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The population of monogeneans on the gills of *Sarotherodon galilaeus* (Linnaeus, 1758) (Cichliformes: Cichlidae) and the impact of abiotic and biotic parameters

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Abstract
From March to September 2016, the parasitic fauna of monogenean gill of 116 specimens of *Sarotherodon galilaeus* caught at Loumbila reservoir was investigated, in rainy and dry seasons. Standard methods of parasitological examination were used for identification of monogenean species. Five parasite species were found: *Cichlidogyrus douellouae, C. acerbus, C. halli, C. tilapiae*, and *Scutogyrus bailloni*. Generally, the mean intensities of the different parasite species were very low, except for *C. halli,* with high mean intensity. From the results obtained, it was observed that the size of fish and host sex do not have (*P*>0.05) any influence on parasitism infection. The infection rate of *C. douellouae* was significantly high in dry season. These results may help to improve strategies in aquaculture management, to reduce potential economic losses of *S. galilaeus* caused by parasitic infection.

Keywords: Monogenean, *Sarotherodon galilaeus*, gill parasites, Loumbila reservoir, Burkina Faso

1. Introduction
Sarotherodon galilaeus (Linnaeus, 1758) is a cichlid fish, which is widely distributed in West and Central Africa. In these regions, the monogenean parasites of the cichlid fish have been intensively studied [1]. In Burkina Faso, data on monogeneans in general and those of cichlid appear very insignificant [2-4]. Those first data on these parasites, showing their important as factors to be known carefully before to start the fish breeding. Indeed, monogeneans are often met on the gills of fish. Some could be found on the skin or fins of their hosts. Some others may also be found in some cavities such as the stomach, intestine, bladder, and nostril [5-7]. These organisms are often in equilibrium with their hosts in the natural environment, though, they could be responsible for many cases of serious morbidity and even mortality during fish breeding [8-11]. In fact, the attachment of monogeneans and their foraging activities can provoke skin and gill lesions, which are frequently precursors of secondary infections [12, 13]. Overloading of parasites can damage both the gill system and the skin, and provoke anemia. In some cases, infested fish become lethargic or die [14]. The Food and Agricultural Organization of the United Nations [15] reported that, to satisfy an increasing demand in freshwater fish, extensive research must include studies of their parasites for optimal production levels. For the authors [16] and [17], knowledge of fish parasites is of particular interest in relation not only to fish health but also to understanding ecological problems. This study was the first to aim for the small fishery reservoir assessment of gill monogeneans of *S. galilaeus* in Burkina Faso. The key objectives of this work were to (1) identify the diversity and the distribution of gill monogeneans of *S. galilaeus*, (2) determine the relationship between parasitic infection of *S. galilaeus* and some biological aspects, and (3) determine the impact of seasons on the dynamic of monogeneans.

2. Materials and Methods
2.1. Study area
The Loumbila reservoir is located at 20 km from Ouagadougou in the department of Loumbila

and in the province of Oubritenga (Figure 1). Its geographic coordinates are the following: 12°29'34" north latitude and 01°24'05" west longitude. This reservoir has a capacity of 42 million cubic meters of water retention [18]. This dam is inhabited by ichthyologic fauna that allow the development of a traditional fishing. Three families of fishes coexist: Cichlid especially those represented by *S. galilaeus* and *Oreochromis niloticus* (Linnaeus, 1758), which are numerically greater than Clariidae (*Clarias* sp.) and Centroponidae (*Lates niloticus*) (Linnaeus, 1758).

