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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/xxx
DOI URL: http://dx.doi.org/10.21474/IJAR01/xxx

ISSN NO. 2320-5407

RESEARCH ARTICLE

SEASONAL VARIATION OF INFESTATION BY GILL MONOGENEAN PARASITES AND CONDITION FACTOR OF *COPTODON GUINEENSIS* (GÜNTHER, 1862) IN THE SECTOR IV OF EBRIE LAGOON (CÔTE D'IVOIRE)

Manuscript Info

Manuscript History

Received: xxxxxxxxxxxxxxx
Final Accepted: xxxxxxxxxxx
Published: xxxxxxxxxxxxxxx

Key words:-
Fish, parasites, infestation, Ebrié Lagoon

Abstract

local population with aquaculture potential, was examined in sector IV of the Ebriré lagoon for the first time. The objective of this study was to evaluate the effect of seasons on parasitism and condition factor of *Coptodon guineensis* in this lagoon. The fish were captured from February 2022 to March 2023. Parasites were sought in the gills and mounted between slide and coverslip according to standard methods for studying parasitic Monogeneans. The values of the diversity index such as specific richness, Shannon weaver, Equitablity and Simpson were the highest in the rainy season. Regarding infestation, the highest prevalence and mean intensity values of parasites were recorded in rainy seasons, indicating that fish were the most infested in the rainy period. All parasitized fish had a lower condition factor than unparasitized fish, and this was more observed during dry seasons. This study highlighted the period of high infestation of this fish species. This information is useful for developing strategies for fish farmers and veterinarians to monitor and control parasitic diseases.

The infestation of *Coptodon guineensis*, a fish prized by the

Introduction:

Parasitism is a lifestyle in which one or more distinct organisms, in this case the parasite, live in close and forced association in or on another, the host, and derive benefits such as food, at the the expense of the latter, normally without killing it (Lafferty et al., 2008). Approximately 40% of animal species known in the living world are parasites (Dobson et al., 2008). They belong to several distinct taxa, phylogenetically different, and as such exhibit a wide variety of life cycles and body forms (Lafferty *et al*., 2008). They often create pathologies and behavioral changes that can affect the individual, the host population dynamics, the community structure, and finally, on a larger scale, the ecosystem (Lafferty *et al*., 2008). Among fish parasites, Monogeneans are mainly ectoparasites with a holoxene life cycle, without an intermediate host (Blahoua *et al*. 2009). They frequently infest various organs, namely the gills, skin, fins, rectal cavity, nostrils and stomach (Blahoua *et al*. 2009). In the natural environment, these parasites are in apparent equilibrium with the host fish. In aquaculture, pathology problems sometimes linked to high parasite loads causing a loss of fish productivity have often been observed (Buchmann and

Lindenstrom, 2002). It therefore appears necessary to know these parasites. Indeed, according to Sures and Streit (2001) and Dudgeon *et al*. (2006), knowledge of these parasites provides not only information on the health of the fish but also helps to understand ecological problems.

In Côte d'Ivoire, apart from the study of Adou *et al*. (2017a) in the Ayamé 2 dam lake, data on the infestation of *Coptodon guineensis* by gill Monogeneans remain little known in other Ivorian rivers. However, this fish is present in many Ivorian rivers (Adou *et al*., 2017b, 2023 ; Adou and Blahoua, 2024), in particular sector IV of the Ebrié lagoon where it is of great economic interest. In addition, *Coptodon guineensis* is the subject of particular attention in aquaculture because of its zootechnical performance (Nobah *et al*., 2008). Despite this importance, no studies have been devoted to the effects of parasitic Monogeneans on this fish in this environment. However, it is well known that parasitic infections in fish cause production and economic losses through direct fish mortality, reduced growth, fecundity and endurance of fish, increased susceptibility of fish to diseases and predation (Cowx, 1992).

This study aim was to evaluate the seasonal effect of infestation and the condition factor of *Coptodon guineensis* in sector IV of the Ebrié Lagoon.

