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Parasitofauna of Blackchin tilapia *Sarotherodon melanotheron* (Teleostei: Cichlidae) from Ebrie Lagoon, Côte d'Ivoire

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Abstract

In this study the ecto and endoparasites infecting *Sarotherodon melanotheron* were investigated in Ebrie Lagoon between February 2019 and November 2019. A total of 108 randomly sampled *Sarotherodon melanotheron* was procured from fishermen and examined for parasites using standard parasitological methods. The parasites such as Monogenean *Cichlidogyrus halinus*, *C. halli*, *C. acerbus* and *Scutogyrus minus*, Myxosporea (*Myxobolus beninensis*, *M. diamensis*, *M. nokouensis* and *M. sarotherodoni*), Copepod (*Ergasilus latus* and *E. sp.*), Acanthocephalan (*Acanthogyrus tilapiae*), Nematode (*Eustrongylides* sp) and the Trematoda (*Clinostomum tilapiae* and *Euclinostomum heterostomum*) were recorded. Gill and intestine were respectively the more and the least infected organ by parasites. The intensity of Monogenean, Copepod and Acanthocephalan were positively increased with host body size. In Contrast, the intensity of Myxosporean, Nematode and Trematode did not increase with host standard length. Monogenean and Copepod were more concentrated in male hosts and Myxosporean in female fish. However, no influence of host sex on parasitism level was observed for population of Acanthocephalan, Nematode and Trematode. This could enable the use of appropriate methods to fight against these pathogens, especially in intensive fish farming.

Keywords: Parasites, *Sarotherodon melanotheron*, Ebrie Lagoon, Côte d'Ivoire

1. Introduction

The blackchin tilapia, *Sarotherodon melanotheron* belonging to the family Cichlidae is the most popular fish food which considered to be one of the most important fish for aquaculture (Ouattara *et al.*, 2005) [34]. This fish species hold great promise in fish farming in Africa due to its wide geographical spread, high growth rate and it resistant to stress (Amoussou *et al.*, 2016) [7]. It's very common in swamps lakes, rivers and lagoon in Côte d'Ivoire and it's the main fish fisherman catches (Adou *et al.*, 2017a) [1]. It is well appreciated, highly priced and requested for by both fish farmers. Like other animals, fishes suffer from parasites and diseases, it's the case of *Sarotherodon melanotheron*.

Parasites are an essential part of each aquatic community (Klimpel *et al.*, 2003) [30]. Parasitism is much more common and diversified in the wild culture than in the farms, ponds, and hatcheries (Goselle *et al.*, 2008) [28]. However, the onset of disease conditions due to parasites has become a major constraint in aquaculture (Akoll *et al.*, 2012) [5]. According to Scholz (1999) [44], parasites causing little apparent damages in fish populations may become causative agents of diseases of great importance in farmed fish and lead to significant health effects. Pathogens that affect teleost fish are reported to be responsible for mortalities, reduced growth and reproduction, reduction of the market value, and significant losses in aquaculture industries (Sakiti *et al.*, 1999; Gbankoto *et al.*, 2003; Costello, 2009) [43, 26, 21].

In Côte d'Ivoire, very little attention has been paid to the parasitic infection in *Sarotherodon melanotheron*. To the best of our knowledge, there has only been two ichthyoparasitological studies (Blahoua *et al.*, 2009; Adou *et al.*, 2017b) [11, 2] in this fish species. These data focused on gill monogenean parasites. Scarcity of information on pathogenic agents hampers the development of ecologically sustainable strategies for disease control (Bondad-Reantaso *et al.*, 2005) [16]. Also, the study area, Ebrie lagoon at Dabou, is influenced by the human activities ("Acadja enclos", washing, bathing, agriculture) that alter the aquatic environment, promote

the proliferation of pathogens and cause diseases to fish and eventually leading to their mortalities. On this view, the aim of this study is provide information on the types and relative abundance of several parasitic species found in *S. melanotheron* from Ebrié lagoon in order to prevent the devastating infestations.

2. Materials and Methods

2.1 Description of study site

The Ebrié Lagoon has an area of 566 km² and stretches on 125 km along the coast of Côte d'Ivoire, between latitudes 5° 10' N - 5° 50' N and longitudes 3° 40' W - 4° 50' W (Dufour, 1982; Tuo *et al.*, 2012) [22, 46]. It communicates with the Atlantic Ocean by the Vridi channel, drilled in 1951, for the building of Abidjan Port, the most important in West Africa. Ebrié Lagoon waters are simultaneously diluted with marine

waters during dry seasons and with freshwaters during the rainy and flood seasons. Its 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). This lagoon is divided into different zones (Sector I to sector VI).

The study area is sector IV of the Ebrié lagoon (Figure 1). It's located between latitudes 05° 16' N - 05° 21' N and longitudes 4 ° 14' W - 4 ° 23' W in the city of Dabou. With a catchment area of 107 km², this central region of the Ebrié lagoon is influenced by the Atlantic ocean and by the human activities ("Acadja enclos", fishing, washing, bathing). Also, it's the most impacted, mainly by activities such as agriculture especially gardening. In fact, this lagoon is located near several plantations, including those belonging to local residents.