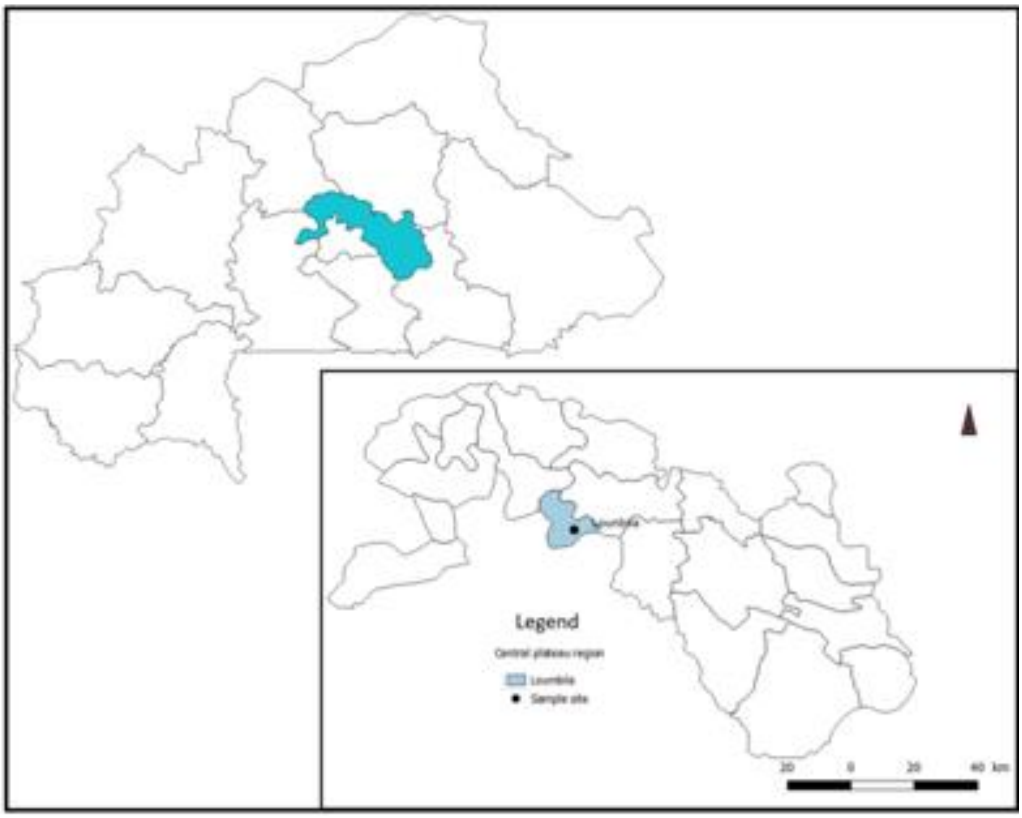

Fig 1: Loumbila reservoir, Ouagadougou, Burkina Faso

2.2. Host collection and fixing of the biological material

The host used in this work was *S. galilaeus*. That fish has great economic interest in Burkina Faso [19]. Its use is therefore widespread in development projects of the fish culture in that country. The fish examined were caught by fishermen using fishnets from March to September 2016. During that period, we harvested and autopsied 116 individuals of *S. galilaeus*, an average of 16 fishes per month. Once caught, the fish were immediately sacrificed and standard length measured using ichtyometer, to the nearest 0.1 cm. Fish, whose standard length (SL) ranged from 8.5 cm to 39.0 cm, have been placed in 4 classes sizes, which are: Class A (SL <8.5cm), Class B (8.5cm ≤ SL <10.5cm), Class C (10.5cm ≤ SL <12.5cm), and Class D (SL ≥12.5cm). Then, fish gill arches were isolated from the bucco-pharyngeal cavity by dorsal and ventral sections and then frozen in liquid nitrogen.

2.3. Survey, coloration and identification of the parasites

In the laboratory, after thawing, the parasites were detached from the gills using strong water current and transferred individually with a needle directly into a drop of ammonium picrate-glycerin mixture [20]. The preparation was then covered with a cover slip and sealed with Glyceel (Gurr, BDH Chemicals).

The identification of species and determining the degree of maturity of individuals' parasites were made under a stereoscopic microscope (Olympus CH-2). Two stages of maturity have been identified: adult or mature (testis, ovary and sclerotized pieces of the observable apparatuses copulatory) and the young or immature (presence of only male genitalia or total absence of genitalia apparatuses).

