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Parasite community of *Oreochromis niloticus* from man-made Lake Ayame I, Côte d'Ivoire

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Abstract

The aim of this study was to provide the first information on the parasitic infestation on Nil Tilapia *Oreochromis niloticus* in a man-made Lake Ayame I. A total of 278 fish were sampled between January and December 2019 and were examined for parasites using standard parasitological methods. The parasites recorded were the Monogeneans (*Cichlidogyrus thurstonae*, *C. halli*, *C. tilapiae*, *C. rognoni*, *C. cirratus* and *Scutogyrus longicornis*), the Myxosporeans (*Myxobolus tilapiae* and *M. camerounensis*), the Copepods (*Lamproglena monody* and *Lernaea* sp.), the Acanthocephalan (*Acanthogyrus tilapiae*), the Nematodes (*Paracamallanus cyathopharynx* and *Contracaecum* sp.), the Trematode (*Clinostomum* sp.) and Cestode (*Diphyllobothrium latum*). The infestation was predominantly by Monogeneans species. Generally, the highest parasitic infection was observed during the rainy seasons. Gills were highly parasitized by Monogeneans. The gut was highly parasitized principally by Nematodes, Acanthocephalan and Cestode. The presence of parasites such as *Clinostomum*, *Contracaecum* and *Diphyllobothrium* species represents the potential public health risks, as these parasites are recognized to infect humans from consumption of raw or inadequately cooked fish. Therefore, appropriate control measures should be put in place in the Lake so as to avoid infection of the fish. Moreover, public awareness creation activities should be conducted on zoonotic nature of fish parasites and danger of consumption of raw or undercooked fish.

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Introduction

Tilapias are becoming increasingly important as culture species particularly in the tropics (Smith and Pullin, 1984; Balogun *et al.*, 2005). They constitute a very important source of protein and subsistence income for fish farm operators. Among the Tilapias, notably *Oreochromis niloticus* is a fast growing fish and has a great importance in aquaculture and screen aquarium (Okoye and Nnaji, 2005). Thus, this fish has a great economic interest in Côte d'Ivoire (Gole-Bi *et al.*, 2005). Indeed, the total annual yield of inland fisheries estimated at 18000 tons are essentially dominated by Cichlidae, notably *O. niloticus* which represents between 50 to 70% of the total catches (Gole-Bi *et al.*, 2005). It is also used extensively in biological and physiological research (Gómez-Márquez *et al.*, 2003; Sandoval-Gío *et al.*, 2008). Besides the growing interest in fish culture development, it has been shown that this fish species harbored many parasites.

Parasite is an important group of pathogen causes infection and diseases of fish both in freshwater and marine environments (Chandra, 2006). Parasitic infection and diseases are some of the factors hindering high productivity in fish farming (Doglel *et al.*, 1961; Kayis *et al.*, 2009). It result in huge economic losses as they increase mortality; increase farm inputs via increased treatment expenses and cause reduction in growth rate, fecundity and possibly weight loss during and after the period of parasitic disease outbreak (Kayis *et al.*, 2009; Salawu *et al.*, 2013). Thus, fish parasites cause physiological, reproductive and physical damage to fishes (Iwanowicz, 2011). Knowledge of fish parasites is of particular interest in relation not only to fish health but also to understanding ecological problems (Dudgeon *et al.*, 2006). Indeed, studies of fish parasites are ecologically important since abundance of fish parasites is likely to have a greater impact on the fish activities and shape of fish community and ecosystem structure through influences in trophic interactions, host fitness, and food webs (Hudson *et al.*, 2006). Fish parasites are also potential biomarkers for ecology and trophic interactions (Cauyan *et al.*, 2013). For Marcogliese and Cone (1996), different parasites have a variety of intermediate hosts and often depend on trophic interactions for transmission, so parasites within a vertebrate host may be excellent indicators of food-web structure and biodiversity. Parasitological knowledge has been useful in the development of the aquaculture industry in many parts of the word through the production of vaccines, antibiotics and introduction of bio-security measures to minimize the mass fish mortalities and boots global food fish (Lom and Dykova, 1992). Despite the economic and cultural importance of tilapia for Côte d'Ivoire, studies that show the parasitic infectious agents dynamics that affect the Nile tilapia (*Oreochromis niloticus*) within natural water systems are lacking. To date, few studies have been conducted on parasites of this fish species (Blahoua *et al.*, 2016). These studies focused on gill monogeneans. However, literature about the other parasitic fauna in this cichlid is scanty. Nevertheless, baseline data, collected from parasitic infections in natural water systems, is useful in the development of measures to their control in aquaculture.This study aims at investigating the preliminary reconnaissance survey parasitic fauna of *O. niloticus* sampled in the man-made Lake Ayame I.