Materials and Methods:-

Study Area

The Ébrié Lagoon originates from a coastal depression of fluvial origin, a consequence of the last glaciation, then gradually isolated from the Gulf of Guinea by a sandy sedimentary barrier (Tastet and Guiral, 1994). With a total surface area of 566 km², it stretches over 130 km and reaches a maximum width of 7 km with an average depth of 4.8 m, reaching 15 to 20 m in places (Affian *et al*., 2002). It consists of a main body of water with an east-west orientation, between longitudes 3°40' and 4°50' W and latitudes 5°15' and 5°20' N. The study area concerns the western lagoon strip; specifically sector IV of the Ebrié lagoon in the Dabou department, which has an area of 107 km^2 (Kouassi, 2010). It is located between longitudes 4°14’ and 4°23’ W and latitudes 5°16’ and 5°17’ N (Figure 1). This area benefits from a transitional equatorial climate with four seasons (Ahoussi *et al*., 2013) : a long rainy season from April to July, a short dry season from August to September, a short rainy season from October to November, and a long dry season from December to March. The average annual rainfall is between 1400 and 1600 mm (Brou *et al*., 2005). Floods occur at two times of the year, from June-July and from October-November. Low water levels occur from December to March and from August to September. Agricultural activities along this body of water include cassava, plantain, and rubber plantations. Most of these plantations use large quantities of fertilizers and phytosanitary products such as insecticides, fungicides, nematocides, rat poisons, and herbicides. The waters of Sector IV receive effluent discharge from palm oil factories (Aboya, 2014).

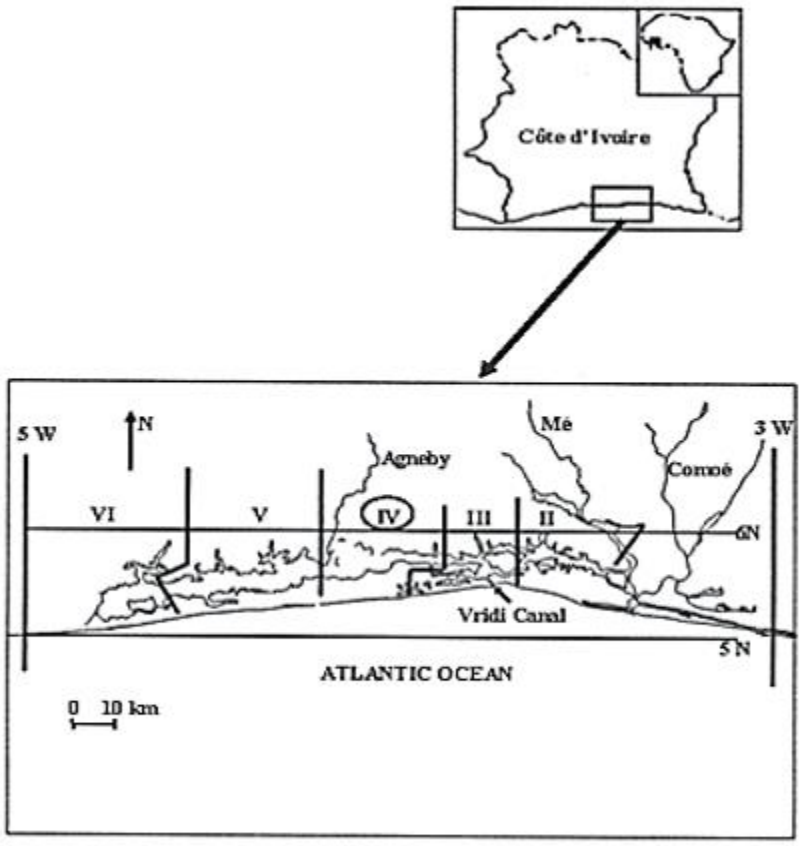

Fig1 :- A map of the Ebrie lagoon showing the study area

Sampling fish and Parasitological examination

The one hundred fifty (150) *Coptodon guineensis* fish were sampled monthly from February 2022 to March 2023 using gillnets and traps. Morphometric measurements including standard lengths (Horizontal distance from the anterior end of the snout to the base of the caudal fin) and total lengths (Horizontal distance from the anterior end of the snout to the posterior end of the caudal fin) all in millimeters of each specimen were taken. The fish were weighed in grams using an electronic balance. The gills were then removed and stored individually in aluminum foil packets, in the cold until examination. In the laboratory, after thawing the gills in the open air, the gill filaments were washed using a wash bottle. The rinsing water collected in a Petri dish and the gill filaments were examined under a binocular microscop (G x 60). The observed Monogeneans were detached using 00 entomology needles mounted between slide and coverslip in a micro drop of the ammonium picrate glycerin mixture (Malmberg, 1957). The determination of the species of branchial parasitic Monogeneans was done under a microscope (G x 100) using the identification key of Pariselle and Euzet (2009).