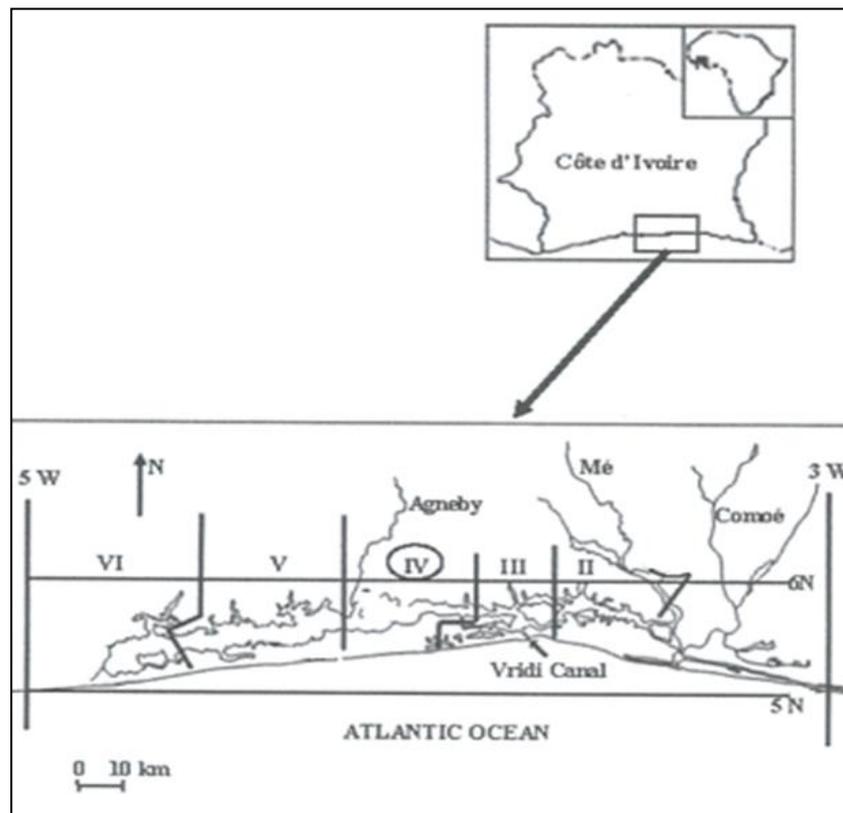


Fig 1: Geographical location of sector IV of Ebrié Lagoon, Côte d'Ivoire.

2.2 Fish collection, identification, morphometry and sex determination

The fish species were collected between February 2019 and November 2019. *Sarotherodon specimens* were randomly selected by us among fisherman catch. Fishes were caught by the fishermen using gill nets which was set in the evening and retrieved the following morning. All the fishes were transported in icebox to the laboratory for analyses. A total of 108 identified as *S. melanotheron* according to Teugles and Thys van den Audernaerde (2003) [45] were sampled and transported to the laboratory.

In the laboratory, the standard length measurements were taken using a calibrated dissecting board. The sexes of the fishes were determined by either the presence or absence of an intromittent organ on the ventral side just before the anal fin which as confirmed later by the presence of testes or ovaries during dissection. The fish sample were divided into three different length classes, which are: class I (SL ≤ 185)

class II (185 < SL ≤ 214) and class III (SL > 214).

2.3 Parasitological analysis

Each fish specimen was dissected, their gills and the alimentary canals were removed and cut into parts in physiological saline for parasite recovery. The esophagus, stomach and intestine were separated and kept in different petri-dishes containing saline solution. The contents of these organs were washed in different petri-dishes for sedimentation and floatation and then examined. Parasites found were transferred into another petri-dish containing normal saline and examined. Parasites species and location in the host species were recorded. According to the parasite taxa, different protocols were used for species identification. For Monogeneans, individual worms were collected and mounted on a slide in a on a slide in a drop of ammonium picrateglycerine mixture. Trematode, Cestode, Copepod and Nematode were fixed in hot alcohol-formal-acetate (AFA)

and preserved in 70% ethyl alcohol (Khalil, 1971) [29]. The acanthocephalans were placed in a refrigerator overnight in Petri dishes containing 0.1% sodium chloride solution and then preserved in 70% ethyl alcohol (Marcogliese, 2011) [31]. Parasites were mounted in Canada balsam. Myxozoa were fixed and stained with fresh Giemsa stain. Parasites were observed by using a Zeiss microscope. Identification of parasites was done using standard text by Robert (1978, 1995, 2000) [38, 39, 40], Paperna (1996) [35] and Pariselle and Euzet (2009) [36].

2.4 Data analysis

The data of prevalence (proportion of the infected population), mean intensity (mean number of parasites of infected hosts) and abundance (mean number of parasites of examined host) for all parasites joined were calculated as suggested by Bush *et al.* (1997) [18]. The distribution of parasites species was analyzed by nonparametric statistics tests, Kruskal Wallis ANOVA test, and followed by Mann-Whitney U tests to determine the parasite population differences between host size classes and sex. The Kruskal Wallis (K) test was to compare the intensities of more than two samples.

