Structure of the gill monogenean parasites of *Tylochromis jentinki* (Teleostei: Haemulidae) from two sectors of Ebrié lagoon, Côte d'Ivoire

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DOI: 10.29322/IJSRP.9.06.2019.p9055
http://dx.doi.org/10.29322/IJSRP.9.06.2019.p9055

Abstract- This study compared gill monogenean parasite of *Tylochromis jentinki* from two sectors in Ebrié lagoon during March 2017 to February 2018. Six hundred specimens of *T. jentinki* were necropsied for parasitological analysis. Gills were prepared from each specimen following standard methods for microscopic analysis. Parasitological indices were calculated. The diversity indices were determined using Berger-Parker dominance index, Shannon-Weaver index, Pielou's measure of evenness, Margalef's diversity index and the Simpson index. Three species (*Cichlidogyrus berrebii*, *C. kothiasi* and *C. pouyaudi*) occurred and the parasitic populations varied depending on the sampling sector. All the indices considered showed significant differences among the two sectors of Ebrié Lagoon except for the evenness which showed no significant differences both study areas. The diversity of monogenean seemed to be influenced by environmental conditions.

Index terms- Monogenea, Diversity index, *Tylochromis jentinki*, Ebrié lagoon, Côte d'Ivoire.

I. INTRODUCTION

The parasitism represents an essential part of ecology because parasites are good tools to study the structure and organization of communities (Mouritsen and Poulin, 2002; Koehler and Poulin, 2010). Thus, the knowledge of parasite species diversity and distribution is very important because it indicates the health and stability of ecosystems and is important in the management of wildlife and aquaculture systems (Lim, 1998). Monogenean gill parasites are not exceptional to this rule. These organisms are the most important helminth group parasitizing the external surfaces of the fish. They are found worldwide in freshwater, brackish and marine environments. Their short growth cycle associated with their easy contamination increase the number of monogeneans per host, particularly among the monopisthocotylea (Silan and Maillard, 1990). The consequence is the presence of several specimens on a restricted surface. Monogeneans are of great importance as agents of fish diseases particularly in aquaculture (Rohde, 2011). Diseases caused by these organisms are among the most important for fish farming, and massive mortalities have been observed in farmed fish due to high rates of infestation by these parasites (Portz *et al.*, 2013). In addition, due to their location, monogenean ectoparasites are subject to changes in the environment in which lives their host and their vulnerability to changes in physico-chemical parameters makes them excellent bio-indicators (Ramadan *et al*., 2014).

Despite this, to date, few studies have been conducted on the Cichlid, *Tylochromis jentinki* which is endemic to western Africa and is distributed from Gambia to Ghana (Paugy *et al*., 2003). In Côte d'Ivoire, this species is important ecologically and commercially, and is widely exploited and cultured. It is one of the most important fishery resources for the Ivorian artisanal fisheries (Amon-Kothias, 1982 ; Konan *et al*., 2011). The species is inexpensive and easily affordable by the low-income segment of the population.

Although much has been done on the taxonomy of monogeneans on fish in Africa (Pariselle and Euzet, 2009), there is little information on parasitic infection in Côte d'Ivoire (Blahoua *et al.*, 2015, 2016, 2018 ; Adou *et al*., 2017a and b). All these investigations were made in freshwaters. The only reports of parasitic infection carried out in Ebrié lagoon are those of Adou *et al*. (2017c). Concerning the monogenean gill parasite of *T. jentinki*, available data was limited to the reports of Pariselle and Euzet (1994), and they have focused on the systematic studies. However, the structure of the monogenean gill parasites of this Cichlid has not been studied.

The present study compared the parasite infracommunities of *Tylochromis jentinki* from two sectors of Ebrié lagoons in Côte d'Ivoire.

II. MATERIAL AND METHODS

A. Study area

The Ebrié Lagoon has an area of 566 km^2 and stretches on 125 km along the coast of Côte d'Ivoire, between 5° 10' N - 5° 50' N and 3° 40' W - 4° 50' W (Dufour, 1982; Tuo *et al*., 2012). 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. This lagoon is divided into different zones (Sector I to sector VI).