Materials and methods

Study area

The Lake Ayame I (5° - 7° 5' N and 2° 6' - 3° 3' W) is an artificial freshwater lake situated in the south-east region of Côte d'Ivoire (Fig. 1). The lake was built in 1959 in the river Bia and has an area comprised between 87 and 194 km² with a mean depth of 30 m.

The study area belongs to an equatorial transition zone, characterized by two rainy seasons (April to July and October to November) and two dry seasons (December to March and August to September). The lake level is subject to fluctuations depending on local rainfall and evaporation. The Lake Ayame I is a deep and open water characterized by muddy substrate and a low transparency with an annual mean Secchi disk of 110 cm. Fishing and agriculture activities have developed around this reservoir since its creation.

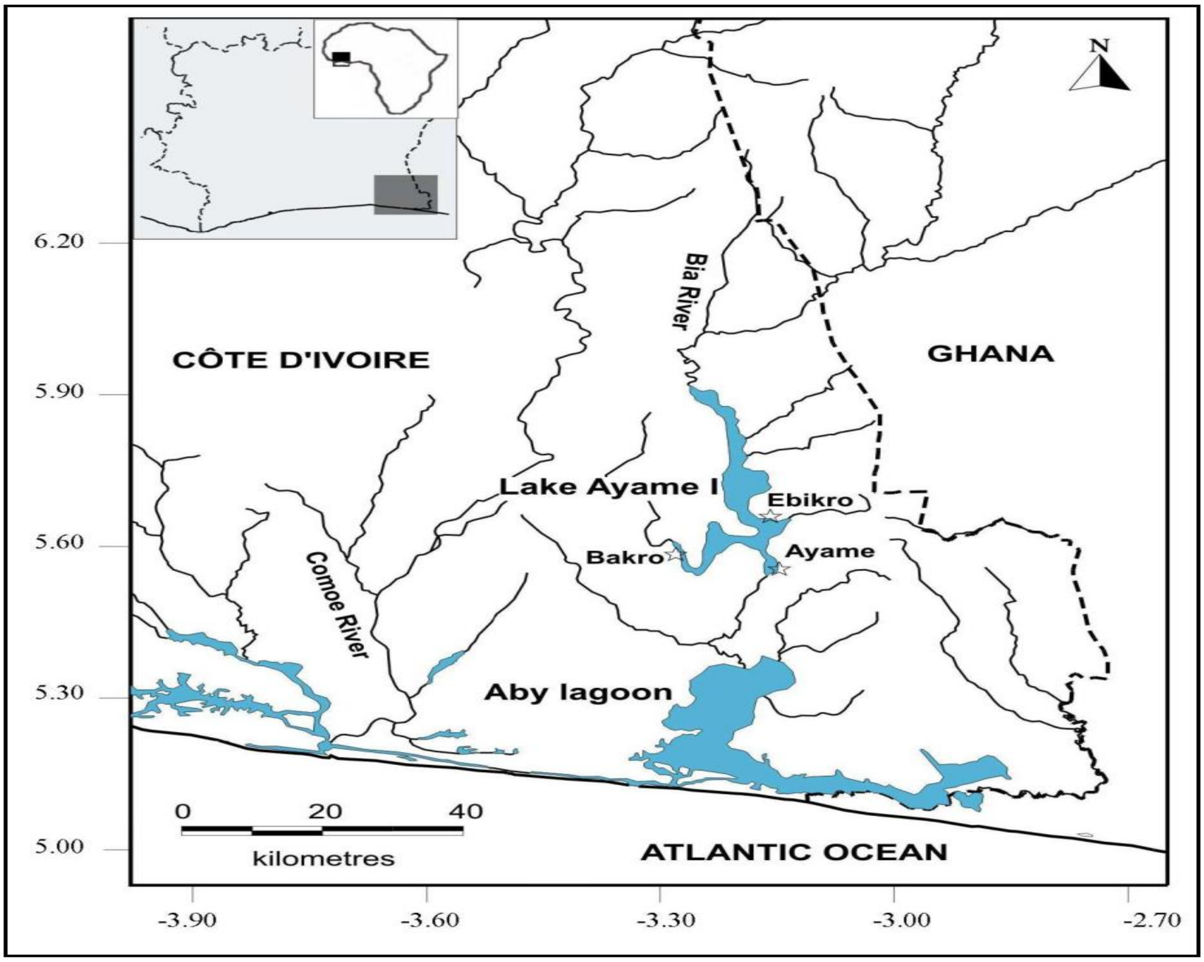

Fig. 1. Geographical location of Lake Ayame I (Côte d'Ivoire).

Collection, Identification and Processing of fish samples for parasite examination

Fishes were caught by the fishermen using gill nets in the Lake Ayame I, between January and December 2019. The fish samples were identified to the species level using taxonomic keys (Teugels and Thys van den Audernaerde, 2003). A total of 278 O*reochromis niloticus* were collected. Fishes were placed in icebox and transported to the laboratory for identification, processing and examination for parasitic fauna. In the laboratory, each fish was laid on its back on plastic dissecting tray and the abdominal cavity was cut open using a scalpel and a pair of surgical scissors which was inserted through the urogenital opening and a slit was made to the pelvic bones following methods described by Olurin and Samorin (2006). Sexes were determined by examination of the gonads by noting the presence of the testes or ovaries. The gills as well as the different part of the digestive tract (esophagus, stomach, and intestines) were isolated. The organs were then extracted and each placed in properly labeled sterile Petri-dishes filled with normal saline (0.9% salt concentration). The freshly recovered parasites were fixed in 70% ethanol for later identification. Parasites were then removed from the preservative, washed with distilled water and placed on a clean slide with a few drops of normal saline. For Monogeneans, individual worms were collected and mounted on a slide in a drop of ammonium picrate-glycerine mixture. For