Data Analysis

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Condition Factor (K)

The Fulton's Condition Factor (K) suggests that the weight of the fish is proportional to the cube of the length and was used to assess the general health of the fishes, on individual and population level. In all individuals' total length, standard length and body mass were measured. The allometric equation where the b exponent is a constant was used to compare the health index of the different category of fishes.

Thus, Fulton's condition factor (K) was calculated using the formula:

$K = W*100/ L^b$ (Le Cren, 1951)

Where W = weight of fish (g), L = standard length of the fish (cm), b = coefficiento f allometry considered equal to 3).

The Fulton's condition factor was multiplied with 100 to get it close to 1, and the number 1 indicated a normal condition of the fish, greater 1 indicated fat fish and less than 1 indicated skinny fish. This morphometric index assumes that the heavier fish for a given length the better condition.

Parasite and diversity indices

The terms "prevalence" and "mean intensity" were defined according to Bush et al. (1997). Prevalence (P%) is the percentage ratio between the number of hosts infested (N) by a given parasite species and the number of fish examined (H).

$P = N/H \times 100$

Based on the prevalence, species was considered as common (core) if the prevalence is greater than 50%, intermediate (secondary) if prevalence is between 10 and 50% and rare if prevalence is less than 10% (Valtonen et al., 1997).

Mean parasite intensity (IM) is the ratio of the total number of individuals of a parasite species (n) in a sample of hosts to the number of infested hosts (N) in the sample.

$IM = n/N$

The assessment of the structure of parasite species communities was carried out using the Shannon and Weaver (1963) (H') index, Piélou equitability index (E) and Simpson index (D). These indices were calculated using the Paleontological Statistic (PAST) software.

Shannon-Weaver index :

$H' = -\Sigma (pi \times \log2\ pi)$

where : pi is the number of parasites of the particular species/total number of parasites in the sample

Pielou equitability index :

$E=H'/ \log2(S)$

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

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

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

where : ni is the total number of parasites of a particular species, N is the total number of parasites in the sample.

Statistical Analysis

Comparison of infestation rate was made using the chi-square test (X^2). The Kruskal-Wallis test allowed comparison of several means while the Mann Whitney U test allowed comparison of means taken two by two. The STATISTICA 7.1 program was used for all statistical tests and the security level retained is 95%.

Results

Specific composition and ecological indices of parasite in *Coptodon guineensis*

Five monogenean species were found to have infested the gills of *Coptodon guineensis* collected at sector IV of Ebrié lagoon. It is composed of *Cichlidogyrus cubitus*, *C. anthemocolpos*, *C. arthracanthus*, *C. lagoonaris* and *C. digitatus*. Among these, *Cichlidogyrus cubitus*, *C. anthemocolpos* and *C. arthracanthus* were classified as core (Prevalence > 50 %) with average parasitic intensity values of 20.2±1.3, 15.74±0.1 and 14.2 ±0.6, species whereas *C. lagoonaris* and *C. digitatus* were classified as secondary species (10 % < Prevalence > 50 %) with mean intensities 9 ±1.1 and 7 ±0.8 respectively (Figure 2 and 3).

