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Diversity and seasonal distribution of parasites of *Oreochromis niloticus* in semi-arid reservoirs (West Africa, Burkina Faso)

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This study aimed to investigate the diversity, abundance, intensity, and seasonal distribution of parasites of *Oreochromis niloticus*. A total of 254 specimens of *O. niloticus* was sampled in Loumbila and Ziga reservoirs in both rainy and dry season and examined for parasites. The total prevalence was 55.90% and the highest seasonal prevalence, abundance and intensity were observed during the rainy season. Recorded parasites were the myxozoan *Myxobolus tilapiae*, the copepode *Lamproglena monodi*, the monogeneans *Cichlidogyrus tilapiae*, *Cichlidogyrus halli*, the digenetic trematode *Clinostomum* species, the nematode *Paracamallanus cyathopharynx*, and the acanthocephalan *Acanthogyrus tilapiae*. The latter species had higher prevalence (45.67%) and high abundance. *L. monodi*, *C. tilapiae*, *C. halli*, and *P. cyathopharynx* were only observed in Loumbila reservoir. *A. tilapiae*, *Clinostomum* spp. and *M. tilapiae* were found in both reservoirs with a high abundance. In conclusion, it was found out that *O. niloticus* specimens were heavy infection with a broad number of parasites. This situation could eventually reduce performance and productivity of the species, especially in aquaculture.

Key words: *Oreochromis niloticus*, parasites, Loumbila reservoir, Ziga reservoir, Burkina Faso.

INTRODUCTION

Fish is an important source of protein to humans and other animals. The tilapias are freshwater fish in the family of Cichlidae and they were considered to be more resistant compared to other species of cultured fish. *Oreochromis niloticus*, *Sarotherodon galilaeus,* and *Tilapia ziilli* are the major species in Burkina Faso fisheries. *O. niloticus* is a fast growing fish and has a great importance for fisheries, aquaculture, and screen aquarium. It is also used extensively in biological and physiological research (Gómez-Márquez et al., 2003; Sandoval-Gío et al., 2008). The size and the stock of these species are decreasing in the Ziga and Loumbila

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reservoirs according to fishermen, suggesting that there are factors limiting their growth, among them are parasitic infections. Indeed, it has been shown that *O. niloticus* is the host of many parasites (Akoll et al., 2012).

The occurrence of disease conditions, particularly due to parasites, is a major burden in aquaculture (Bondad-Reantaso et al., 2005). Parasites cause direct losses of fish through mortal infections and have considerable impact on fish growth, resistance to other stressing factors, susceptibility to predation, and marketability. Besides, parasites pave the way for secondary infections (Scholz, 1999). Therefore, 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). 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 (Marcogliese and Cone, 1996).

To date, few studies have been conducted on fish parasites of Cichlidae, including *O. niloticus* in West Africa semi-arid areas like Burkina Faso (Boungou et al., 2006a, b, 2008; Boungou, 2007; Coulibaly, 1995; Coulibaly et al., 1995, 1999; Kabré, 1997). These studies focused on ectoparasites diversity and endoparasites biology. However, there is no data about infection dynamic. In this study, *O. niloticus* was chosen as the model to investigate seasonal dynamic of parasites, using diversity, abundance, and intensity as indicators. The study is conducted in two reservoirs located in semi-arid areas in West Africa.

MATERIALS AND METHODS

Study area

Two study areas, Loumbila and Ziga reservoirs, were selected for this study. Loumbila reservoir was chosen because it is one of the oldest fisheries of the country. On the other hand, Ziga is one of the recent and developing fisheries. The second reason is that both sites are not so far from Ouagadougou. The Loumbila reservoir (12°29' N 01°24' W) was built in 1947. It is located in the North East of Ouagadougou, at about twenty kilometres. Its capacity is about 42.2 million m^3 in flood and its maximum surface is about 16.80 km². Ziga reservoir (12°37' N and 0°49' W) was built in 2000 and is located in the East of Ouagadougou. It has a capacity of 200 million m^3 and cover an area of 70 km² (AFD, 2015). These reservoirs are located in a Soudano-Sahelien climate type, characterized by one long dry season (October to May) and one rainy season (June to September). Both reservoirs are located at the outskirts of Ouagadougou, the city, capital of Burkina-Faso. Fishing and agriculture activities have developed around these reservoirs since their inception. The reservoir of Loumbila is the most impacted, mainly by activities such as agriculture especially gardening. During the dry season, the bed of this reservoir is used for crops and often more than chemicals are used.