2.4. Epidemiological Approach

The terms «prevalence», «mean intensity» and «mean abundance» were defined according to [21]. The prevalence (p), expressed as a percentage, is the ratio between the number of individuals of a host species infested by a parasite species and the total number of hosts examined. The mean intensity (MI) is the ratio of the total number of individuals of a parasite species to the number of hosts infested by that parasite. Finally, the mean abundance (MA) is the ratio of the total number of individuals of a parasite species in a sample of hosts (parasitized and non-parasitized) of the sample examined. This is the average number of individuals of a parasite species per host examined. 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 (satellite) if prevalence is less than 10% [22, 23]. The mean intensity (MI) was high if MI is greater than 100; medium if MI ranged between 50 and 100; low if MI ranged between 10 and 50; and very low if MI is less than 10 as described by [24]. Statistical analysis of the data was carried out, with the aid of the SPSS 21.

2.5. Statistical Analysis

The Chi-square ($\chi 2$) test was used to compare two or more proportions and the Kruskal-Wallis test was used to compare the mean intensities of more than two samples. Man-Whitney test was used to compare the mean intensities of two different samples. All tests were considered significant at the 5% level ($p < 0.05$).

The Principal component analysis (PCA), performed using CANOCO (Canonical Community Ordination, version 4.5) [26], was used to investigate possible correlations between prevalence of monogeneans and months. Prior to ordination, prevalence of monogeneans data was transformed to better meet the assumptions of normality [25] using ln(x+1).

3. Results

3.1. Diversity of gill monogeneans

The observation of *S. galilaeus*'s gills, revealed the presence of five species of monogeneans belonging to *Cichlidogyrus* Paperna 1969 and *Scutogyrus* Pariselle & Euzet 2003 genera. These monogeneans are *Cichlidogyrus douellouae* Pariselle *et al*. 2003, *Cichlidogyrus acerbus* Dossou 1982, *Cichlidogyrus halli* (Price & Kirk 1967), *Cichlidogyrus tilapiae* Paperna 1960 and *Scutogyrus bailloni* Pariselle & Euze 1995.

3.2. Epidemiological indexes of gill monogeneans

The results in Table 1 show that *C. halli* and *C. acerbus* have the highest prevalence, respectively 64.7% and 53.5%. The means intensities and their abundances follow the same trend. However, *S. bailloni* has the lowest prevalence (12.1%), as well as its mean intensity and abundance. There was no significant difference between the mean intensity of gill monogeneans collected according to the species (Kruskal-Wallis multiple comparison test, HW = 4, dl = 4 P = 0.406).

Table 1: Prevalence, mean intensity and mean abundance of gill monogeneans of *Sarotherodon galilaeus*, sampled at Loumbila reservoir, Ouagadougou, Burkina Faso

Parasite species	Prevalence (%)	Mean intensity	Mean abundance
Cichlidogyrus acerbus	53.5	2.4	1.3
Cichlidogyrus douellouae	27.6	2.1	0.6
Cichlidogyrus halli	64.7	3.9	2.5
Cichlidogyrus tilapiae	27.6	1.8	0.5
Scutogyrus bailloni	12.1	1.3	0.2

3.3. Parasitical dynamic in relation to host sex

The variations of epidemiological indices in relation to host sex are included in Table 2. Prevalence of *C. douellouae* and *C. acerbus* in fish male (28.1% and 59.6%) and female (27.1% and 47.5%) were respectively observed. The Chi-square test did not reveal a significant difference between the infestation of male and female fish ($\chi 2 = 0.0345$, df = 1, p-value = 0.8527). In contrast, the values of prevalence and mean intensities revealed differences between fish male and female for *C. halli* (prevalence: 71.9% males and 57.6% females; intensities: 3.9 males, 3.9 females), *C. tilapiae* (prevalence: 29.8% males and 25.4 females; intensities: 2.1% males and 1.5% females), and *S. bailloni* (12.3; 11.9), respectively. The chi-square tests on the prevalence (χ^2) and the Man-Whitney test (U) on mean intensities (see Table 2), do not indicate a significant difference between the infestation of male and female fish.

Table 2: Prevalence (%), mean intensity and mean abundance in relation to host (*Sarotherodon galilaeus*) sex.