The Mann-Whitney (U) test was used to compare the intensity of infection of two different samples. The Chi square (X^2) test was used to compare two or more proportions. Differences of $p < 0.05$ were considered significant. Statistica 7.1. and Microsoft Excel software were used for the analysis of various data.

3. Results

3.1 Parasitic fauna

Total of 14 parasites species belonging to 6 parasitic classes were isolated from the gills, intestines and the pharyngeal region of *Sarotherodon melanotheron*. There were Monogenean (*Cichlidogyrus halinus*, *C. halli*, *C. acerbus* and *Scutogyrus minus*), Myxosporean (*Myxobolus beninensis*, *M. diamensis*, *M. nokouensis* and *M. sarotherodoni*), Copepod (*Ergasilus latus* and *E. sp.*), Acanthocephalan (*Acanthogyrus tilapiae*), Nematode (*Eustrongylides sp.*) and Trematode (*Clinostomum tilapiae* and *Euclinostomum heterostomum*).

3.2 Global prevalence, abundance, and intensity of parasites

The prevalence, mean intensity and abundance of various parasites in *S. melanotheron* were observed in Table 1. The number of infected fish of Monogenean ranged from 52,77-90,74%. The mean intensity and abundance varied $2,24 \pm 0,02$ - $7,18 \pm 0,1$ and 1,18 to 6,52 respectively. The Monogenean, *Cichlidogyrus halinus* was the most prevalent (90,74 %), mean intensity ($7,18 \pm 0,1$) and abundance (6,52). For Myxosporean, the highest prevalence (31,48%), mean intensity ($1,05 \pm 0,01$) and abundance (0,29) were recorded for *Myxobolus sarotherodoni*. Higher prevalence (50%), mean intensity ($1,44 \pm 0,1$) and abundance (0,72) of Copepod were obtained by the *Ergasilus sp.* *Euclinostomum heterostomum* was the most prevalent (1,85%), mean intensity ($1,5 \pm 0,03$) and abundance (0,02) for the Trematode. The Monogenean and Myxosporean were the most abundant species.

Table 1: Prevalence, Mean intensity and abundance of parasite species of *Sarotherodon melanotheron* sampled in Ebrie lagoon.

Taxa	Parasites species	Fishes Examined Infected		Prevalence (%)	Mean intensity \pm SE	Abundance
Monogenean	<i>Cichlidogyrus halinus</i>	108	98	90.74	7.18 ± 0.1	6.52
	<i>Cichlidogyrus halli</i>	108	81	75	6.43 ± 0.2	4.96
	<i>Cichlidogyrus Acerbus</i>	108	57	52.77	2.24 ± 0.02	1.18
	<i>Scutogyrus minus</i>	108	62	57.41	3.26 ± 0.02	1.87
Myxosporean	<i>Myxobolus beninensis</i>	108	28	25.92	1.1 ± 0.002	0.18
	<i>Myxobolus diamensis</i>	108	21	19.44	1.14 ± 0.01	0.22
	<i>Myxobolus nokouensis</i>	108	18	16.66	1.1 ± 0.001	0.18
	<i>Myxobolus sarotherodoni</i>	108	34	31.48	1.05 ± 0.01	0.29
Copepod	<i>Ergasilus lotus</i>	108	48	44.44	1.1 ± 0.1	0.49
	<i>Ergasilus sp.</i>	108	54	50	1.44 ± 0.1	0.72
Acanthocephalan	<i>Acanthogyrus tilapiae</i>	108	12	11.11	2.16 ± 0.03	0.24
Nematode	<i>Eustrongylides sp.</i>	108	18	16.66	1.22 ± 0.02	0.2
Trematode	<i>Clinostomum tilapiae</i>	108	7	6.48	1.57 ± 0.01	0.1
	<i>Euclinostomum heterostomum</i>	108	2	1.85	1.5 ± 0.03	0.02

3.3 Occurrence of parasite species according to length classes of the host fish

The population of Monogenean, Myxosporean, Copepod and Trematode infested individuals of all any of length class (Table 2). For each group, the minimum prevalence, mean intensity and abundance were observed in the smallest length class (standard length < 180 mm) and the maximum in the largest individuals (standard length ≥ 215 mm). The prevalence of Monogenean varied from 75% to 100%, the mean intensity ranged from 4.77 ± 0.02 parasites/fish to 26.36 ± 0.73 parasites/fish and the abundance ranged 3.58 to 26.36 parasites/fish. Statistically, difference was highlighted between prevalence of the all size classes ($X^2 = 11.86$, $df = 3$, $p = 0.003 < 0.05$). There was a significant difference in the number of this species between size classes of fish (Kruskal Wallis $K = 7.62$, $p = 0.00 < 0.05$). The intensity of infection of this parasite group increased significantly from one size

class to another (Mann-Whitney U test, $p < 0.05$). For Myxosporean the lowest prevalence was 16.66% and the highest was 50%. There was a significant difference between the rates of infestation ($X^2 = 67.8$, $df = 3$, $p = 0.00 < 0.05$). The intensity of infection varied 3.11 ± 0.3 to 3.36 ± 0.2 and the abundance 0.58 to 1.52. Statistically difference was not recorded between the intensity of infection of these parasites according to size classes (Kruskal Wallis $K = 8.12$, $p = 0.00 < 0.05$; Mann-Whitney U test, $p < 0.05$). The prevalence of Copepod varied from 33.33% to 63.15%, the mean intensity ranged from 1.05 ± 0.01 parasites/fish to 3.08 ± 0.02 parasites/fish and the abundance ranged 0.5 to 1.94 parasites/fish. A significant difference in prevalence and mean intensity according to size group was observed ($X^2 = 20.54$, $df = 3$, $p = 0.001 < 0.05$). The statistical analyse revealed that there was a significant difference in the intensity of infection among three size classes (Kruskal Wallis $K = 6.43$, $p = 0.00 <$