Sample collection

Fish samples were collected monthly from March 2012 to August 2012. *Oreochromis* specimens were randomly selected by us among fisherman catch. Fish were captured using gill nets. All the fishes were transported in icebox to the laboratory for analyses. A total of 254 identified as *O. niloticus* according to Paugy et al. (2004) were sampled and transported to the laboratory.

In the laboratory, sexes of the specimens were determined by checking gonads. Each fish specimen was dissected; their gills as well as the different part of the digestive tract (esophagus, stomach, and intestines) were isolated, kept in different Petri dishes, and screened for parasites. The parasites found were collected, counted and kept in 70% ethanol for later identification.

Parasites species identification

According to the parasite taxa, different protocols were used for species identification. For Acantocephalans and Digeneans, specimens were stained with carmine, dehydrated through a gradient series of ethanol, cleared in clove oil and mounted in Canada balsam. For nematodes, lactophenol was used as the cleaning agent. Myxozoa were fixed and stained with fresh Giemsa stain. Parasites were observed by using a Zeiss microscope.

Data analysis

Data were analyzed under the Statview 5.0.1.0 version SAS Institute Inc. and Xlstat 2015 version.1.02 Addinsoft software. Prevalence, mean intensity, and mean abundance were calculated after Bush et al. (1997).

Proportions test was used to compare the prevalence between season and studies area, and non-parametric tests (Mann-Whitney and Kruskall-Wallis tests) to compare parasites intensity between season and study area. Results were considered significant if its corresponding p-value was less than 0.05 (at the 95% level).

RESULTS

Parasites diversity

Seven ectoparasites and endoparasites species were recovered from *O. niloticus* in Ziga and Loumbila reservoir. Recorded species were distributed among Acanthocephalan (*Acanthogyrus tilapiae*), Trematode (*Clinostomum* species), Monogenean (*Cichlidogyrus tilapiae* and *Cichlidogyrus halli*.), Nematode (*Paracamallanus cyathopharynx*), Copepod (*Lamproglena monodi*), and Myxosporeans (*Myxobolus tilapiae*).

Global prevalence, abundance, and intensity of parasites

Table 1 shows the prevalence, total, and mean abundance and infection intensity for the six groups of parasites found during this study. In total, 254 specimens of *O. niloticus* were examined for the two localities, 55.90% of them were found positive for various parasites.

Table 1. Prevalence, abundance and mean intensity of parasites observed in *O. niloticus*.

Factor	Parasite group	NES	NIS	P%	TA	MA	MI
Groups	Acantocephalan	254	116	45.67	1836	7.23	15.83
	Copepod	254	3	1.18	5	0.02	1.67
	Monogenean	254	1	0.39	68	0.27	68.00
	Myxosporea	254	10	3.94	49	0.19	4.90
	Nematode	254	1	0.39	1	0.00	1.00
	Trematode	254	45	17.72	212	0.83	4.71
Sites	Loumbila	112	73	65.18	1020	9.11	13.97
	Ziga	142	69	48.59	1116	7.86	16.17
All parasites and sites		254	142	55.90	2171	8.54	15.28

NES: Number of examined specimen, NIS: number of infected specimens, P%: prevalence, TA: total abundance, MA: mean abundance, MI: mean intensity.