Parasite species	***Prevalence***			***Mean intensity***			***Mean abundance***	
	Male	**Female**	**χ^2**	**Male**	**Female**	**U**	**Male**	**Female**
Cichlidogyrus acerbus	59.6	47.5	0.24	2.1	2.7	0.56	1.3	1.3
Cichlidogyrus douellouae	28.1	27.1	0.89	2.1	2.0	0.82	0.6	0.5
Cichlidogyrus halli	71.9	57.6	0.21	3.9	3.9	0.86	2.8	2.3
Cichlidogyrus tilapiae	29.8	25.4	0.55	2.1	1.5	0.24	0.6	0.4
Scutogyrus bailloni	12.3	11.9	0.94	1.4	1.1	0.60	0.8	0.1

3.4. Variations of parasitism according to the size of the fish

Table 3 shows the variations of the epidemiological indices according to the size classes of *S. galilaeus*. The results revealed that prevalence's of *C. acerbus*, *C. halli* and *C. tilapiae* increase with the fish size up to 12.5 cm and decrease, but only one species (*S. bailloni*) parasitic prevalence reach it maximum earlier (fish size, 10.4) and drop to zero. The Krustal-Wallis test did not show that significant difference between parasitism level and fishes size (P= 0.392).

Table 3: Prevalence (and mean intensity) of Monogeneas in relation size class of their host (*Sarotherodon galilaeus*)

Parasite species	**Host class sizes**			
	LS < 8.5	**[8.5 - 10.5 [**	**[10.5 - 12.5 [**	**LS ≥ 12.5**
Cichlidogyrus acerbus	41.7 (1.6)	53.3 (2.6)	73.3 (2.4)	50.0 (1.0)
Cichlidogyrus douellouae	12.5 (1)	32.0 (2.3)	26.7 (1.8)	50.0(1.0)
Cichlidogyrus halli	62.5 (3.9)	64.0 (4.0)	66.7 (4)	50.0 (2.0)
Cichlidogyrus tilapiae	25 (1.3)	26.7 (2.1)	40.0 (1.3)	0.0
Scutogyrus bailloni	8.3 (1.0)	16 (1.3)	0.0	0.0

3.5. Relationship between months and parasites

The monthly variation of prevalence of infection is observed in the Figure 2. Four Groups of month variation are distinguished in relation to both PCA Axes 1 and 2 of Figure 2: Group A, represented by the month of April; Group B, including the months of August and March; Group C, bringing together the months of May, Jun and July; and Group D, composed by the month of September. The main highest prevalence found in Group B, positively correlated with Axis 1 and negatively correlated with Axis 2 is for *C.*

douellouae. In Group C, negatively correlated with Axis 1, the main highest prevalence observed are for *C. acerbus*, *C. halli* and *C. tilapiae*. Group D, negatively correlated with Axis 1 and positively correlated with Axis 2, include the high prevalence for *S. bailloni*.