The survey includes two sectors (sectors I and IV) of the lagoon (Figure 1). The sector I (commonly named Aghien lagoon) is located in South East of Côte d'Ivoire (05° 22' N - 05° 26' N and 3° 49' W - 3° 55' W) near of the city of Bingerville. With a catchment area of 20.2 km^2 and a volume of 25 km^3, the rivers Djibi and Bété are tributaries of this lagoon's sector. It communicates with the Potou lagoon by the channel in which river Mé water flows. The sector IV is between 05° 16' N - 05° 21' N and 4 ° 14' W - 4° 23' W in the city of Dabou. With a catchment area of 107 km^2, this central region of the Ebrié lagoon is influenced by the Atlantic ocean and by the human activities ("Acadja enclos", washing, bathing, agriculture). This region is located near several plantations, including those belonging to local residents.

According to Issola *et al*. (2008), in the sector I, the salinity varied between 0‰ and 9‰ while it ranged from 2‰ to 15‰ in the sector IV.

B. Collection of fish specimens and parasitological analysis

Six hundred specimens of *Tylochromis jentinki* (Two hundred and forty individuals in the sector I and three hundred and sixty individuals in the sector IV) were caught monthly using gillnets from March 2017 to February 2018. Immediately after capture, the fish were stored in plastic bags with lagoon water to avoid loss or mixing of monogeneans among fishes and transported them to the laboratory. Thereafter, the fish specimens were necropsied for parasitological analysis. We examined only freshly killed fish. For each individual host, the gill arches removed, examined and the monogeneans were mounted in glycerine ammonium picrate mixture (GAP) to observe the sclerotized reproductive structures under a compound microscope (Olympus SZ 60). The worms were identified according to Parisellle and Euzet (2009) with a microscope magnification of 400 and 1000X.

C. Physico-chemical parameters

The physical and chemical parameters (water temperature, dissolved oxygen concentration, electrical conductivity, pH and salinity) were measured in situ with a portable multi-parameter probe (HANNA HI 9828010-02) and the transparency with Secchi disk. Water samples were collected with a sterile bottle and preserved for subsequent analyses of nutrients (phosphate, nitrite, nitrate and ammonia) using the spectrophotometry method using to the French Normalization Agency (AFNOR, 1994).

D. Data analysis

Epidemiological parasitological indices (prevalence, mean intensity and range of intensity of infection) were calculated according to Bush *et al*. (1997). The data were analyzed using Dominance index, Berger-Parker dominance index, Shannon-Weaver index, Pielou's measure of evenness, Margalef's diversity index and the Simpson index. Those diversity indices are depicted on annual mean basis and are calculated by the software Paleontological Statistic (PAST) version 2.15 (Hammer *et al*. 2001).

- Dominance index was calculated according to the formula:

$$D_i = n_i \times 100 / N[\%]$$

where : n_i – total number of parasites of a particular species, N – total number of all parasites

The following scale was used to determine species dominance: $D_i > 10\%$ – eudominants; $5.01\% < D_i < 10\%$ – dominants; $2.01\% < D_i < 5\%$ – subdominants; $1.01\% < D_i < 2\%$ – recedents; $D_i > 1\%$ – subrecedents

- Berger-Parker dominance index was calculated according to the formula :

$$d = n_{max} / N$$

where: n_{max}- number of parasites of the most abundant species, N-total number of parasites in the sample

- Shannon-Weaver species diversity index:

$$H' = -\Sigma (p_i \times \log_2 p_i)$$

where: p_i-number of parasites of the particular species/total number of parasites in the sample