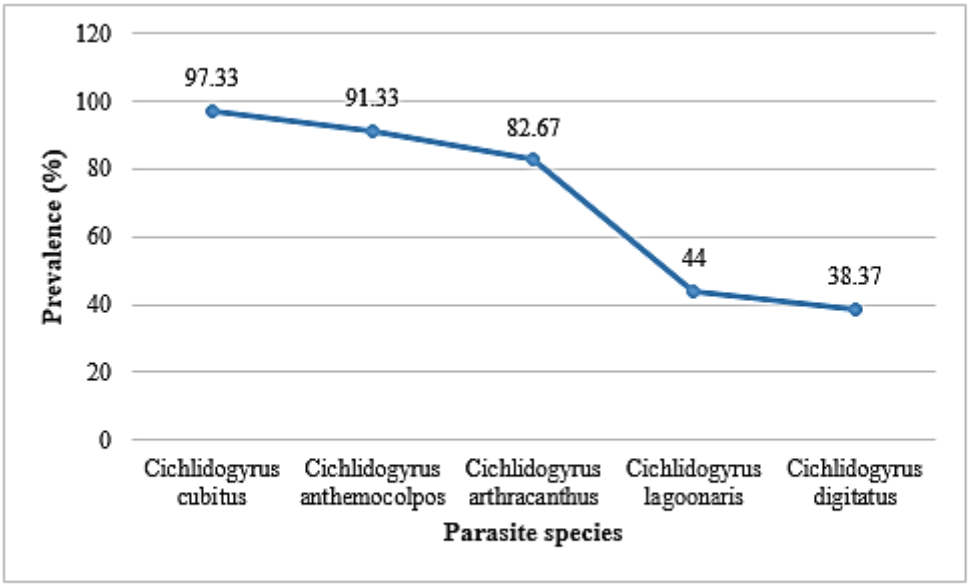

Fig 2:- Prevalence of each parasite species collected in *Coptodon guineensis* captured in sector IV of Ebrie lagoon

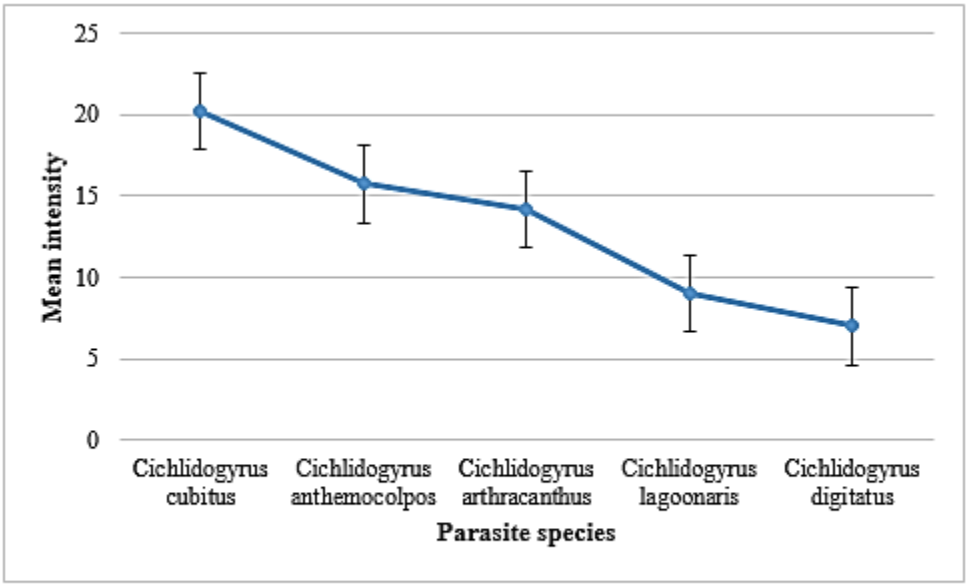

Fig 3:- Mean intensity of each parasite species collected in *Coptodon guineensis* captured in sector IV of Ebrie lagoon

The parasite diversity indices were recorded in Table 1. The results showed that the species richness varied over the seasons with a maximum of 5 species obtained in the rainy season. Shannon-Weaver index values observed in *Coptodon guineensis* parasite populations ranged from 1.84 in the dry season to 2.61 in the rainy season. These values obtained in the dry season are below the average (2.5). The values of the Piélou equitability index were well above the average (0.5) with the maximum (0.79) noted in the rainy season. Regarding the Simpson diversity index, the values are well above the average in each season, with the maximum (0.86) recorded in the rainy season.

Table 1:- Diversity indices of Monogenean species of *Coptodon guineensis* captured in sector IV of Ebrie lagoon

Diversity indices	Rainy season	Dry season	All seasons
Richness	5	4	5
Shannon-Weaver	2.61	1.84	2.12
Piélou equitability	0.79	0.74	0.71
Simpson	0.86	0.79	0.83

