absent.

Table 2. Total prevalence, mean intensity and relative abundance of parasites infesting wild and cultured *O. niloticus*.

Host environments	Number of fish examined	Number of fish infested	Total number of parasites recovered	Prevalence	Mean intensity	Mean abundance
Cultured	146	81	128	55.48	1.58	0.88
Wild	159	62	93	38.99	1.50	0.58
Total	305	143	221	46.89	1.55	0.72

recorded for the infested skin. Also, among the internal organs of the fish samples, the intestine of the infested fish had higher number of parasites, 29(22.66%), prevalence (9.59) and abundance (0.20) than the stomach with the total number/percentage parasites, prevalence and abundance of 26(20.31%), (8.22) and (0.18), respectively.

Also, out of the total number (93) of parasites recorded from the wild *O. niloticus*, it was generally observed that the highest number/percentage parasite, 49(52.69), prevalence (23.90), and abundance (0.31) were recorded for the infested gills while the least number/percentage parasite 11(11.83%), prevalence (3.77) and abundance (0.07) were recorded for the infested skin. Among the internal organs of the fish samples, the intestine of the infested fish also had higher number of parasites, 19(20.43%), prevalence (6.29) and abundance (0.12) than the stomach with the total number/percentage parasites, prevalence and abundance of 14(15.05%), (5.03) and (0.09), respectively.

There were variations in the mean abundance of parasites species between culture and wild *O. niloticus*. The most abundant parasite species in culture and wild *O. niloticus* was *Argulus spp.* (0.23) and (.0.18), respectively. However, while *Trichodina spp.* and *Cichlidogyrus spp.* were the least abundant parasites (0.05) each in the cultured (*O. niloticus*), *I. multifilis* was the least (0.01) parasite in the wild *O. niloticus*. The abundance of each species was higher in cultured *O. niloticus*as compared to the wild *O. niloticus*. A significant difference was found in abundance of infection in all parasite species between culture and wild *O. niloticus* except for *I. multifilis.*

Generally, cultured *O. niloticus* had higher total number/percentage, 128(57.92%), prevalence (55.48) and abundance (0.88) than the wild *O. niloticus* with total number/percentage, 93(42.08%), prevalence (38.99) and abundance (0.58), respectively. Also, the prevalence of each species of parasites recorded was higher in the cultured *O. niloticus* as compared to that of the wild Nile tilapia (*O. niloticus*). A significant difference was found in the prevalence of infection between cultured and wild *O. niloticus*with respect to nematode (*Camallanus spp*.) infection with crustacean (*Argulus spp*. and *Ergasilus spp*.), protozoa (*Trichodina spp*. and *Ichyophthyirius multifilis*), cestode (*Ligula intestinalis* and *Bothriocephalus spp*.).

The prevalence and intensity of parasite population of *O. niloticus*per host length groups are presented in Table 5. For cultured *O. niloticus*, the prevalence of infection varied by host length class being significantly higher for *Argulus spp*. (6.85%) and *Ligula intestinalis*(2.05) in the length class B and for *Ergasilus spp*. (6.16), *Trichodina spp*. (2.05), *Clinostomum spp*. (2.05), *Cichlidogyrus spp*. (2.05), *Ligula intestinalis* (2.05), *Bothriocephalus spp*.(4.79) and *Camallanus spp*. (2.06) in the length class C.In the wild, the prevalence of infection also varied by the host length class being significantly higher for *Ligula intestinalis* and *Cichlidogyrus spp*. (1.26) each in the length classes A and B and for *Ergasilus spp*. (3.77), *Trichodina spp*. (1.26), *Ichthyophthirius multifilis* (0.63), *Clinostomum spp*. (1.89), *Bothriocephalus spp*. (2.52) and *Camallanus spp*. (1.26) in

Table 3. Prevalence and mean intensity of parasite community of wild and cultured *O. niloticus.*