0.05; Mann-Whitney U test, $p < 0.05$). The highest prevalence 24% of Copepod was observed in the fish of the classes with the standard length ≥ 215 mm. Statistical tests showed significant difference in prevalence according to the size classes ($X^2 = 92.36$, $df = 3$, $p < 0.05$). The mean intensity and abundance were lower for in the size class with a standard length of < 180 mm respectively 1.5 ± 0.01 and 0.5 and higher (3.08 ± 0.02 and 1.94) for the class with the standard length ≥ 215 mm Globally, there was also a significant difference from one size class to another (Kruskal Wallis $K = 7.64$ and 7.08 ; $p = 0.00 < 0.05$; Mann-Whitney U test, $p < 0.05$). For the Acanthocephalan, the lowest prevalence was 8.33% and the highest was 14.7%. The Chi-square (X^2)

indicated that the prevalence of these parasites depends on the size of the host ($X^2 = 51.33$, $df = 3$, $p < 0.05$). The mean intensity ranged from 1.06 ± 0.01 parasites/fish to 3 ± 0.003 parasites/fish and the abundance ranged 0.16 to 0.31 parasites/fish. The difference was statistically significant between the size class (Kruskal Wallis $K = 6.09$ and 8.03 ; $p = 0.00 < 0.05$; Mann-Whitney U test, $p < 0.05$). The prevalence of Nematoda varied 14.7% to 19.44%. The mean intensity and abundance ranged from 1.14 ± 0.01 to 1.4 ± 0.01 and 0.18 to 0.22 . There was no significant difference between the prevalence, mean intensity and abundance and host size class ($X^2 = 32.28$, $df = 3$, $p > 0.05$; Kruskal Wallis $K = 9.02$ and 9.47 ; $p = 0.1 > 0.05$; Mann-Whitney U test, $p > 0.05$).

Table 2: Prevalence (%), mean intensity and abundance of parasites of *Sarotherodon melanotheron* according to the size of the host.

Host length Classe (mm)	No. examined	No. Infected	Prevalence (%)	Mean intensity \pm SE	Abundance
Monogenean					
< 180	36	27	75	4.77 ± 0.02	3.58
185-214	34	33	97.05	12.84 ± 0.6	12.47
>215	38	38	100	26.36 ± 0.73	26.36
Myxosporean					
< 180	36	6	16.66	3.16 ± 0.1	0.58
185-214	34	9	26.47	3.11 ± 0.3	0.94
>215	38	19	50	3.36 ± 0.2	1.52
Copepod					
< 180	36	12	33.33	1.5 ± 0.01	0.5
185-214	34	18	52.94	2.16 ± 0.1	1.14
>215	38	24	63.15	3.08 ± 0.02	1.94
Acanthocephalan					
< 180	36	3	8.33	2 ± 0.002	0.16
185-214	34	5	14.7	1.6 ± 0.01	0.24
>215	38	4	10.52	3 ± 0.003	0.31
Nematode					
< 180	36	7	19.44	1.14 ± 0.01	0.72
185-214	34	5	14.7	1.4 ± 0.01	0.2
> 215	38	6	15.78	1.14 ± 0.01	0.18
Trematode					
< 180	36	1	2.77	3 ± 0.02	0.08
185-214	34		5.88	2.5 ± 0.01	0.14
> /15	38	4	10.52	1.5 ± 0.02	0.16

3.4 Occurrence of parasite species on fish hosts in relation to host sex

Infection rates of parasitic were observed for different sexes to study the effect of sex on infection (Table 3). The rate of infestation by Monogenean was 86.53% for female fish and 94.64% for male fish. The Chi-square test (X^2) applied at the occurrence of this parasite showed that these values were not statistically significant ($X^2 = 0.06$, $df = 1$, $p = 0.4 > 0.05$). Mean intensity and abundance of infestation were 10.2 ± 0.2 and 8.83 respectively for female and 20.67 ± 0.1 and 19.57 for male. The difference between host sex was statistically significant (Mann-Whitney $p < 0.05$) (Table 3). For Myxosporean, prevalence, mean intensity and abundance values were 30.76%, 4.5 ± 1 and 1.38 for female and 32.14%, 2.16 ± 0.1 and 0.69 for male fish respectively. Differences were not significant between the male and female ($X^2 = 1.12$, $df = 1$, $p = 0.1 > 0.05$). However, Mann-Whitney U test analysis showed that the females were more parasitized than males ($p < 0.05$) (Table 3). The population of Copepod were present in 53.84% of female host and 46.42% male host. These values were not statistically significant ($X^2 = 0.02$, $df = 1$, $p = 0.9 > 0.05$). The values of mean intensity and abundance were higher in male (3.2 ± 0.2 and 1.5) than