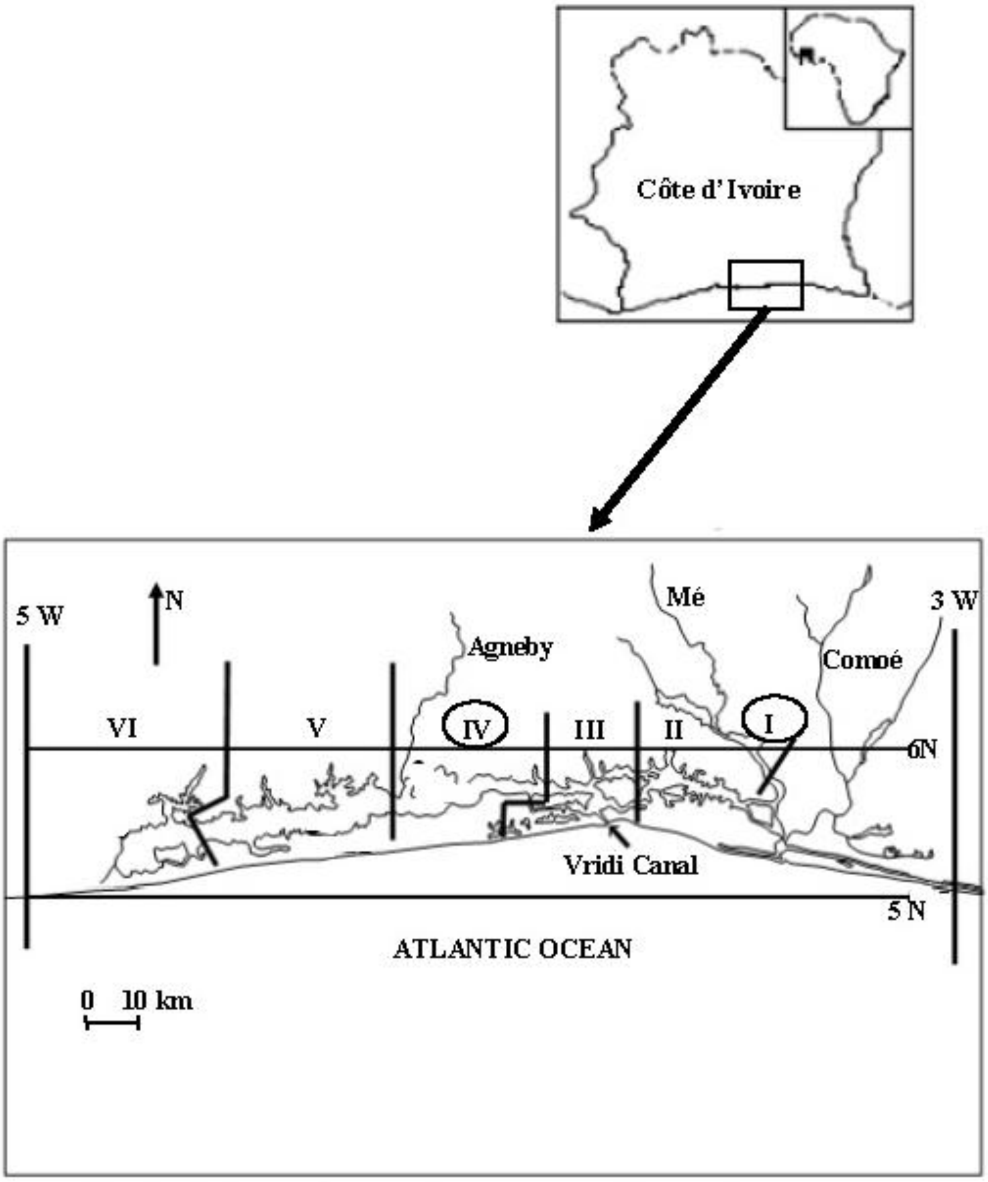

Fig 1. Localization of the sampling sites (sectors I and IV) in the Ebrié Lagoon (Côte d'Ivoire).

- Pielou's measure of evenness

$$E = H' / \log_2(S)$$

where: S-number of observed species, H'-Shannon-Weaver index

- Margalef index, specifying the relative species richness:

$$M = S-1 / \ln N$$

where: S-number of species, N-total number of parasites in the sample

- Simpson index, which is a measure of species diversity in the community:

$$D = \Sigma n_i (n_i-1) / N (N-1)$$

where: n_i-total number of parasites of a particular species, N-total number of parasites in the sample

The Chi Square X^2 test allowed to compare two or more proportions. The Mann Whitney (U) and Kruskal-Wallis (K) tests were respectively used to compare two and several averages. The degree of security for statistical analyses is 95%. Computations were performed using Statistical Package for Social Science (SPSS) 16.0. A non-parametric test was adopted because the values of normality and homoscedasticity did not allow the use of a parametric test.