Acanthocephalans and Trematodes, specimens were stained with carmine, dehydrated through a gradient series of ethanol, cleared in clove oil and mounted in Canada balsam. Cestodes and Nematodes parasites recovered were stained using the following procedure. Fixative used was Formaline acetic acid (FAA); cestodes were stained using acetocarmine; Nematodes were stained with Horen's trichome stain. Parasites were mounted in Canada balsam. Specimens of copepods were fixed in 70% AFA (Alcohol Formaldehyde Acetic) and 70%

ethanol. Ethanol fixed specimens were cleared in 90% lactic acid. Parasites were observed under using a Zeiss microscope. Identification of parasites were done using taxonomic key of freshwater fish parasite pictorial guides by Roberts (1978, 1995, 2000), Paperna (1996) and Pariselle and Euzet (2009). Parasites were picked out carefully from each individual fish sample and were counted to know their prevalence, intensity and abundance in that sample.

Epidemiological approach

Classical epidemiological variables (prevalence, abundance and mean intensity) were calculated according to formula given by Bush *et al.* (1997) as follows:

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

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

$$\text{Mean intensity} = \frac{\text{Number of collected parasites}}{\text{Total number of infected fish}}$$

Statistical analysis

The relationship that exists between the parasite burden and other tested variables (taxonomic, effect of host sex and season) were compared using Chi-square (X^2), Mann-Whitney (U) and Kruskal Wallis (K) tests to assess the significance of the difference. Differences of $p < 0.05$ were considered significant. Computations were performed using Statistical Package for Social Science (SPSS) 16.0.

Results

Taxonomic groups

Fifteen parasites species were recorded from *Oreochromis niloticus*. Recorded fauna was composed of seven taxonomic groups including six Monogeneans (*Cichlidogyrus thurstonae*, *C. halli*, *C. tilapiae*, *C. rognoni*, *C. cirratus* and *Scutogyrus longicornis*), two Myxosporeans (*Myxobolus tilapiae* and *M. camerounensis*), two Copepods (*Lamproglena monody* and *Lernaea* sp.), one Acanthocephalan (*Acanthogyrus tilapiae*), two Nematodes (*Paracamallanus cyathopharynx* and *Contracaecum* sp.), one Trematode (*Clinostomum* sp.) and one Cestode species (*Diphyllobothrium latum*) (Table 1).