Parasites species	Sex of Host fish	Number of hosts Infested		Number of parasites recovered		Prevalence (%)		Mean intensity	
		cultured	Wild	cultured	wild	Cultured	Wild	Cultured	wild
Argulus spp.	Male	11	10	13	12	7.53	6.29	1.18	1.20
	Female	14	11	21	16	9.59	6.92	1.50	1.45
Ergasilus spp	Male	8	7	9	9	5.48	4.40	1.13	1.29
	Female	11	10	15	13	7.53	6.29	1.36	1.30
Trichodina spp.	Male	3	1	4	3	2.05	0.63	1.33	3.00
	Female	2	2	3	1	1.37	1.26	1.50	0.50
I. multifilis	Male	0	0	0	0	0.00	0.00	0.00	0.00
	Female	0	1	0	2	0.00	0.63	0.00	2.00
Clinostomum spp	Male	2	0	3	0	1.37	0.00	1.50	0.00
	Female	4	4	5	5	2.74	2.52	1.25	1.25
Cichlidogyrus spp	Male	3	2	3	3	2.05	1.26	1.00	1.50
	Female	1	0	4	0	0.68	0.00	4.00	0.00
L. intestinalis	Male	2	1	6	3	1.37	0.63	3.00	3.00
	Female	3	2	10	8	2.05	1.26	3.33	4.00
Bothriocephalus spp	Male	5	4	8	5	3.42	2.52	1.60	1.25
	Female	8	5	15	8	5.48	3.14	1.88	1.60
Camallanus spp	Male	1	0	2	0	0.68	0.00	2.00	0.00
	Female	3	2	7	5	2.05	1.26	2.33	2.50

the length class C.

Additionally, for cultured *O. niloticus*, intensity of infection varied by host length class being significantly higher for *Ergasilus spp*. (1.67) and *Ligula intestinalis* (5.00) in length class A, *Trichodina spp*. (1.50), *Cichlidogyrus spp*. (3.00) and *Camallanus spp*. (3.00) in length class B while length class C recorded (1.56), (1.67), (5.00) and (2.43) for *Argulus spp*., *Clinostomum spp*., *Ligula intestinalis* and *Bothriocephalus spp*., respectively.

In the wild *O. niloticus*, intensity of infection also varied by host length class being significantly higher for *Trichodina spp*. (2.00), *Cichlidogyrus spp*. (1.50) and *Ligula intestinalis* (6.00) in the length class B and for *Argulus spp*. (1.36), *Ergasilus spp*. (1.50), *Ichthyophthirius multifilis* (2.00), *Clinostomum spp*. (2.00), *Bothriocephalus spp*. (1.75) and *Camallanus spp*. (2.50) in the length class C.

Generally, prevalence and intensity of infection of cultured and wild *O. niloticus*were higher ($p<0.05$.) for bigger fish samples (length classes A and B) than the smaller fish samples of length class A.

DISCUSSION

Nine (9) parasite species belonging to five (5) parasitic groups; two (2) species each of crustacean (*Argulus spp*. and *Ergasilus spp*.), protozoa (*Trichodina spp*. and *Ichyophthyirius multifilis*), cestode (*Ligula intestinalis* and *Bothriocephalus spp*.) and a species of nematode (*Camallanus spp*.) were all recovered from the infested cultured and wild *Oreochromis niloticus* with the exception of *I. multifilis*that was recovered from the wild *O. niloticus*. The parasitic groups encountered in this present study had been reported by Addo *et al.* (2021). Recovery of these species of parasite is not surprising as they have been previously recovered from the same or related fish species; infestation by *Camallanus spp*.

Table 4. Total number (%) of parasites, prevalence and abundance of parasite community of wild and cultured *O. niloticus* based on site of attachment.

Parasite species	Site of Attachment	Number of infested fish		Total number parasites recovered		Prevalence (%)		Abundance (%)	
		Cultured	Wild	Cultured	Wild	Cultured	Wild	Cultured	Wild
Crustacean									
Argulus spp.	Skin	10	6	14	11	6.85	3.77	0.10	0.07
	Gill	15	13	20	17	10.27	8.18	0.14	0.11
Ergasilus spp	Gill	19	17	24	21	13.01	10.69	0.16	0.13
Protozoa									
Trichodina spp.	Gill	5	3	7	4	3.42	1.89	0.05	0.03
I. multifilis	Gill	0	1	0	2	0.00	0.63	0.00	0.01
Digenean									
Clinostomum spp	Gill	6	4	8	5	4.11	2.52	0.05	0.03
Cichlidogyrus spp	Stomach	4	2	7	3	2.74	1.26	0.05	0.02
Cestode									
L. intestinalis	Intestine	7	4	16	11	4.79	2.52	0.11	0.07
Bothriocephalus spp	Intestine	7	6	13	8	4.79	3.77	0.09	0.05
	Stomach	4	3	10	6	2.74	1.89	0.07	0.038
Nematode									
Camallanus spp	Stomach	4	3	9	5	2.74	1.89	0.06	0.031
Total		81	62	128(57.92)	93(42.08)	55.48	38.99	0.88	0.58