female (1.67 ± 0.02 and 0.9) respectively. Host sex affects significantly the infection (Mann-Whitney U test, $p < 0.05$). Prevalence of Acanthocephalan was 9.61% in female and 12.5% in male host (Table 3). The mean intensity and abundance were 2 ± 0.01 and 0.9 parasites/fish respectively in female and 2.28 ± 0.03 and 0.29 parasites/fish in male. No significant differences were noted among abundance values based on host sex ($X^2 = 3.9$, $df = 1$, $p = 0.07 > 0.05$; Mann-Whitney U test, $p > 0.05$). The number of infected fish of Nematode was 15.38% with a mean intensity and abundance of 1 ± 0.002 and 0.15 respectively for female and 17.85% with a mean intensity and abundance of 1.4 ± 0.004 and 1.4 for male host. The prevalence and the intensity of infestation were not significantly different ($X^2 = 2.31$ and 1.98 , $df = 1$, $p = 0.25$ and $0.1 > 0.05$; Mann-Whitney U test, $p > 0.05$). The population of Trematode were present in 3.84% of female host and 9.82% male host. Statistical tests showed significant difference in rates of infestation between host sex ($X^2 = 0.37$, $df = 1$, $p = 0.4 > 0.05$). The mean intensities and abundance of infestation were 2 ± 0.001 and 0.11 in the female and 1.6 ± 0.01 in the male. These value were not significantly different (Mann-Whitney U test, $p > 0.05$).

Table 3: Prevalence (%), mean intensity and abundance of parasites of *Sarotherodon melanotheron* according to the sex of the host.

Sex of fish	No. examined	No. infected	Prevalence (%)	Mean Intensity \pm SE	Abundance
Monogenean					
Females	52	45	86.53	10.2 \pm 0.4	8.83
Males	56	53	94.64	70.67 \pm 2	19.57
Myxosporean					
Females	52	16	30.76	4.5 \pm 1	1.38
Males	56	18	32.14	2.16 \pm 0.1	0.69
Copepod					
Females	52	28	53.84	1.67 \pm 0.02	0.9
Males	56	26	46.42	3.2 \pm 0.2	1.5
Acanthocephalan					
Females	52	5	9.61	2 \pm 0.01	0.19
Males	56	7	12.5	2.28 \pm 0.03	0.29
Nematode					
Females	57	8	15.38	1 \pm 0.002	0.15
Males	56	10	17.85	1.4 \pm 0.004	1.4
Trematode					
Females	52	2	3.4	2 \pm 0.001	0.11
Males	56	5	9.82	1.6 \pm 0.01	0.14

3.5 Microhabitats in host fish

Three fish organs (gills, intestine and pharyngeal region) of *Sarotherodon melanotheron* were infected by the parasites recolted in this study (Table 4). Gill was infected by three groups of parasite, Monogenean represented by *Cichlidogyrus halinus*, *C. halli*, *C. acerbus* and *Scutogyrus minus*, Myxosporean by *Myxobolus beninensis*, *M. diamensis*, *M.*

nokouensis and *M. sarotherodoni* and Copepod represented by *Ergasilus latus* and *E. sp.* The intestine was found to be harbouring one Acanthocephalan (*Acanthogyrus tilapiae*) and one Nematode (*Eustrongylides sp.*). The Trematode *Clinostomum tilapiae* and *Euclinostomum heterostomum* were observed in Pharyngeal region. Gill was the more infected organ (with high prevalence).

Table 4: Microhabitats of parasites in *Sarotherodon melanotheron* sampled in Ebrie lagoon.

Taxa	Species	Microhabitats in host fish
Monogenean	<i>Cichlidogyrus halinus</i>	Gill
	<i>Cichlidogyrus halli</i>	Gill
	<i>Cichlidogyrus Acerbus</i>	Gill
	<i>Scutogyrus minus</i>	Gill
Myxosporean	<i>Myxobolus beninensis</i>	Gill
	<i>Myxobolus diamensis</i>	Gill
	<i>Myxobolus nokouensis</i>	Gill
	<i>Myxobolus sarotherodoni</i>	Gill
Copepod	<i>Ergasilus latus</i>	Gill
	<i>Ergasilus sp</i>	Gill
Acanthocephalan	<i>Acanthogyrus tilapiae</i>	Intestine
Nematode	<i>Eustrongylides sp</i>	Intestine
Trematode	<i>Clinostomum tilapiae</i>	Phayngeal region
	<i>Euclinostomum heterostomum</i>	Phayngeal region

4. Discussion

Parasites recorded in *Sarotherodon melanotheron* from Ebrie lagoon were dominated by Monogenean. The site of Monogenean infection was restricted to the fish gill. Acanthocephalan and Nematode were also recovered in the gill. Many authors have also reported the high infection of gill (Sakiti *et al.* 1999; Akoll *et al.*, 2012; Fonkwa *et al.*, 2018) [43, 5, 25]. Blahoua *et al.* (2020) [15] made the same observation with Monogenean parasites of *Oreochromis niloticus* from man-made lake Ayamé 1. Monogenean for gill region as site of attachment could be explained by the fact that Monogenea have a direct life cycle requiring no intermediate host (Roberts and Janovy, 1996) [41], and for the propagation, it is sufficient if only a few host specimens become heavily parasitized (Balling and Pfeiffer, 1997) [8]. The high infection rate found on the gill could be a result of the continuous movement of water current over the gill which may include survival of parasite there.