The global mean abundance was 8.54 parasites per fish specimen examined with mean intensity up to 15.28 parasites per specimen infected. A total of 2171 parasites were identified as helminthes (n=2117), copepods (n=05) and Myxosporean spores (n=49) were collected from fish species. Helminthes are Acanthocephalans, Trematode, Monogenean, and Nematode. The Acanthocephalans, mainly larvae, were the most prevalent group (45.67%) (Figure 1). Among them, *Acanthogyrus* was the most prevalent and most abundant specie in the two localities. The Monogenean and Nematode showed the lowest prevalent. Higher prevalence was also reported for Trematodes (17.72), while the other groups show prevalence under 5%. However, this difference was not significant statistically (p=0.41).

There was little variation of prevalence according to sex (56 and 57%, respectively for male and female), indeed there was no statistical difference between these values (p<0.73). The same pattern was noticed with the mean intensity (mean intensity of male=17.52; female=12.27); the difference was not statistically significant between male and female (p<0.77, Mann Withney U test).

Parasite location

In this study, parasites were found in intestine and on gill of *O. niloticus.* Intestine was infected by two groups of parasite, Acanthocephala and Nematode. Adult Acanthophalans were observed in intestine posterior portion and their larva encysted in anterior intestine wall. Gill parasites were *L. monodi*, *C. tilapiae, C. halli*, *M. tilapiae*, and *Clinostomum* spp. *Clinostomum* spp. was met on gill and after oral cavity towards the pharyngeal region and beneath operculum. Intestine was the more infected organ (with high prevalence). The parasite *L. monodi* is firmly fixed in the gill arch.

Infection pattern between sites

Four species (*L. monodi*, *C. tilapiae*, *C. halli*, and *P. cyathopharynx*) were observed only in Loumbila reservoir; three others which were the most abundant species were common to both reservoirs.

Table 1 also presented the parasitic indices variations between sites. Around 112 fishes were examined for Loumbila reservoir and 142 fishes for Ziga. The nfection prevalence was 65.18% (n=73) in Loumbila and 48.59% (n=69) in Ziga. The analysis showed the infection prevalence was significantly higher in Loumbila reservoir than Ziga reservoir (p=0.008; Proportions test). The difference of intensity was also statically significant between the two localities (p<0.0003, Mann Withney U test). The prevalence, mean abundance, and mean intensity of infection of the species are summarized in Table 2. This table shows that at species level, the prevalence of *A. tilapiae* does not vary between the two reservoirs. But, the prevalence of *Clinostomum* spp. was higher in Loumbila reservoir.

Parasites distribution within season

Four species were found in dry season and six species in rainy season. Indices variations according to season and sites are shown in Table 3. In both reservoir, the prevalence of parasites were higher in rainy season than in dry season (p= 0.0001, proportion test). Prevalence of infection was higher in Loumbila reservoir than Ziga reservoir without regard to season. The prevalence of infection significantly varies also across seasons, with the