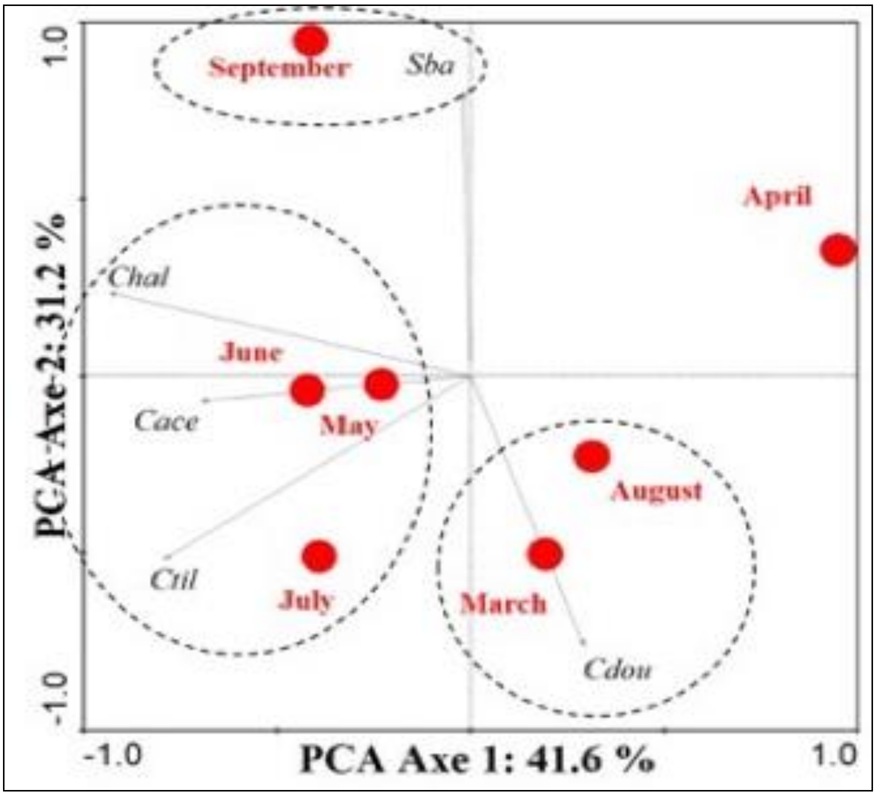

Fig 2: PCA of prevalence of monogeneans in relationship with months. *Cichlidogyrus acerbus* (Cace); *C. douellouae* (Cdou); *C. halli* (Chal); *C. tilapiae* (Ctil); *Scutogyrus bailloni* (Sba) infecting *Sarotherodon galilaeus.*

3.6. Seasonal variations in the prevalence of parasitic species

The prevalence values of the parasitic gill monogeneans of *S. galilaeus* are shown in Table 4. This table shows that prevalences of *C. douellouae*, *C. acerbus*, and *C. tilapiae* were high in dry season contrast, the prevalence of *C. halli* was high in rainy season. The assessment rate of parasitism of *C. acerbus* and *C. halli* is found to be higher than *C. douellouae*, *C. tilapiae* and *S. bailloni*. These species were considered as common (core) regarding their prevalence greater than 50% in dry season. But, in the rainy season, only the assessment of *C. halli* is higher than the other four species of monogeneans. Species of *C. douellouae*, *C. acerbus*, and *C. tilapiae* were considered intermediate (secondary) about their prevalence (10% ≤ prevalence <50%). However, *S. bailloni*, based on the prevalence, was considered as rare (satellite) (prevalence <10%). The Chi-square test (X^2) applied show that there was no significant difference between the prevalences of *C. acerbus*, *C. tilapiae*, *C. halli*, and *S. bailloni* see table 4), but there was significant in variations of epidemiological indices of *C. douellouae* between seasons ($X^2 = 6{,}68$, df = 1, P = 0.0097).

Table 4: Prevalence (%) of parasites of *Sarotherodon galilaeus* in function of seasons (dry and rainy), and Chi-square test value

Parasites	Dry	Rainy	Chi-square value X^2
Cichlidogyrus acerbus	57.4	45.8	-0.2567
Cichlidogyrus douellouae	35.3	16.7	0.009745
Cichlidogyrus halli	58.8	70.8	0.2915
Cichlidogyrus tilapiae	29.4	22.9	0.3689
Scutogyrus bailloni	14.7	8.3	0.1846

4. Discussion

The gill monogeneans of *S. galilaeus* collected at Loumbila reservoir were infected by five species of monogeneans namely: *C. douellouae*, *C. acerbus*, *C. halli*, *C. tilapiae*, and *S. bailloni*. Usually, the number of monogenean species per fish host varied [1]. This diversity of gill monogeneans of Cichlids has already been mentioned by several authors, which sampled fishes in Mékrou River at "W" National Park, Niger and in Bama near Bobodioulasso, Burkina Faso [27, 28].

This variability of parasites richness has been associated to various factors related to: the phylogeny of hosts and parasites [21, 29]; host [30]; ecology [31] and water quality [32]. The absence of some species of gill monogeneans that *S. galilaeus* is the host- type has been noted. This is the case of: *Cichlidogyrus tubicirrus magnum* encountered in Ghana [33, 34]; *C. cirratus*, found in Israel and Egypt [35, 36] and *Cichlidogyrus falcifer* described in Ghana [33]. Even if *S. galilaeus* is known as an original host of *Gyrodactylus cichlidarum*, which was described by Paperna in 1968 from Ghana [37], none of the species of this genus (*Gyrodactylus*) were found in our monogenean specimens. The absence of those species of monogeneans in our recorded could be explained by the difficulty for them to survive in the water of Loumbila reservoir. It is known that, the ecological conditions of water might lead, not only to an increase in the number of parasites but also to a decrease in parasite diversity [38].