III. RESULTS

Three monogenean species (*Cichlidogyrus berrebii* Pariselle and Euzet, 1994; *C. kothiasi* Pariselle and Euzet, 1994 and *C. pouyaudi* Pariselle and Euzet, 1994) were recorded on the gills of *Tylochromis jentinki* from the two sectors (sectors I and IV) of Ebrié lagoon.

A. Distribution of parasitic indices and dominance

The distribution of parasitic indices and dominance results are summarized in Tables 1 and 2. Of 240 specimens examined in the sector I, 45, 132 and 6 specimens were sheltered respectively by: 442 *Cichlidogyrus berrebii*, 1701 *C. kothiasi* and 31 *C. pouyaudi*. The prevalences of these parasites were respectively: 18.75%, 55% and 2.5%. Their mean intensities were 4.2 ± 1.1, 6 ± 2.5 and 2.5 ± 0.1 (Table 1). The first two monogenean species were eudominant and the last one was recedent. It appears that *C. kothiasi* occurred the highest prevalence, intensity, mean intensity of infection and dominance, while *C. pouyaudi* with the lowest ones (Table 2).

Of the 360 specimens examined in the sector IV, 300, 180 and 35 specimens were infested respectively by: 6540 *Cichlidogyrus berrebii*, 2214 *C. kothiasi* and 180 *C. pouyaudi*. The prevalence values of monogenean parasites were 83.33%, 50% and 9.72%, respectively. Their mean intensities of infection were 21.8 ± 7.1, 12 ± 3.4 and 5.1 ± 0.2 (Table 1). The species (*C. berrebii* and *C. kothiasi*) also belonged to eudominant and *C. pouyaudi* was subdominant (Table 2). It appears that *C. berrebii* occurred the highest prevalence, intensity, mean intensity of infection and dominance. The lowest values of the above parameters were observed in the case of *C. pouyaudi*.

The results from statistical comparison of infection revealed that there was a significant difference between the rate of infection (prevalence) of monogenean gill parasites of *T. jentinki* from sector I (Aghien) and those from sector IV (Dabou) of Ebrié lagoon (Chi square X^2, $p < 0.05$). Most parasites were mainly isolated from this host fish in the sector IV (Mann Whitney, $p < 0.05$).

B. Diversity parameters of monogenean parasites

The biodiversity index of *Cichlidogyrus berrebii*, *C. kothiasi* and *C. pouyaudi* on the gills of *T. jentinki* from the two sectors of Ebrié lagoon was analyzed (Table 3). The results showed that the number of species (N = 3) caught during the study period was not statistically different in the two sectors ($p > 0.05$). The Shannon's diversity index, the Simpson's diversity index, the Margalef's diversity index and the Berger-Parker's diversity index were significantly greater in the sector IV of Ebrié lagoon ($p < 0.05$). Only the Pielou's evenness index reached a higher value (0.7±0.01) in the sector I.

C. Physico-chemical parameters

The values of the physical and chemical parameters of two sectors (sectors I and IV) of the Ebrié lagoon were analyzed (Table 4). In the sector I, pH ranged between 6.6 and 8.81, water temperature varied from 24.4 to 27.2 °C, dissolved oxygen ranged between 5.9 and 7.8 mg/L and transparency varied from 68.2 to 124 cm. The values recorded for ammonia ranged from 0.01 to 0.06 mg/L, the nitrate varied from 0.16 to 0.37 mg/L, the nitrite and total phosphorus ranged within respectively: 0.001-0.003 mg/L and 0.05-0.12 mg/L. Conductivity varied from 65.4 to 98.1 mg/L and salinity ranged within 0-0.002‰. In the sector IV, the values of pH varied from 6.9 to 7.4, water temperature ranged within 28.62-30.5 °C, dissolved oxygen varied from 5.66 to 6.16 mg/L and transparency ranged between 70.7 and 118.7 cm. The inorganic nutrients ranged (mg/L) within 0.02-0.09 for ammonia, 0.32-0.6 for nitrate, 0.004-0.006 for nitrite and 0.9-1.32 for total phosphorus. Conductivity ranged between 3206.74 and 5756.9 mg/L and salinity varied from 2.11 to 3.3‰. The variations recorded were significant between the two sectors sampling of the Ebrié lagoon ($p < 0.05$), except for dissolved oxygen and pH.