Table 1. Prevalence, mean intensity and abundance of parasites of *Oreochromis niloticus* sampled in the man-made Lake Ayame I.

Parasites groups	Number of examined fish	Number of infected fish	Number of parasites	Number of (%)	Number of ± SE	Abundance
MONOGENEAN	278	264	6786	94.96	25.7 ± 1.02	24.41
MYXOSPOREAN	278	126	308	45.32	2.44 ± 0.01	1.11
COPEPOD	278	32	37	11.51	1.15 ± 0.01	0.12
ACANTHOCEPHALAN	278	77	81	27.69	1.05 ± 0.03	0.3
NEMATODE	278	53	64	19.06	1.2 ± 0.02	0.23
TREMATODE	278	12	16	4.31	1.33 ± 0.03	0.06
CESTODE	278	4	5	1.44	1.25 ±0.01	0.018
All parasites	278	268	7297	96.40	27.22 ± 1.3	26.24

SE: Standard error.

General prevalence, mean intensity and abundance of parasites

Table 1 shows the prevalence, mean intensity and abundance of parasites as recovered in this fish host. Of the 278 *Oreochromis niloticus* examined, 268 (96.40 %) were infected by parasites. The mean intensity for all parasites was 27.22 ± 1.3 parasites per infected specimen with abundance up to 26.24 parasites per examined fish specimen. A total of 7297 parasites were collected from fish species including Monogeneans (n = 6786 specimens), Myxosporeans (n = 308 specimens), Copepods (n = 37 specimens), Acanthocephalans (n = 81 specimens), Nematodes (n = 64 specimens), Trematodes (n = 16 specimens) and Cestodes (n = 5 specimens). The highest prevalence of Monogenean (94.96%) followed by Myxosporean (45.32%) was observed, while the Cestode showed the lowest prevalence (1.44%). The prevalence of other groups ranged between 4.31 and 27.69%. Significant differences were noticed among infestation rate of parasites groups (Chi-square X^2 test, $p < 0.05$). Higher mean intensity (25.7 ± 1.02) and abundance (24.41) were also reported for Monogenean. However, lower mean intensity (1.05 ± 0.03) and abundance (0.018) were observed respectively with Acanthocephalan and Cestode.

A significant difference was found in the specimen number of all parasite groups (Kruskal Wallis (K) and Mann-Whitney (U) tests, $p < 0.05$).

Table 2. Prevalence, mean intensity and abundance of parasite species of *Oreochromis niloticus* sampled in the man-made Lake Ayame I.

Parasites species	Number of parasites	Prevalence (%)	Mean intensity ± SE	Abundance
MONOGENEAN				
Cichlidogyrus thurstonae	2134	94.96	8.08 ± 1.1	7.67
Cichlidogyrus halli	1753	87.05	7.24 ±1.03	6.31
Cichlidogyrus tilapiae	931	47.84	7 ± 0. 09	3.35
Cichlidogyrus rognoni	448	26.26	6.14 ± 0.03	1.61
Cichlidogyrus cirratus	284	16.54	6.17 ± 1.16	1.02
Scutogyrus longicornis	1236	42.08	10.56 ± 1.4	4.45
MYXOSPOREAN				
Myxobolus tilapiae	242	40.28	2.16 ± 0.01	0.87
Myxobolus camerounensis	66	14.75	1.61 ± 0.02	0.24
COPEPOD				
Lamproglena monodi	28	10.07	1 ± 0.01	0.1
Lernaea sp.	9	1.79	1.8 ± 0.1	0.03
ACANTHOCEPHALAN				
Acanthogyrus tilapiae	81	25.9	1.13 ± 0.04	0.29
NEMATODE				
Paracamallanus cyathopharynx	51	11.15	1.65 ± 0.01	0.18
Contracaecum sp.	13	3.23	1.44 ± 0.02	0.047
TREMATODE				
Clinostomum sp.	16	4.32	1.33 ± 0.03	0.06
CESTODE				
Diphyllobothrium latum	5	1.44	1.25 ±0.01	0.018