Relationship of parasite infestation between seasons

Temporal variations in the parasite indices of the 5 Monogenean species collected are illustrated in figures 4 and 5. They reveal that for all parasites, the highest mean prevalence values were obtained in rainy seasons. These values were 97.33; 91.33; 82.67; 44 and 38.67% respectively for *Cichlidogyrus cubitus*, *C. anthemocolpos*, *C. arthracanthus C. lagoonaris* and *C. digitatus*. However, these values remain low in the dry season. The chi-square test performed on the prevalence of *Cichlidogyrus cubitus*, *C. anthemocolpos* and *C. arthracanthus* during the seasons did not reveal any significant differences (Chi-square test (X^2) ; $p > 0.05$). On the other hand, the difference is significant for *C. lagoonaris* and *C. digitatus* ($p < 0.05$). Regarding the average intensity, the average variation shows the same evolution as that of the prevalence. The high intensities were noted in the rainy season. These values were 19.7±0.2 for *C. cubitus*, 14.9±1.6 for the parasite *C. anthemocolpos*, 12.2±0.3; 8.6±0.1 and 7.6±0.2 respectively for the parasites *C. arthracanthus*, *C. lagoonaris* and *C. digitatus*. The Mann-Whitney test applied to the intensities indicates that fish are more parasitized during the rainy season ($p < 0.05$).

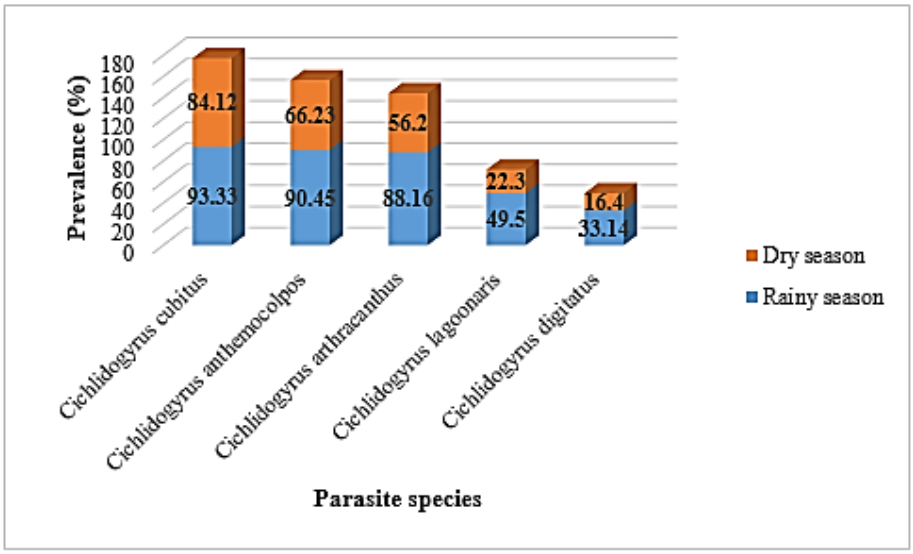

Fig 4:- Temporal variation of the parasites prevalence collected in *Coptodon guineensis* captured in sector IV of Ebrie lagoon

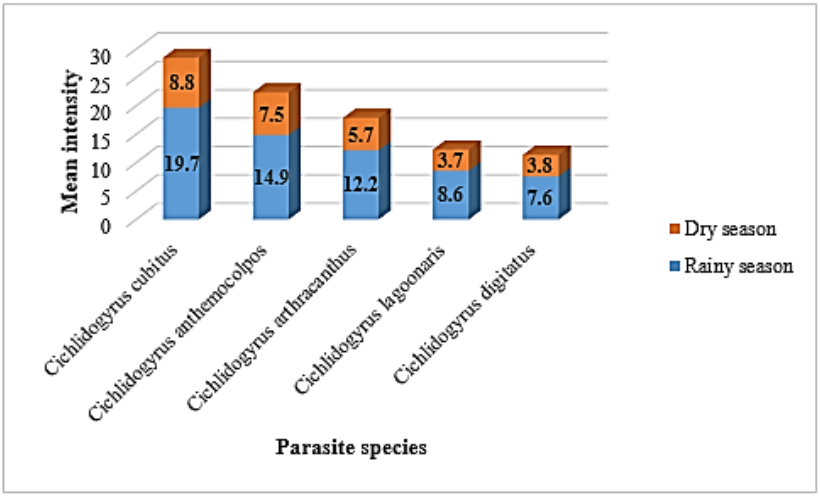

Fig 5:- Temporal variation of the parasites mean intensity collected in *Coptodon guineensis* captured in sector IV of Ebrie lagoon