Table 1: Infection parameters of *Tylochromis jentinki* from sites of Ebrié lagoon.

Sites of Ebrié lagoon	Monogenean parasites	Prevalence [%]	Intensity			Number of parasites
			Mean	Range	SD	
Sector I (Aghien)	*C. berrebii*	18.75	4.2	0-12	1.1	189
	C. kothiasi	55	6	0-25	2.5	792
	C. pouyaudi	2.5	2.5	0-3	0.1	15
Sector IV (Dabou)	*C. berrebii*	83.33	21.8	0-52	7.1	6540
	C. kothiasi	50	12.3	0-37	3.4	2214
	C. pouyaudi	9.72	5.1	0-6	0.2	180

C: *Cichlidogyrus*, SD: standard deviation

Table 2: Dominance index (D) and class of domination of monogenean parasites of *Tylochromis jentinki* from Ebrié lagoon.

Sites of Ebrié lagoon	Monogenean parasites	Dominance [%]	Class of domination
Sector I (Aghien)	*C. berrebii*	79.5	eudominant
	C. kothiasi	19	eudominant
	C. pouyaudi	1.5	recedent
Sector IV (Dabou)	*C. berrebii*	73.2	eudominant
	C. kothiasi	24.8	eudominant
	C. pouyaudi	2.01	subdominant

C: *Cichlidogyrus*

Table 3: Biodiversity index of Monogenean parasites of *Tylochromis jentinki* at the sectors I and IV of the Ebrié lagoon.

Host	Richness	Shannon's diversity index	Shannon-based evenness	Simpson's diversity index	Margalef's diversity index	Berger-Parker's diversity index
Sector I (Aghien)	3	2.1±0.2	0.7±0.01	0.41±0.1	0.3±0.02	0.21±0.01
Sector IV (Dabou)	3	3.9±0.01	0.47±0.2	0.8±0.01	0.6±0.004	0.44±0.12

Table 4: Physical and chemical parameters of Ebrié lagoon (sectors I and IV).

	Ebrié lagoon	
Parameters	Sector I	Sector IV
pH	7.6±1.5 (6.6-8.81)	7.1±0.84 (6.9-7.4)
Temperature (^{0}C)	25.8±0.7 (24.4-27.2)	29.6±1.35 (28.62-30.5)
DO (dissolved oxygen) (mg/L)	6.85±0.02 (5.9-7.8)	5.11±0.65 (5.66-6.16)
Transparency (cm)	96.1±16.4 (68.2-124)	84.7±28.3 (70.7-118.7)
Ammonia (mg/L)	0.025±0.1 (0.01-0.06)	0.05±0.07 (0.02-0.09)
Nitrate (mg/L)	0.20±0.07 (0.16-0.37)	0.48±0.2 (0.32-0.6)
Nitrite (mg/L)	0.02±0.01 (0.001-0.003)	0.005±0.007 (0.004-0.06)
Total phosphorus (mg/L)	0.08±0.1 (0.05-0.12)	1.1±0.9 (0.9-1.32)
Conductivity (µs/cm)	81.75±12.5 (65.4-98.1)	4481.82±1787.67 (3206.74-5756.9)
Salinity (‰)	0.002±0.1 (0-0.002)	2.7±0.9 (2.11-3.3)

IV. DISCUSSION

This study has underlined occurrences of three monogenean species parasitizing the gills of *Tylochromis jentinki* from Ebrié lagoon. Such observation has already been reported (Pariselle and Euzet, 1994). The reason for this might be the phylogeny of hosts and parasites (Bush *et al*., 1997; Sasal *et al*., 1997), host (Morand *et al*., 1999) and ecology (Zharikova, 2000). Indeed, all these factors were due to the equal chances of infection of hosts with the monogenean eggs regardless of their location.