SE : Standard error

Table 2 presents the summary of prevalence, mean intensity and abundance of each parasite species. Higher prevalence (94.96%) was reported for *Cichlidogyrus thurstonae* (Monogenean), whereas lower prevalence (1.44%) was recorded for *Diphyllobothrium latum* (Cestode). Prevalence of other parasites species ranged from 3.23 and 87.05%. Pattern of infection was significantly different in the prevalence of parasites species (Chi-square X^2 test, $p > 0.05$). *C. thurstonae* showed the highest mean intensity (8.08 ± 1.1) and abundance (7.67), whereas the lowest mean intensity (1 ± 0.01) and abundance (0.018) recorded respectively with *Lamproglena monodi* (Copepod) and *D. latum* (Cestode). The difference in the specimen number of parasite species was statistically significant (Kruskal Wallis (K) and Mann-Whitney (U) tests, $p < 0.05$).

Infection pattern in relation to host sex

Table 3 shows the infection pattern (prevalence, mean intensity and abundance) of parasites in relation to *Oreochromis niloticus* sex. Of 278 sampled of both host sexes examined, 268 (96.4%) were infected by different parasites. Out of 150 males and 128 females examined fish, respectively 144 (96 %) and 124 (94.53%) were infected by parasites.

The mean intensity and abundance were higher in males (respectively 34.74±0.4 parasites/infected fish and 33.35 parasites/examined fish) than in females (18.50 ± 1.2 parasites/infected fish and 17.92 parasites/examined fish).

No significant differences were noticed among prevalence of parasites in male and female hosts (Chi-square X^2 test, $p > 0.05$).

Table 3. Prevalence, mean intensity and abundance of parasites of *Oreochromis niloticus* according to host sex.

Host sex	Number of examined fish	Number of infected fish	Number of parasites	Prevalence (%)	Mean intensity ±SE	Abundance
Males	150.	144	5003	96	34.74± 0.4	33.35
Females	128	124	2294	94.53	18.5 ± 1.2	17.92
Combined	278	268	7297	96.4	27.22 ± 0.8	26.25

SE: Standard error.

However, statistical tests revealed that the infection level varied significantly between males and females (Mann-Whitney (U) test, $p < 0.05$, respectively).

Infection pattern of parasites within sites

The parasites infected three fish organs (gills, intestine and pharyngeal region) of *O. niloticus* (Table 4).

Six Monogenean species (*Cichlidogyrus thurstonae*, *C. halli*, *C. tilapiae*, *C. rognoni*, *C. cirratus*, *Scutogyrus longicornis*) and two Myxosporean (*Myxobolus tilapiae*, *M. camerounensis*) and two Copepod species (*Lamproglena monody*, *Lernaea* sp.) were found in the gills. Internal worms were encountered: one Acantocephalan species (*Acanthogyrus tilapiae*), two Nematodes species (*Paracamallanus cyathopharynx*, *Contracaecum* sp.), one Trematode species (*Clinostomum* sp.) and one Cestode (*Diphyllobothrium latum*). The distribution of parasites in organs was found in gills (79%), intestine (20%) and pharyngeal region (1%).

Temporal variation of the occurrence of the parasites

Seasonal prevalence, mean intensity and abundance of parasite fauna in the gill, pharyngeal region and intestine of *O. niloticus* are summarized in Table 5. Fifteen (15) species were collected in rainy season and eleven (11) species in dry season. For all Monogenean species (*Cichlidogyrus thurstonae*, *C. halli*, *C. tilapiae*, *C. rognoni*, *C. cirratus* and *Scutogyrus longicornis*) and *Myxobolus tilapiae* (Myxosporean), the highest prevalence, mean intensity and abundance were observed in the rainy season.