The Acanthocephalan *Acanthogyrus tilapiae* and Nematoda

Eustrongylides sp. were the parasites observed in the fish intestine. This is similar to those of Amin *et al.* (2008) [6] who had mentioned that *A. tilapiae* was restricted to the fish intestine. Blahoua *et al.* (2020) [15] reported an infection with *A. tilapiae* and *Eustrongylides sp.* in the *Oreochromis niloticus* intestine. Some factors such as differences in physical environment in the gut, availability, nature, and amount of food supply were most likely limit the distribution of parasites in different sections of alimentary tract (Nkwengulila and Mwita, 2004) [32]. Hence, the preference of *A. tilapiae* (Acanthocephalans) and *Eustrongylides sp.* (Nematode) for intestinal region as site of attachment could be attributed to food availability in this region. Indeed, Acanthocephalans do not have a gut, nutrients from the lumen of the host gut are absorbed across the body wall of the parasites. Our results also suggest that these parasite species were better adapted to this fish intestine. In this study, *Clinostomum tilapiae* and *Euclinostomum heterostomum* were the trematodes species recovered in phayngeal region.

This result is similar to those of Ochieng *et al.* (2012) [33] and Bekele and Hussien (2015) [9] who observed *Clinostomum spp.* below the operculum and in the pharyngeal region in *Oreochromis leucostictus* in Lake Naivasha and *O. niloticus* in Lake Ziway. The report of *Clinostomum spp.* from these studies confirms the assertion of Gebreegziabher and Tsegay (2017) [27] who said that *Clinostomum spp.* are among the major trematode species found affecting Cichlidae fish. It has known that Digeneans (*Clinostomum spp.*) have complex life cycles involving 3 hosts: snail, fish or amphibian, and bird (Bonett *et al.*, 2011) [17]. Snail is considered as first intermediate host, with fish acting as second intermediate host and aquatic birds as definitive host. When the fish species *Oreochromis niloticus* feeds mainly on benthic materials, including detritus, by picking up larval stages of parasites, it was susceptible to harbor trematodes (*Clinostomum*). The metacercariae of *Clinostomum* in the specimens of fish host suggested the presence of snails in the study area which are the first intermediate hosts of parasites (*Clinostomum*). These parasites are known to damage the muscles of fish making it disgusting and unmarketable (Coulibaly *et al.*, 1995) [20].

The level of infection by Monogenean, Copepode and Acanthocephalan increased with the standard length of the fish. The larger fish were more infected. Several authors have found a positive relationship between parasitic load and host body size (Biu *et al.*, 2014; Blahoua *et al.* 2015, 2016 and 2018; Adou *et al.*, 2017 c and d) [10, 12, 13, 14, 3, 4]. The increase of parasitism with the host size could be explained by the increase in organs surface area with body length (Cable *et al.*, 2002) [19]. According to these authors, larger-sized fish provide a larger gill and intestine surface area that can hence accommodate greater numbers of parasites. Our result agrees with the findings of Poulin (2000) [37] who stated that larger fish have more internal and external space for parasite establishment and therefore tend to have heavier infestations. In this study, males fish were more parasitized by the Monogenean and Copepod parasites and the females fish by Myxosporean. Various authors have found the same results. This is the case of the Emere (2000) [23] with *Lates niloticus* and Emere and Egbe (2006) [24] with *Clarias gariepinus*. This could be attributed to differential feeding pattern which could be in terms of quality and quantity. It could also be attributed to differences in the degree of resistance to infection. 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. Conversely, no influence of host sex on parasitism level were observed for population of Acanthocephalan, Nematode and Trematode. Our results are in parallel with the idea by that very few parasites species have a preference in relation to the host sex mentioned by Rohde (1993) [42].

5. Conclusion

The study of the distribution of parasites has identified the most vulnerable hosts. Such information allows envisaging some protocols for monitoring parasitic infection in intensive fish farming. In hatcheries, much care should be given to fry and young fish since they have not yet developed robust immunological processes that enable them to effectively fight against polyparasitism.