and *I. multifilis* of *C. gariepinus* and *O. niloticus* polycultured in earthen concrete ponds had been reported by Enyidi and Uwanna (2019). Also, infestation by protozoa (*Trichodina spp*.), monogenea (*Cichlidogyrus spp*.), digenea (*Clinostomum spp*.) and nematode (*Camallanus spp*.) had been reported by Akoll *et al.* (2011). Infestation of wild and cultured *O. niloticus* from lake Manzalah, Egypt *by Ergasilus spp*. and *Trichodina spp*. had also been reported by Ibrahim and Soliman *(*2011).

Irrespective of the large number of fish (sample size of the parasite hosts) examined in this work, only 9 parasite species were found. Other common parasites infecting fish such as those belonging to Anisakidae and Diplostomidae were not detected in this study. The absence of these parasites may be due to the absence of their intermediate host and even the physicochemical characteristics of the water where the host fish were obtained.

The overall prevalence (55.48%), mean intensity (1.58) and abundance (0.88) were higher for cultured Nile tilapia (*O. niloticus*) compared to the overall prevalence (38.99%), mean intensity (1.50) and abundance (0.58) recorded for the wild Nile tilapia (*O. niloticus*). The higher prevalence, mean intensity and abundance recorded for cultured Nile tilapia (*O. niloticus*) compared to the wild could be attributed to the higher fish densities in the culture systems which might have paved way for more contact between the parasites and their hosts. This agrees with the reported work of Violante-González *et al.* (2009) who found higher infections level of *Diplostomum* (*Austrodiplostomum*) *compactum* in cultured tilapia than the wild specimens and Sami *et al.* (2020) who reported higher prevalence

Table 5. Prevalence and intensity of parasite community of *O. niloticus* per host length groups.

Parasites species	Sex of host fish	No. of host Infested		Total number of parasites		Prevalence (%)		Mean intensity	
		Cultured	wild	Cultured	wild	Cultured	wild	cultured	Wild
Argulus spp.	Group A	6	4	8	5	4.11	2.52	1.33	1.25
	Group B	10	6	12	8	6.85	3.77	1.20	1.33
	Group C	9	11	14	15	6.16	6.92	1.56	1.36
Ergasilus spp	Group A	3	5	5	4	2.05	3.14	1.67	0.80
	Group B	7	6	8	8	4.79	3.77	1.14	1.33
	Group C	9	6	11	9	6.16	3.77	1.22	1.50
Trichodina spp.	Group A	0	0	0	0	0.00	0.00	0.00	0.00
	Group B	2	1	3	2	1.37	0.63	1.50	2.00
	Group C	3	2	4	2	2.05	1.26	1.33	1.00
I. multifilis	Group A	0	0	0	0	0.00	0.00	0.00	0.00
	Group B	0	0	0	0	0.00	0.00	0.00	0.00
	Group C	0	1	0	2	0.00	0.63	0.00	2.00
Clinostomum spp.	Group A	2	1	3	2	1.37	0.63	1.50	2.00
	Group B	1	0	0	0	0.68	0.00	0.00	0.00
	Group C	3	3	5	3	2.05	1.89	1.67	1.00
Cichlidogyrus spp.	Group A	0	0	0	0	0.00	0.00	0.00	0.00
	Group B	1	2	3	3	0.68	1.26	3.00	1.50
	Group C	3	0	4	0	2.05	0.00	1.33	0.00
L. intestinalis	Group A	1	2	5	5	0.68	1.26	5.00	2.50
	Group B	3	1	6	6	2.05	0.63	2.00	6.00
	Group C	1	0	5	0	0.68	0.00	5.00	0.00
Bothriocephalus spp.	Group A	2	3	3	4	1.34	1.89	1.50	1.33
	Group B	4	2	9	3	2.74	1.26	2.25	1.05
	Group C	7	4	17	7	4.79	2.52	2.43	1.75
Camallanus spp.	Group A	0	0	0	0	0.00	0.00	0.00	0.00
	Group B	1	0	3	0	0.68	0.00	3.00	0.00
	Group C	3	2	6	5	2.06	1.26	2.00	2.50