The Chi-square (X^2) applied to the temporal variations of the infestation rate of *C. thurstonae*, *C. halli* and *C. tilapiae* showed that these values did not statistically significant ($p > 0.05$). In contrast, significant differences were noticed among seasonal infestation rate of *C. rognoni*, *C. cirratus*, *Scutogyrus longicornis* and *Myxobolus tilapiae* (Chi-square (X^2) test, $p < 0.05$). High mean intensity and abundance of these worms were recorded in rainy season. A significant difference of seasonal infestation was observed (Mann-Whitney (U), $p < 0.05$). Furthermore, the parasites *Lamproglena monody* and *Lernaea* sp. (Copepod), *Contracaecum* sp. (Nematode) and *Diphyllobothrium latum* (Cestode) did not collect from gill and intestine in dry season. The highest prevalence, mean intensity and abundance of these parasites were registered in rainy season. Significant differences were noticed among seasonal infestation rate (Chi-square (X^2) and Mann-Whitney (U) test, $p < 0.05$). For *Myxobolus camerounensis* (Myxosporean), *Acanthogyrus tilapiae* (Acanthocephalan), *Paracamallanus* *cyathopharynx* (Nematode) and *Clinostomum* sp. (Trematode), prevalence, mean intensity and abundance were the highest in dry season.

There were significant differences in the prevalences and in seasonal intensity of infestation (Chi-square (X^2) and Mann-Whitney (U) test, $p < 0.05$).

Table 4. List of parasites recovered and their site of infection in *Oreochromis niloticus*.

Parasites groups	Species	Sites of infection
MONOGENEAN	*Cichlidogyrus thurstonae*	Gill
	Cichlidogyrus halli	Gill
	Cichlidogyrus tilapiae	Gill
	Cichlidogyrus rognoni	Gill
	Cichlidogyrus cirratus	Gill
	Scutogyrus longicornis	Gill
MYXOSPOREAN	*Myxobolus tilapiae*	Gill
	Myxobolus camerounensis	Gill
COPEPOD	*Lamproglena monodi*	Gill
	Lernaea sp.	Gill
ACANTOCEPHALAN	*Acanthogyrus tilapiae*	Intestine
NEMATODE	*Paracamallanus cyathopharynx*	Intestine
	Contracaecum sp.	Intestine
TREMATODE	*Clinostomum* sp.	Gill, pharyngeal region
CESTODE	*Diphyllobothrium latum*	Intestine

Discussion

In this study, 15 parasite species, into 7 taxonomic groups were recovered. The identified parasites were dominated by Monogeneans. The site of Monogenean infection was the fish gill. The susceptibility of fishes to infestation with parasites differs and depends on various factors, including morphology, physiology, immunology and diet of the host. In this study, this could lead to transmission of parasites from one generation to the other thus ensuring the propagation of the parasites like Monogeneans that have a direct life cycle and depend on host availability for propagation. This agreed with findings of Akoll *et al.* (2012) who had reported that the gills were highly susceptible to parasite, mainly by Protozoans and Monogeneans parasites. These parasites can affect the fish in exhibited depigmentation, skin ulceration, scale loss, excessive mucus production and gill lesions. Myxosporean parasites represented by *Myxobolus tilapiae* are the second dominated parasites species recovered on gill in O. *niloticus*. These parasites affect many fish families and are common in Cichlidae (FAO, 1996).

In Africa, more than 135 species of Myxozoans are known to infect freshwater, brackish water and marine fishes (Kostroingue *et al.*, 2001). Sakiti *et al.* (1999) observed and described 17 species, prominent among which were the following parasitic protozoan genera: *Henneguya, Myxobolus, Myxobilatus* and *Parahenneguya*. Similarly, Fonkwa *et al.* (2018) reported that *O. niloticus* is infected by 12 Myxosporean species belonging to the genus *Myxobolus*. This could be due to the fact that Myxosporean parasites as such, have the potential to form species rich infracommunities and component communities that might equal or surpass those formed by other groups of fish parasites (Marcogliese and Cone, 2001).Most infections in fish create minimal problems, however heavy infestations by these parasites can be more prevalent, especially in young fish (Klinger and Francis-Floyd, 2013).

Acanthogyrus tilapiae was acanthocephalan species which is more abundant in fish intestine. This finding supports earlier work of Sinaré *et al.* (2016) who discovered higher number of *A. tilapiae* in *O. niloticus*. Okpasuo *et al.* (2016) also reported the presence of *Acantogyrus* spp. in *C. gariepinus* and *O. niloticus* from Esa Odo reservoir.

Table 5. Prevalence (%), mean intensity and abundance of parasites species according to season.