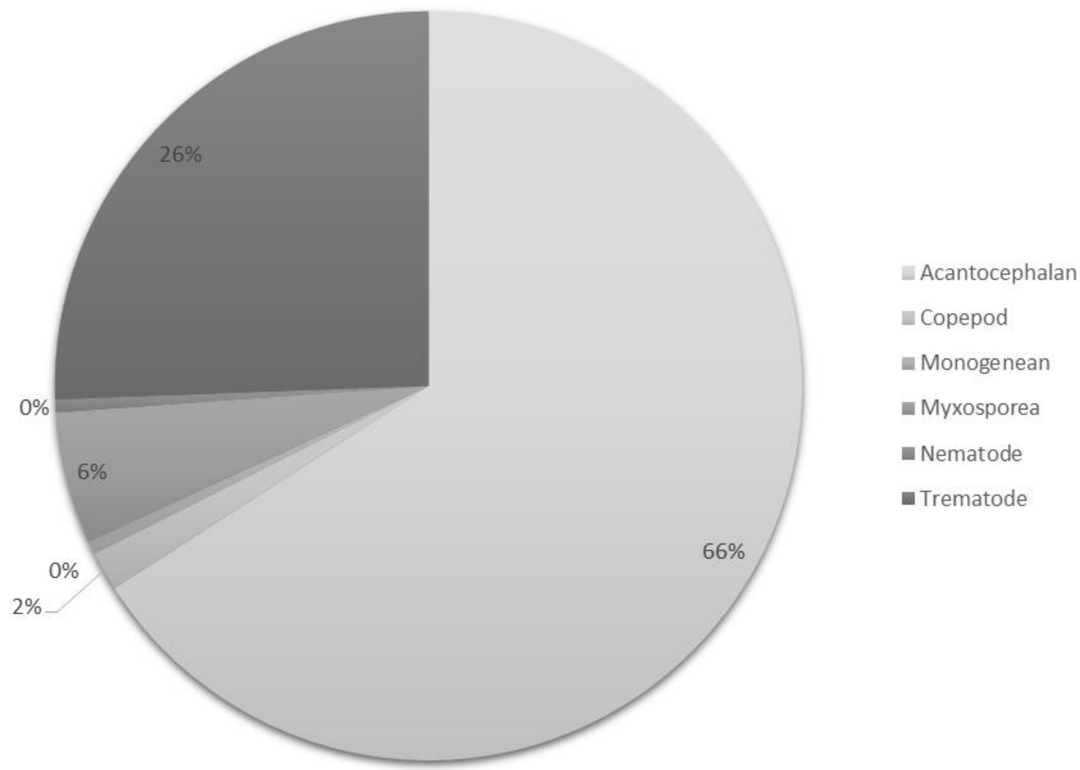

Figure 1. Pie chart presenting percentages of frequency of parasite occurrence.

Table 2. Prevalence, abundance and mean intensity of three species recorded in both localities.

Sites	Species	TA	MA	P%	MI
Ziga	*Acanthogyrus tilapiae*	1076	4.24	45.77	16.55
	Clinostomum spp.	37	0.15	5.63	4.63
	Myxobolus tilapiae	42	0.17	4.93	6.00
Loumbila	*Acanthogyrus tilapiae*	760	2.99	45.54	14.90
	Clinostomum spp.	175	0.69	33.04	4.73
	Myxobolus tilapia	7	0.03	2.68	2.33
	Cichlidogyrus monodi	5	0.02	1,18	1,67
	Cichlidogyrus tilapiae	23	0.09	0,39	23
	Cichlidogyrus halli	45	0.18	0,39	45
	Paracamallanus cyathopharynx	1	0.00	0,39	1

P%: Prevalence, TA: total abundance, MA: mean abundance, MI: mean intensity.

highest infection prevalence being observed in rainy season. The number of parasites was higher in rainy season than in dry season (p< 0.0001, Mann Whitney test,).

Concerning the seasonal dynamics in the examined *O. niloticus,* Table 4 revealed that the highest seasonal prevalence of parasite species was recorded in rainy season. The peak of seasonal dynamic of *A. tilapiae* in total examined *O. niloticus* was observed in rainy season. All examined fish in rainy season was infected with *A. tilapiae*. Figure 2 shows the parasitic indices of *O. niloticus* by month in the two reservoirs; months of rainy (June, July, August) record the higher indices. The month of July harbored higher prevalence, higher mean intensity and abundance. The lower prevalence was observed in month of April and the average lower intensity and abundance in March. Nonparametric test of Kruskall Wallis showed a difference of number of parasites

Table 3. Prevalence, mean abundance and intensity of parasite according to season in the two localities.

Season	Localities	NES	NIS	P%	TA	MA	MI
Rainy	Loumbila	55	46	83.64	699	12.71	15.19
	Ziga	40	30	75	785	19.62	26.17
Total rainy	-	95	76	80	1484	15.62	19.53
Dry	Loumbila	57	27	47.37	321	5.63	11.89
	Ziga	102	39	38.23	331	3.24	8.49
Total dry	-	159	66	41.51	652	4.10	9.88
General total	-	254	142	55.90	2136	8.41	15.04

NES: Number of examined specimen, NIS: number of infected specimens, P%: prevalence, TA: total abundance, MA: mean abundance, MI: mean intensity.