Group A = 1-10.00cm length, Group B = 10.10 – 20.0, Group C = 20.1 and above.

(72.30%) of infection of *O. niloticus*from cultured habitat in Egypt. On the contrary, Ayanda (2009) recorded a higher total prevalence of 27.5% in wild fish samples of *Clarias gariepinus* compared to the 0% prevalence in cultured samples. According to the author, the improved management practices such as avoidance of overcrowding, poor environmental conditions and pollution and good environmental conditions carried out by the fish farmers in the study area might have been the reasons for the 0% prevalence in the cultured samples.

Also, the overall prevalence (38.99%) in the wild *O. niloticus* in the present study was higher compared to the 25.34% recorded in Edo State, Nigeria (Osimen and Anagha, 2020), 32.90% recorded in Warri River, Delta State (Ejere *et al.,* 2014), 17.10% recorded in Osse River (Okaka and Akhigbe (1999), 6.90% in Okhuo River (Edema *et al*., 2008) and 3.30% recorded in Great Kwa River (Ekanem *et al.,* 2011) but lower than the 100% recorded for Nile Tilapia (*Oreochromis niloticus*) from Lake Koftu in central Ethiopia (Mitiku *et al.,* 2018), 73.2% recorded for Nile Tilapia (*Oreochromis niloticus*) in selected fish farms, Amhara Regional State (Adugna, 2020), 67.5% recorded in Abuja, Nigeria (Kawe *et al.,* 2016), 65.0% recorded in Ebonyi River, Enugu State, Nigeria (Onyishi and Aguzie, 2018), 61.00 and 62% recorded for *O. niloticus* from River Nile and drainage branch, respectively in Egypt (Sami *et al.,* 2020), 60.23% recorded in Elemi River, Ado Ekiti, Ekiti State, Nigeria (Olofintoye, 2006), 59.20% recorded for fishes in Niger River at Illushi, Edo State, Nigeria (Onyedineke *et al.,* 2010) and the 57.34% recorded in Eleyele dam, Ibadan, Nigeria (Simon-Oke, 2017). Variations in the prevalence of infection of the studied fish between the two locations existed. This variation in the parasitic fauna may be due to shifts in the host's feeding behaviour as well as the available food items from one ecological niche/location to another. This variation in the parasitic fauna may be due to shift in the host's feeding behaviour as well as the available food items from one ecological niche/location to another. A similar observation had been made by Osimen and Anagha (2020). Furthermore, prevalence could be due to the differences in environmental fluctuation, availability of parasitic intermediate host and the life history patterns of parasites (Marcogliese, 2005). Also, the rate of parasitic prevalence could be determined by the sanitary condition of the River prior to its increase in the nutrient status by the anthropogenic activities of (Onyedineke *et al.,* 2010).

Generally, the prevalence and intensity of infection in most of the parasite species were higher in females than those in males of both cultured and wild *O. niloticus*. The sexual diversity in infection may be due to the immune response of the host as a result of the difference in endocrine glands activities between the male and female host fishes which have been suggested by many authors (Gbankoto *et al.*, 2001; Ibrahim and Soliman, 2010). Also, the higher prevalence and intensity in female fishes of *O. niloticus* may be related to investment in the reproduction of female fishes which is more costly than in male ones, so females are more susceptible to parasite infection in periods of investment in gonad development (Šimková *et al.*, 2005). This observation agrees with the findings of Ibrahim and Soliman *(*2011) who reported that females *Tilapia niloticus* were generally more parasitized than the males*.* Similarly, Ibrahim and Soliman (2010) reported that the mean infection intensity of *P. ascolonga* was higher in females than in males *T. zillii*. On the other hand, Aloo *et al.* (2004) reported that males seemed to be more parasitized than females in many freshwater fish species.