Parasites groups and species	Seasons	Number of examined fish	Number of infected fish	Number of parasites	Prevalence (%)	Mean intensity ± SE	Abundance
MONOGENEAN							
Cichlidogyrus thurstonae	Dry	116	106	331	91.37	3.12 ± 0.09	2.85
	Rainy	162	158	1803	97.53	11.41 ± 1.3	11.12
Cichlidogyrus halli	Dry	116	83	147	62.93	1.77 ± 0.03	1.26
	Rainy	162	159	1606	98.15	10.10 ± 1.8	9.91
Cichlidogyrus tilapiae	Dry	116	37	40	31.89	1.08 ± 0.01	0.34
	Rainy	162	96	891	52.25	9.28 ± 1.5	5.5
Cichlidogyrus rognoni	Dry	116	22	82	18.96	3.72 ± 0.08	0.7
	Rainy	162	51	366	31.48	7.18 ± 1.2	2.26
Cichlidogyrus cirratus	Dry	116	12	46	10.34	3.83 ± 0.09	0.39
	Rainy	162	34	238	20.99	7 ± 1.1	1.47
Scutogyrus longicornis	Dry	116	30	34	25.86	1.13 ± 0.01	0.29
	Rainy	162	87	1202	53.70	13.82 ± 1.6	7.42
MYXOSPOREA							
Myxobolus tilapiae	Dry	116	11	31	9.48	2.82 ± 0.04	0.28
	Rainy	162	101	211	62.36	2.1± 0.02	1.3
M camerounensis	Dry	116	33	57	28.45	1.73 ± 0.06	0.5
	Rainy	162	8	9	4.93	1.12 ± 0.02	0.1
COPEPODE							
Lamproglena monodi	Dry	116	0	0	0	0	0
	Rainy	162	28	28	17.28	1 ± 0.01	0.17
Lernaea sp.	Dry	116	0	0	0	0	0
	Rainy	162	5	9	3.09	1.8 ± 0.03	0.1
ACANTHOCEPHALAN							
Acanthogyrus tilapiae	Dry	116	65	74	56.03	1.13 ± 0.02	0.64
	Rainy	162	7	7	4.32	1 ± 0.001	0.04
NEMATODE							
Paracamallanus cyathopharynx	Dry	116	26	43	22.41	1.65 ± 0.01	0.37
	Rainy	162	5	8	3.08	1.6 ± 0.02	0.05
Contracaecum sp.	Dry	116	0	0	0	0	0
	Rainy	162	9	13	55.55	1.44 ± 0.04	0.08
TREMATODE							
Clinostomum sp.	Dry	116	10	14	8.62	1.4 ± 0.001	0.12
	Rainy	162	2	2	1.23	1 ± 0.01	0.01
CESTODE							
Diphyllobotrium latum	Dry	116	0	0	0	0	0
	Rainy	162	4	5	2.46	1.25 ± 0.01	0.03

SE : Standard error

Differences in physical environment in the gut, availability, nature, and amount of food supply were factors that most likely limit the distribution of parasites in different sections of alimentary tract (NKwengulila and Mwita, 2004). In this study, the preference of Acanthocephalans for gill region as site of attachment could be attributed to food availability in this region. In fact, these parasites do not have a gut. Nutrients from the lumen of the host gut are absorbed across the body wall of the parasites. These results suggest that this Acanthocephalan species was better adapted to some cichlid hosts than to others.

Paracamallanus cyathopharynx (Nematode) was recorded with prevalence 11.15% in fish intestine. This is in line with the findings of Sinaré *et al.* (2016) who found *P. cyathopharynx* (prevalence = 0.39%) in *O. niloticus* in Burkina Faso. Eissa *et al.* (2011) have also recorded *P. cyathopharynx* and *Procamallanus laeviconchus* in stomach of *O. niloticus* in Egypt. The higher prevalence of *P. cyathopharynx* might be due to the fact the Nematodes are known to occur worldwide particularly the species utilizing fish as intermediate or transient hosts and can infect all organs of their hosts with heavier infections in predatory fishes (FAO, 1996; Klinger and Floyd, 2002). Hence, the prevalence of *P. cyathopharynx* obtained in this study suggests that *O. niloticus* is intermediate host in the local trophic web. Copepod *Lamproglena monody* was recovered on the gill of *O. niloticus*. It was fixed deeply in the gill arch. Previous findings have shown the same result (Boungou *et al.*, 2013; Sinaré *et al.*, 2016). Probably, the location of this parasite species was due to the food availability in this region. It could create damage in gill tissue. Trematode *Clinostomum* sp. was also recorded on the gills, operculum and in the pharyngeal region of the host. Some authors such as Ochieng *et al.* (2012) and Bekele and Hussien (2015) observed the same trend in this host fish.