Impact of parasite infestation on *Coptodon guineensis* condition factor

The condition factor (K) results of infested and uninfested hosts are presented in Table 2. With an average weight of 47.1±0.03 g and standard length of 18.21±0.1 cm, uninfected fish had an average condition factor of 0.78±0.1 g/cm^3. On the other hand, the condition factor (K) of infested fish was 0.46±0.1 g/cm^3 for an average weight of 25.33±0.02 g and an average standard length of 17.66±0.1 cm. A significant difference in condition factors was observed between infected and uninfected fish (Mann Whitney U test; p = <0.05). These condition factor values in both the rainy and dry seasons were less than 1 (K<1) for uninfested *Coptodon guineensis* specimens (Table 3). For infested fish these values are 0.6±0.4 g/cm^3 in the rainy season and 0.3±0.01 g/cm^3 in the dry season. The Mann Whitney U test established a significant difference in condition factors between infested and uninfested fish in both seasons ($p < 0.05$). Infested fish were generally leaner than uninfested ones.

Table 2:- Fulton condition factor (K) (g/cm^3) of infected and uninfected by gill Monogenean parasites of *Coptodon guineensis* captured in sector IV of Ebrie lagoon

Examined fish	Parameters	Mean Values
Uninfected	Total Length (cm)	18.21±0.1
	Weight (g)	47.1±0.03
	Condition Factor (K) (g/cm^3)	0.78±0.1
Infected	Total Length (cm)	17.66±0.1
	Weight (g)	25.33±0.02
	Condition Factor (K) (g/cm^3)	0.46±0.1

Table 3:- Fulton condition factor (K) (g/cm^3) of infected and uninfected by gill Monogenean parasites of *Coptodon guineensis* according to seasons

		Seasons	
Examined fish	Parameters	Rainy	Dry
Uninfected	Total Length (cm) mean±SE	19.2±1.2	18.61±0.7
	Weight (g) mean±SE	52.21±1.1	45.11±1.3
	Condition Factor (K) (g/cm^3) mean±SE	0.9±0.3	0.7 ±0.01
Infected	Total Length (cm) mean±SE	18.37±0.2	17.15±0.1
	Weight (g) mean±SE	37.19±0.1	15.13±0.2
	Condition Factor (K) (g/cm^3) mean±SE	0.6±0.4	0.3±0.01

SE : Standard error

Discussion

Examination of *Coptodon guineensis* specimens allowed the identification of 5 species gill Monogeneans. Adou *et al*. (2017a) have noted 11 species of this fish in the Ayamé 2 dam lake. It is well known that factors such as the number of host individuals examined, host social behavior, life history traits, size, habitat, and host and parasite phylogeny determine species richness (Ternengo (2004). Furthermore, Zharikova (2000) mentioned that the ecological conditions of ecosystems determine the quality and quantity of parasite species composition. Similarly, water quality, influenced by environmental factors, directly affects specific parasite compositions

ISSN: 2320-5407 Int. J. Adv. Res. X(X), XX-XX

(Galli et al., 2001; Mahmood *et al*., 2011). The low number of parasite species obtained in this study could be attributed to the ecological conditions of sector IV of the Ebrié lagoon, which could make it favorable or unfavorable to the development of certain parasite species.

The results of the seasonal study showed that the species richness of parasite populations presented little variation in relation to the seasons. Furthermore, species richness was higher during the rainy season and lower in the dry season. Bilong Bilong (1995) founded seasonal variation with three gill monogeneans (*Cichlidogyrus longicirrus*, *Onchobdella voltensis*, and *O. aframae*) on *Hemichromis fasciatus* in the Yaoundé municipal lake. The Shannon-Weaver and Simpson indices showed higher values during the rainy season and above average, while they were low during the dry season. The low Shannon-Weaver values observed during the dry season are characteristic of communities with low diversity and a low degree of organization (Dajoz, 2000). The Equitability values obtained over the seasons were very high, close to 1. This indicates the existence of a certain homogeneity in the temporal distribution of *Coptodon guineensis* parasites, as indicated by Zander (2005). Indeed, according to this author, Equitability values greater than 0.6 indicate that there is homogeneity in the distribution of parasites within hosts. When these values exceed 0.7, the homogeneity of the population is considered high. The high species richness in the rainy season is related to the new ecological conditions created which favor the development of several species of parasites as noted Zharikova (2000).