Table 4. Seasonal dynamics of different parasite species among examined *O. niloticus.*

Season	Parasite species	NES	NIS	TA	MA	MI	P (%)
Rainy	*Acanthogyrus tilapiae*	95	95	1563	16.45	16.45	100.00
	Clinostomum spp.	95	36	183	1.93	5.08	37.89
	*Cichlidogyru*s *monodi*	95	3	5	0.05	1.67	3.16
	Cichlidogyrus tilapiae	95	1	23	0.24	23.00	1.05
	*Cichlidogyru*s *halli*	95	1	45	0.47	45.00	1.05
	Myxobolus tilapiae	95	7	40	0.42	5.71	7.37
Dry	*Acanthogyrus tilapiae*	159	20	273	1.72	13.65	12.58
	Clinostomum spp.	159	9	29	0.18	3.22	5.66
	Myxobolus tilapia	159	3	9	0.06	3.00	1.89
	Paracamallanus cyathopharynx	159	1	1	0.01	1.00	0.63

NES: Number of examined specimen, NIS: number of infected specimens, P%: prevalence, TA: total abundance, MA: mean abundance, MI: mean intensity.

between months ($h = 14.84$, $p < 0.011$).

DISCUSSION

Parasites recorded in *O. niloticus* from Ziga and Loumbila reservoirs were dominated by acanthocephalan. The site of acanthocephalan infection was restricted to the fish intestine. 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). Hence, the preference of Acanthocephalans for intestinal region as site of attachment could be attributed to food availability in this region. Acanthocephalans do not have a gut. Nutrients from the lumen of the host gut are absorbed across the body wall of the parasites. Amin et al. (2008) reported that test results suggest that *A. tilapiae* was better adapted to some cichlid hosts than to others. Sanil et al. (2010) reported a heavy infection with Acanthophalan (*Tenuiproboscis* species) in posterior intestine of *Lutjunus argentimaculatus* in Southern India.

Clinostomum spp. larvae are the second dominated parasites species of *O. niloticus* observed in this study. It was observed beneath operculum, in pharyngeal region and on gill. This result is similar to those of Aloo (2002) and Ochieng et al. (2012) who observed *Clinostomum* spp. below the operculum and in the pharyngeal region in *Oreochromis leucostictus* in Lake Naivasha. *O. niloticus* is more receptive for larva of *Clinostomum* (Coulibaly, 1995). Digeneans (*Clinostomum* spp.) have complex life cycles involving 3 hosts: snail, fish or amphibian, and bird (Bonett et al., 2011). Snail is considered as first intermediate host, with fish acting as second intermediate host and aquatic birds as definitive host. *O. niloticus* feeds mainly on benthic materials, including detritus, by picking up larval stages of parasites. Maguza-Tembo and Mfitilodze (2008) reported that *Oreochromis shiranus* was susceptible to harbor trematodes (*Clinostomum*). The