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7. References

1. Adou YE, Blahoua KG, Bamba M, Yao SS, Kouamelan EP, N'Douba V. Premières données sur l'inventaire du peuplement ichtyologique d'un lac ouest Africain situé entre deux barrages hydroélectriques: Lac d'Ayamé 2 (Côte d'Ivoire). *J. Appl. Biosci* 2017a;110:10808-10808.
2. Adou YE, Blahoua KG, Yao SS, N'Douba V. Spatial distribution of two gill monogenean species from *Sarotherodon melanotheron* (Cichlidae) in man-made Lake Ayamé 2, Côte d'Ivoire. *J. Biodivers. Environ. Sci* 2017b;10(2):35-44.
3. Adou YE, Blahoua KG, Etilé NR, Yao SS, N'Douba V. Ecological aspects of gill monogeneans of *Tilapia zillii* (Teleostei: Cichlidae) from man-made Lake Ayamé 2 (Côte d'Ivoire). *European j biotechnol. biosci* 2017c;5(4):18-28.
4. Adou YE, Blahoua KG, Kamelan TM, N'Douba V. Prevalence and intensity of gill monogenean parasites of *Tilapia guineensis* (Bleeker, 1862) in man-made Lake Ayamé 2, Côte d'Ivoire according to season, host size and sex. *Int. j. biol. chem. sci* 2017d;11(4):1559-1576.
5. Akoll P, Konecny R, Mwanja WW, Nattabi JK, Agoe C, Schiemer F. Parasite fauna of farmed Nile tilapia (*Oreochromis niloticus*) and African catfish (*Clarias gariepinus*) in Uganda. *Parasitol. Res* 2012;110(1):315-323.
6. Amin OM, Oosterhout CV, Blais J, Robinson RL. On the Ecology and Host relationships of *Acanthogyrus* (Acanthosentis) tilapiae (Acanthocephala: Quadrigyridae) from Cichlids in Lake Malawi. *Comp. Parasitol* 2008;75(2):278-282.
7. Amoussou TO, Toguyeni A, Toko II, Chikou A, Karim IYA. Caractéristiques biologiques et zootechniques des tilapias africains *Oreochromis niloticus* (Linnaeus, 1758) et *Sarotherodon melanotheron* Rüppell, 1852: *Int. J. Biol. Chem. Sci* 2016;10(4):1869-1887.
8. Balling TE, Pfeiffer W. Location-dependent infection of fish parasites in Lake Constance. *J Fish. Biol* 1997;51:1025-1032.
9. Bekele J, Hussien D. Prevalence of internal parasites of *Oreochromis niloticus* and *Clarias gariepinus* fish species in Lake Ziway, Ethiopia. *J Aquac. Res. Dev* 2015;6:308.
10. Biu AA, Diyaware MY, Yakaka W, Joseph E. Survey of Parasites Infesting the Nile Tilapia (*Oreochromis niloticus*, Linnaeus, 1758) from Lake Alau, Maiduguri, Nigeria. *Nig. J. Fish. Aqua* 2014;2(2):6-12.
11. Blahoua KG, N'Douba V, Koné T, Kouassi NJ. Variations saisonnières des indices épidémiologiques de trois Monogènes parasites de *Sarotherodon melanotheron* (Pisces: Cichlidae) dans le lac d'Ayamé I (Côte d'Ivoire). *Sci. Nat* 2009;6(1):39-47.
12. Blahoua KG, Yao SS, Etilé RN, N'Douba V. Infection dynamics of four gill Monogenean species from *Tilapia zillii* (Gervais, 1848) in man-made Lake Ayame I, Côte d'Ivoire. *Int. J. Biol. Chem. Sci* 2015;9(1):12-23.
13. Blahoua KG, Yao SS, Etilé RN, N'Douba V. Distribution of gill monogenean parasites from *Oreochromis niloticus* (Linné, 1758) in man-made Lake Ayamé I, Côte d'Ivoire. *Afr. J Agric. Res* 2016;11(2):117-129.
14. Blahoua KG, Adou YE, Etilé RN, Yao SS, N'Douba V. Occurrence of gill Monogenean parasites in Redbelly tilapia, *Tilapia zillii* (Teleostei: Cichlidae) from Lobo River, Côte d'Ivoire. *J Anim. Plant. Sci* 2018;35(3):5674-