The report of *Clinostomum spp*. from these studies confirms the assertion by Gebreegziabher and Tsegay (2017) that *Clinostomum* sp. are among the major trematode species found affecting *O. niloticus*. It has known that trematode (*Clinostomum* sp.) have complex life cycles involving 3 hosts: snail, (first intermediate host), fish or amphibian (second intermediate host) and aquatic birds (definitive host) (Bonett *et al.*, 2011). Hence, the presence of *Clinostomum* (metacercariae) in the specimens of fish host suggests the presence of snails which are the first intermediate hosts of the parasites in the study area and specimens of *O. niloticus* are intermediate hosts in the local trophic web. Probably, this is due to the fact that *O. niloticus* feeds mainly on benthic materials, including detritus by picking up larval stages of parasites. *Clinostomum* is known to damage the muscles of fish making it disgusting and unmarketable (Coulibaly *et al.*, 1995).

Cestode *Diphyllobothrium latum* was recorded in fish intestine. Similarly, Awosolu *et al.* (2018) reported the same results in *O. niloticus* from Igbokoda River (Nigeria). According to Dan-kishiya *et al.* (2013), the higher number of parasites in the intestine was attributed to several factors among which, was the presence of digested food or due to the greater surface area presented by the intestine. In this study, the preference of cestodes for intestine region as site of attachment could be attributed to food availability in this region.

Most of parasites were recovered from gills, with a few from intestine. The parasites observed on the gills were regarded as Monogenean species, while those on the intestine were identified as nematode species. It could be due to the fact that the gills were more exposed to more water currents containing Monogenean larvaes. Also, these parasites develop different modes of attachment associated with mechanical and chemical factors to the specific host (Buchmann and Lindenstrom, 2002). In this study, the male's fish were more infected than the female's fish. Several authors have found that most of the parasites infected males more than females.

It is the case of Ohaeri (2012) with *Oreochromis niloticus*, Olurin *et al.* (2012) with *Sarotherodon galilaeus* and *Tilapia zillii* and Amaechi (2014) with *O. niloticus* and *T. zillii*. The differences in infestation between males and females could be due to differential feeding pattern which could be in terms of quality and quantity (Emere, 2000). Indeed, males are always in movement, but females are in egg-laying period, keeping eggs in their mouths and feeding less during that period. Males eat more and accumulate parasite in their organism. In general, the highest prevalence, abundance and intensity of parasites were observed in rainy seasons. The trend of the results obtained during this study agrees with the reports of Bichi and Bizi (2002) and Usip *et al.* (2010), but it disagrees the findings of Fonkwa *et al.* (2018). Seasonal variation in the occurrence of these parasites could be related to the food availability for fish.

In fact, *Oreochromis niloticus* being a phytoplanktivorous fish and sometimes feeding on decomposed organic matter could be directly infected by parasites during feeding. Also, the rainy season corresponds to the period of reproduction and proliferation of intermediate hosts.

The increase of intermediate hosts of these parasites at these seasons and increase the feeding activity of this fish species in this period could explain the increased of infection rate of parasites observed in this study. Furthermore, this seasonal variation in the infection rate could be due to the increase of activities around this lake during the rainy season. Indeed, animal activities such as watering of cattle, sheep, defecation and disposition of sewage coupled with abundance of birds and aquatic animals such as mollusk which enhance parasites life-cycle can increase the infection.

Conclusion

The component community of parasites in *Oreochromis niloticus* from man-made Lake Ayame I was demonstrated. Fish parasites were distributed among Monogenean, Myxosporean, Acanthocephalan, Nematode, Copepod, Trematode and Cestode. This fish species was mostly infected by Monogenean. There was host sex effect in the distribution of these parasites and seasonal differences in infections were demonstrated. Some of the helminthes isolated are of zoonotic potential, thus, removal of the intestine and thorough cooking of fish will ensure humans safety even when they consume infected fish.

Conflict of interest

The authors have not declared any conflict of interests.

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