Variation in the ectoparasites of cultured and wild *O. niloticus* between the infested body parts existed being more in the gills compared to the skin. The higher number of ectoparasites recorded for the gills could be due to the fact that the gills are the center of filter feeding and sites of gaseous exchange for the fish; the sieving ability of the gill rakers to a greater level may help to trap some parasitic organisms. This observation agrees with the reported works of Omeji *et al. (*2011) who reported highest load of protozoan parasites in the gills of *Clarias gariepinus* from the wild and cultured environments in Benue State, Nigeria, Emere and Egbe (2006) reported the highest load of protozoan parasites in the gills of *Synodontis clarias* and Nyaku *et al*. (2007) reported the highest load of protozoan parasites in the gills of *Auchenoglanis ocidentalis, Oreochromis niloticus*, and *Bagrus bayad* in River Benue.

Variation in the endoparasites of cultured and wild *O. niloticus* between the infested body parts (stomach and intestine) also existed being more in the intestine compared to the stomach. The higher number of parasites recorded in the intestine compared to the stomach could be due to the occurrence of most digestion activity in the intestine which could have resulted in the release of parasite ova/cysts in the available food particles. This agrees with the reported work of Solomon *et al. (*2018) who reported higher helminths of *Bagrus bayad* from lower River Benue Makurdi, Nigeria in the intestine than the stomach, Onyedineke *et al.* (2010) who reported higher number of helminth parasites in the intestine of some freshwater fish from River Niger at Illushi Edo State. Similarly, Dan-kishiya *et al.* (2013) reported higher number of Helminth parasites in the intestine of wild African sharptooth catfish *Clarias gariepinus* (Siluriformes: Clariidae) in Gwagwalada, Nigeria than the stomach and attributed it to several factors among which, is the presence of digested food there or due to the greater surface area presented by the intestine. On the other hand, the low number of the parasites in the stomach compared to the intestine could be due to the movement of the stomach muscle, and probably hydrochloric acid nature of the stomach (Omeji *et al.,* 2022; Ajala and Fawole, 2014, Akinsanya *et al.,* 2008).

Variation in parasite prevalence among the various sizes

of the cultured and wild *O. niloticus* existed, being highest in the bigger fish samples than the smaller ones. This could be attributed to their foraging habit, food abundance and availability to the parasite host organisms for consumption. A similar result for *Clarias gariepinus* and *Tilapia zilli* obtained from Lamingo Dam, Jos, Nigeria had been reported by Goselle *et al.* (2008). However, Bichi and Ibrahim (2009) reported higher prevalence of smaller sizes of *Tilapia zilli* compared to the bigger ones in their survey of Tiga Lake, Kano, Nigeria and attributed the reason in the prevalence variation to the varying distribution of parasites in the different habitat which could be due to host-parasite interaction and the water quality parameters of dissolved oxygen, temperature and pH of the fish environment. A similar observation had been made by Oghenochuko *et al. (*2020) in their reported work of endo and ect parasite prevalence and abundance in some fish species from Akomoje, Ogun River South-West, Nigeria.

Conclusively, the cultured and wild *O. niloticus* used for the parasitological examination in this study were found rich in parasite burden ranging from ecto to endo parasites. The parasites include *Argulus spp*., *Ergasilus spp*., *Trichodina spp*., and *Clinostomum spp*. (ectoparasites); *Cichlidogyrus spp*., *Ligula intestinalis*, *Bothriocephalus spp.,* and *Camallanus spp*. (endoparasites).These parasites were recovered from both environments with the exception of *I*. *multifilis* which was recovered from the wild *O. niloticus*. It is recommended that constant good management practices and surveillance of the water bodies should be carried out in order to determine their parasites prevalence so as to prevent possible food-borne parasitic disease outbreak. In addition, a detailed study of the seasonal variations of parasite load in these water bodies is also recommended. The need to characterize these parasites molecularly in future so as to throw more light on their genetic diversity in the study areas is very essential.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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