- 5688.
15. Blahoua KG, Adou YE, Etilé NR, Tiho S. Parasite community of *Oreochromis niloticus* from man-made Lake Ayame I, Côte d'Ivoire. *Int. J. Biosci* 2020;16(3):321-333.
 16. Bondad-Reantaso MG, Subasinghe RP, Arthur RJ, Ogawa KC, Chinabut ST, Adlard RE, *et al.* Disease and health management in Asian aquaculture. *Vet. Parasitol* 2005;132:249-272.
 17. Bonett RM, Steffen MA, Trujano-Alvarez AL, Martin SD, Bursey CR, McAllister CT. Distribution, abundance, and genetic diversity of *Clinostomum spp.* Metacercariae (Trematoda: Digenea) in a Modified Ozark Stream System. *J. Parasitol* 2011;97(2):177-184.
 18. Bush AO, Kevin DL, Jeffrey ML, Allen WS. Parasitology meets ecology on its own terms. *J. Parasitol* 1997;83:575-583.
 19. Cable J, Harris PD. Gyrodactylid developmental biology: historical review, current status and future trends. *Int. J. Parasitol* 2002;32:255-280.
 20. Coulibaly ND, Salembere S, Bessing R. Larval *Clinostomum* in Cichlid fish in Lake Kompeinga, Burkina Faso. A threat to fishing and public health. *Francophone Sante* 1995;5(3):199-205.
 21. Costello MJ. How sea lice from salmon farms may cause wild salmonid declines in Europe and north America and be a threat to fishes elsewhere. *Proceedings of the royal society* 2009;276:3385-3394.
 22. Dufour P. Influence des conditions du milieu sur la biodégradation des matières organiques dans une lagune tropicale. *Oceanol. Acta* 1982;5(3):355-363.
 23. Emere MC. Parasitic infection of the Nile Perch (*Lates niloticus*) in River Kaduna. *J Aquat. Sci* 2000;15:51-54.
 24. Emere MC, Egbe, NEL. Protozoan Parasites of *Synodontis clarias* (A Freshwater Fish) in River Kaduna. *The Best Journal* 2006;3:58-64.
 25. Fonkwa G, Tchuinkam T, Nana TA, Tchoumboue J. Prévalences des Myxosporidioses Chez *Oreochromis niloticus* Linné, 1758 (Cichlidae) au barrage réservoir de la Mapé (Adamaoua-Cameroun). *J. Appl. Biosci* 2018;123:12332-12345.
 26. Gbankoto A, Pampoulie C, Marques A, Sakiti GN, Dramane KL. Infection patterns of *Myxobolus heterospora* in two tilapia species (Teleostei: Cichlidae) and its potential effects. *Dis. Aquat. organ* 2003;55:125-131.
 27. Gebreegziabher HG, Tsegay KA. Review on distribution of endo-parasites of fish in Ethiopia. *Parasite. epidemiol. Control* 2017, 42-47.
 28. Goselle ON, Shir GI, Udeh EO, Abelau M, Imandeh GN. Helminth parasites of *Clarias gariepinus* and *Tilapia zilli* at Lamingo dam, Jos, Nigeria. *Sci. world j* 2008;3(4):23-28.
 29. Khalil LF. Check list of the helminth parasites of African fresh water fishes. Commonwealth Institute of Helminthology, St Albans. Technical Communication 1971, 42.
 30. Klimpel S, Palm HW, Seehagen A. Metazoan parasites and food composition of juvenile *Etmopterus spinax* (L., 1758) (Dalatiidae, Squaliformes) from the Norwegian Deep. *Parasitol. Res* 2003;89:245-251.
 31. Marcogliese DL. Parasitology Module Steering Committee PMSC. Protocols for measuring biodiversity: parasites of fishes in freshwater update. *Protocols Manual for Water Quality Sampling in Canada. Ecological Monitoring and Assessment Network EMAN, Canada* 2011.
 32. Nkwengulila G, Mwita C. Spatial distribution of parasites along the gut of the catfish *Clarias gariepinus* (Burchell, 1822) (Clariidae) from the Mwanza gulf, lake Victoria. *Tanzan. J Sci* 2004;30(1):63-70.
 33. Ochieng VO, Matolla GK, Khyria SK. A study of *Clinostomum* affecting *Oreochromis niloticus* in small water bodies in Eldoret-Kenya. *Int. J. Sci. Eng. Res* 2012;3(4):1-6.
 34. Ouattara NI, N'Douba V, Teugels GG, Philippart JC. Effects of three agricultural by-products on cage culture growth performances of a landlocked population of *Sarotherodon melanotheron* (Teleostei: Cichlidae) in man-made Lake Ayame, Côte d'Ivoire. *Afr. J. Aquat. Sci* 2005;30:125-129.
 35. Paperna I. Parasites, infections and disease of fishes in Africa: An update, CIFA Technical paper 31, FAO. Rome 1996, 220p.
 36. Pariselle A, Euzet L. Systematic revision of Dactylogyridean parasites (Monogenea) from cichlid fishes in Africa, the Levant and Madagascar. *Zoosystema* 2009;31(4):849-898.
 37. Poulin R. Variation in the intraspecific relationship between fish length and intensity of parasitic infection: Biological and statistical causes. *J. fish. biol* 2000;56(1):123-137.
 38. Roberts RJ. *Fish Pathology*, Bailliere Tindall. London 1978.
 39. Roberts RJ. *Parasitology of Teleosts in: Fish Pathology*. 2nd edition. London, UK 1995.
 40. Roberts RJ. *Fish pathology*. 3rd edition. Hagerman, Idaho 2000, 472 p.
 41. Roberts L, Janovy J. *Foundation of Parasitology*. Wm. C. Brown Publishers, Dubuque, IA 1996, 659 p.
 42. Rohde K. *Ecology of marine parasites. An introduction to marine parasitology*, 2nd Ed. Cab International, Wallingford, Oxon 1993, 298 p.
 43. Sakiti N, Kabre G, Marques A, Dossou C. Gill diseases caused by Myxozoa in fishes of Inland waters of the south of Benin. *J. Eukaryot. Microbiol* 1999;46:15A.
 44. Scholz T. Parasites in cultured and feral fish. *Vet Parasitol* 1999;84:317-335.
 45. Teugels GG, Thys van den Audenaerde DFE. Cichlidae. In: Lévêque C, Paugy D, Teugels GG, eds. *Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest*, Tome 2. Musée Royal d'Afrique Centrale Tervuren, ORSTOM Paris 2003, 521-600.
 46. Tuo AD, Soro MB, Trokourey A, Bokra Y. Assessment of waters contamination by nutrients and heavy metals in the Ebrie lagoon (Abidjan, Ivory Coast). *Res. J. Environ. Toxicol* 2012;6(5):198-209.