This study highlighted that fish are more infested during rainy seasons. Similar results were obtained by Adou *et al*. (2017b, 2021) and Blahoua *et al*. (2015, 2016, 2018, 2020) This could be explained by several factors. In fact, the rainy season corresponds to the period when there is a lot of food available for fish. These fish, while feeding, are more exposed to parasitic infestations. This result confirms that of Usip *et al*. (2010) in Nigeria, who reported that during the rainy season, most Cichlid species had a high infection rate. Differences in parasite infection between the dry and rainy seasons could be attributed to the eutrophication observed in this environment, which often increases parasitism. Eutrophication leads to algal blooms at the peak of the rainy season, which leads to an increase in species diversity and parasite population in fish that feed on them towards the end of the rainy season as observed by Lafferty and Kuris (1999). During the rainy seasons, the aquatic environment is contaminated by domestic wastewater discharges and drainage from agricultural runoff (plant protection products), making aquatic organisms vulnerable to parasitic infestation, as observed by Kemp and Spotila (1997). According to Khan and Thullin (1991), chronic exposure to pollutants over a certain period causes biochemical, physiological, and behavioral changes in the host that finnaly influence the parasites prevalence and intensity. These same authors believe that pollutants could lead to increased parasitism in fish by suppressing the host's immune response or altering host physiology. They also report that experimental studies have shown that the number of ectoparasites such as trichonid ciliates and Monogeneans increases significantly on the gills of fish exposed to a pollutant and that finnaly, immunosuppression may underlie the mechanism behind the increase in parasitism. In this lagoon, the fishing technique ""accadja enclos"" is

practiced a lot. It consists of making enclosures with branches and wood from trees that are immersed in water to favor the reproduction and growth of fish. During the rainy seasons, this practice of accadja enclos favors an accumulation of organic matter. The accumulation of organic matter composed of leaf debris and dead wood leads to the transport of parasite larvae to the fish, thus increasing their infestation The low infestations observed during dry seasons are due to the fact that this period is characterized by the mortality of adult worms due to increases in temperature, salinity, and conductivity (Modu *et al*., 2014, Adou *et al*., 2021). According to these authors, these water variables are important in controlling variation in the Monogenean intensity. These variables can modify the parasite's specificity (Zander, 1998). This may be due to changes in parasite physiology or a change in competitive interactions with other species that may be less tolerant of these environmental variations, as noted by Desdevises (2001). Many parasites have free-living stages (eggs, larvae, or both) where they are exposed to the external environment (ectoparasites). Like any other organism, their distribution and abundance can therefore be affected by environmental conditions, as is the case for host organisms (Marcogliese, 2003).

The condition factor (K) which is a morphometric index used to assess the physiological condition of fish based on whether individuals of a given length that have a higher mass are in better condition was assessed in *Coptodon guineensis*. All infested fish had lower body weights than uninfested fish. This is because parasitic infection causes loss of nutrition and energy in infected individuals. Furthermore, Combes, (1995) indicated that parasitic infections increase the sensitivity of their hosts to various other stressors that can reduce their weight. However, in parasitized fish, the condition factors are low during dry seasons. The fish are very thin during this period. These results are explained by the fact that in addition to the parasitic infestation, fish undergo other environmental stress such as the reduction of oxygen in the water, the lack of available food which act in synergy. On the other hand, the high values of the condition factors noted during the rainy seasons, would be in the new conditions characterized by more oxygenated waters a significant quantity of food is available which makes the fatness of infected hosts stable even though they are more parasitized in this season.

Conclusion

Examination of *Coptodon guineensis* gills revealed five Monogenean species. These are *Cichlidogyrus cubitus*, *C. anthemocolpos*, *C. arthracanthus*, *C. lagoonaris* and *C. digitatus*. The Shannon-Weaver and Simpson diversity indices recorded showed that parasite diversity is relatively high. The Equitability values showed homogeneity in the parasites distribution on this fish. A seasonal effect on the values of the epidemiological indices was noted. Fish were more

infested in the rainy season. Among the infested, the condition factors of the fish in the dry season are even lower than in the rainy season.

Acknowledgements

The authors thank all the fishing actors in the study area as well as the local population who helped with data collection.

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