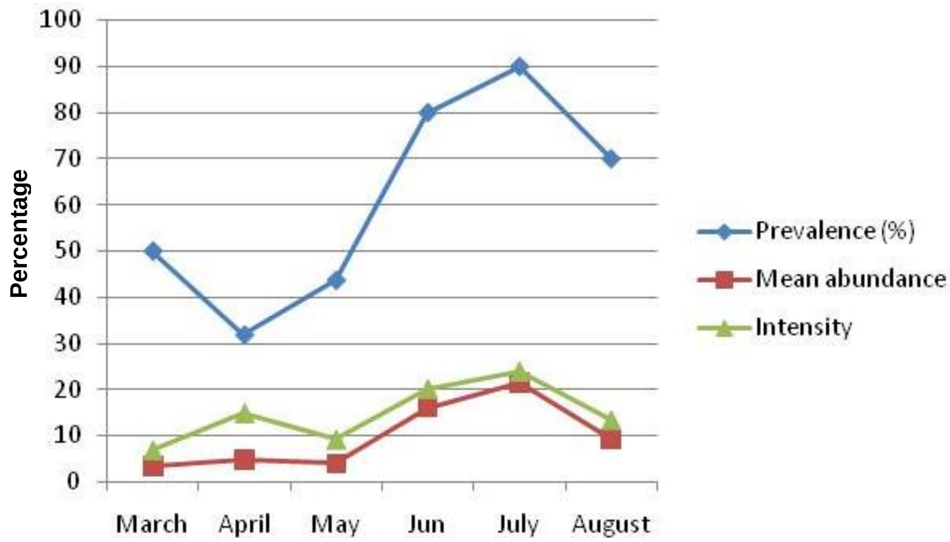

Figure 2. Prevalence, mean abundance and mean intensity of the parasites in *O. niloticus* in the two sites per month.

metacercariae of *Clinostomum* in the specimens of fish host suggested the presence of snails in the sites of study which are the first intermediate hosts of parasites (*Clinostomum*). The metacercariae of *Clinostomum* is known to damage the muscles of fish, making it degusting and unsalable (Coulibaly, 1995).

M. tilapiae was the myxosporean species recovered on gill in *O. niloticus* in this study. Most infections by Myxozoa in fish create minimal problems, but heavy infestations can be more prevalent, especially in young fish (Klinger and Francis-Floyd, 2013).

Gill parasites (*L. monodi*, *C. tilapiae*, and *C. halli*) were recorded in low prevalence. *L. monodi* was found in *O. niloticus* in three sites (Bazèga, Bagré, and Loumbila) in Burkina Faso with prevalence 3.60% (Boungou et al., 2013). *L. monodi* was fixed deeply in the gill arch. It could create damage in gill tissue.

Nematodes *P. cyathopharynx* was recorded with prevalence 0.39% in fish intestine. Eissa et al. (2011) recorded in Egypt *P. cyathopharynx* and *Procamallanus laeviconchus* in stomach of *O. niloticus*. Moyo et al. (2009) found *P. cyathopharynx* (prevalence = 11.1%) in *O. mosambicus* in Zimbabwe. *P. cyathopharynx* was recorded and described in Burkina Faso for first time by Kabré (1997) in Siluriform fish. The prevalence of *P. cyathopharynx* was low for *O. niloticus* (0.39%), which could be a post cyclic or accidental host.

Analysis of the results shows that the prevalence is higher in the reservoir of Loumbila. This could be due to difference in intensity and numbers of human impact in the two reservoirs. The reservoir of Loumbila is an old reservoir (established since 1947) when compared with the reservoir of Ziga (created in 2000). In addition, this reservoir faced more and longtime impact from human activities, including: silting, accumulation of chemical product from agriculture (over time) and eutrophication which promotes the proliferation of algae and the intermediate hosts. Therefore, the proliferation of intermediate hosts may increase the chance of contamination.

The results showed that male fish recorded higher mean abundance and intensity of parasites than female fish, although both sex have the same chance to be infected (no significant difference of prevalence and intensity between the sex). Most researchers have reported that male fish are usually more infected than female (Aloo, 2002; Idris et al., 2013) and these same researchers observed a higher incidence of parasites in males than in females. That could be due to certain ecological factors emanating probably from feeding differences between the males and females. Males are always in movement, but females are in egg-laying period, keeping eggs in their mouths and feeding less during that period. Male eat more and accumulate parasite in their organism.

The higher prevalence, abundance and intensity of parasites in July and June could be explained by the season. It means that in July, the rainy season is well established and food is available for fish. This period also corresponds to the period of reproduction and proliferation of intermediate hosts. The increase of intermediate hosts could explain the increased rate of infection in the rainy season observed in the results during this period. This result confirms the result of Usip et al. (2010) in Nigeria, who had reported that during the rainy season, most species of cichlids had a high level rate of infection. *A. tilapiae* appear to be recruited in the summer (Amin et al., 2008). The high number of parasites species in rainy season could be explained by the presence of their intermediates hosts in this season.

Conflict of Interests

The authors have not declared any conflict of interests.

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