However, the distribution of parasites varied according to the site. It appeared that the hosts caught in the sector IV (Dabou) shelter more parasites than those which have been caught in the sector I (Aghien). Factors linked to habitat environmental and biological aspects can affect structure and species composition (Vidal-Martinez and Poulin, 2003; Tavares and Luque, 2008; Violante-Gonzalez *et al*., 2010). In this study, the difference of the prevalence and the intensity of infection of monogenean could be attributed to some different environmental conditions in these two sectors of Ebrié lagoon such as anthropogenic activities that occur in the areas and an increasing discharge of effluents. Indeed, in the sector IV (Dabou), fishermen most use "acadja enclos" as the type of fishing for improving their fisheries productivity. On the one hand, the decomposition of brushwood used in this type of fishing causes the lagoon pollution (Aboya, 2014). Furthermore, all wastewaters (domestic, industrial, agricultural, etc) from its agglomeration are introduced in this sector of the lagoon waters without any treatment or in a best case, after summarily treatment. Such wastes are known as vectors of many pollutants (nutrients, heavy metals, organic components, etc.) (Monou *et al*., 2010; Tuo *et al*., 2012; Tuo *et al*., 2013) which can affect fish health. This situation reduces fish immune capability which favors parasites to build up in the affected fish. On the other hand, the decomposition of "acadja enclos" twigs is expected to increase with suspended materials which will cause the infective larvae transport on the fish gills. The lagoon pollution combined with the suspended particles may well result in higher infection statistic values recorded during surveys performed in the sector IV (Dabou) of the Ebrié lagoon. This study also agrees with Sulgostowska *et al*. (1987), Cone *et al*. (1993) and Barker *et al*. (1996), that the water pollution can induce an increase in the number of parasites. On the contrary, in the sector I (Aghien), the low levels of host infection could be due to the entry permanent of rivers water Djibi, Bété and Mé in this part of the lagoon. Indeed, the water current can helps fish host get rid of monogeneans (infective larvae and mature individuals), thus reducing the intensity of parasitism because it is often evoked as a factor limiting the recruitment of infective larva stages.

Also, the higher prevalence and mean intensities of parasitism by monogenea occurred in fishes from sector IV of the Ebrié lagoon could be attributed to variations in environmental parameters such as temperature, transparency, salinity, conductivity and mineral salts. Indeed, the stress caused by variations in the aquatic parameters are the main causes of parasitic infections besides the host susceptibility and social hierarchy associated with this fish species as reported (Alves *et al*., 2001; Gómez-Laplaza and Morgan, 2003). For example, according to Smallbone *et al.* (2016), the high availability of certain nutrients in the water can promote the proliferation of monogenean parasites. Thus, our results suggest that the environmental factors of Ebrié lagoon' sector IV may provide better eco-climatic conditions for the development of these parasites. Furthermore, taking into account consideration of Zharikova (2000), other factors might influence the abundance of specific parasites species.

The low Shannon-Weaver index (H') values obtained in the two sectors of Ebrié lagoon indicate the presence of species predominate. This is much appreciated with the values of Shannon based evenness which are below 1 indicating the poor distribution/organization within the hosts. But, it appeared that gill monogenean species from hosts in the sector IV (Dabou, E= 0.7) are more organized than those in the sector I (Aghien, E= 0.47). The Berger-Parker Dominance index, the Simpson's diversity index and the Margalef's diversity index indicate significant difference in the monogenean species diversity. This variation could be attributed to differences in the level of pollution or anthropogenic activities. Indeed, any ecological imbalance arising from any severe alterations of the factors (water quality, immediate substrates for occupation, food availability etc…) are some important factors governing the abundance and distribution of aquatic communities which could affect the environment and therefore could lead the periodic or permanent elimination of monogenean species.

V. CONCLUSION

The study was the first report on the structure of gill monogenean parasites of *Tylochromis jentinki* and it showed that these parasites had similar parasite infracommunities, characterized by low species diversity, low evenness and species richness. The distribution and diversity of monogeneans can be affected by variations in abiotic factors. Special attention should be given to make aware farmers about the impact of chemical fertilizers in aquatic ecosystem and enhance them to use biofertilizers. This assessment provides useful data for implementation of adequate prophylactic measures to prevent losses caused by monogenean in fish farming.

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