The polyparasitism observed in this study has also been reported by various authors in mouthbreeder tilapias [39] mentioned the presence of four monogenean species on the gills of *O. niloticus*, while [40] showed that, the gill system of *Coptodon zillii* (Gervais, 1848) was parasitized by eight

monogenean species [41], who worked on *Sarotherodon melanotheron*, found three monogenean species [4] found five monogenean species colonized the gills of *O. niloticus.* That polyparasitism can be explained by the fact that in wild environment, the parasitic densities are generally weak and therefore, the niches are always available on the gill of hosts [42, 43, 44], facilitating the simultaneous colonization of the same host by several monogeneans' species.
Monogeneans parasitized individuals of all length classes and in almost all cases, the prevalence and mean intensity increased with the standard length (SL) of the fish [41] showed that specimens of *S. melanotheron* whose standard length varied between 100 and 250 mm harbored more monogeneans than those whose SL was between 50 and 100 mm [40] reported the positive significant correlation of prevalence and mean intensity of monogenean infracommunities with the total length of *C. zillii*. In contrast to these results [4], showed that the size of *O. niloticus* had no influence on the prevalence of its monogeneans gill parasites [39] justified the increase of parasitism with the size of *O. niloticus* from Melen station by the fact that, larger fish had more time to accumulate parasites than younger ones [40, 44]. According to [45] and [46], larger (older) fish offer large colonized surfaces area to parasites. This study also does not agree with [43], who stipulated that the volume of water that passes through the gills of larger fish is more important and thus conveys more oncomiracidium. We think that considering the mode of infestation of Monopisthocotylea monogenean, the volume of water passing through the gills should not influence the prevalence or intensity parasitic on those biotopes. In fact, the infesting larva settles first on the skin before scrawling and settling on the gills [47].
The study of parasitism according to the sex of *S. galilaeus*, show no significant difference in prevalence, mean intensities and abundances of monogeneans was observed between male and female fish. This indicates that they are infected in the same way. The absence of the influence of the sex of the fish on the infection has already been revealed by [41] and [4] respectively in the gill monogeneans of *S. melanotheron* and *O. niloticus*. Moreover, in the Padda Dam (South Africa) [48], observed no sex influence on the infection of *Pseudocrenilabrus philander* (Weber, 1897) gill filaments by *Cichlidogyrus philander* Douëllou, 1993. These observations corroborate with the idea that very few parasites species have a preference in relation to the sex of the host [49]. However, some studies have revealed that monogenean infection sometimes correlate with sex of fish host [51, 40].
About the monthly infestation, all species of monogeneans identified have been present all months in the host-fish, except *C. tilapiae*, *C. douellouae* and *S. bailloni* which were absent during some months. Thus, the host-fish is vulnerable at any period. Under the tropics, analogous remarks have been reported. In fact, in Cameroon [24], considered eutrophic basin in urban areas and showed that in this lentic environment, the monogeneans gill parasites of the fish *Hemichromis fasciatus* Peters, 1857 appear all months. Later [51], studied the temporal structure of six species gill parasites *Enteromius martorelli* (Roman, 1971) of the Mfoulou stream (under-affluent of the Sanaga river) in the surrounding areas of Yaoundé. That study conducted in oligotrophic water showed that, except for the species of monogeneans *Dactylogyrus maillardi* Birgi & Lambert, 1987 absent during the month of July, all species of xeno community were present on that Cyprinid during all months. The same remarks were made in Nigeria [52] and Burkina Faso [4] respectively with species of monogeneans of *Clarias angularis* (Linnaeus, 1758) and *O. niloticus*, that appear all months.
The analysis of the results on the impact of the seasons on parasitism of gill monogeneans, shows that the infection rate of *Cichlidogyrus halli* (Price and Kirk 1967) obtained from the 116 *S. galilaeus* of Loumbila reservoir decreases during the dry season. This depression corresponds to worm mortality phases. This mortality occurs as water temperatures become higher in the dry season. Similar contact has already been found in several streams in other fish of the family Cichlidae. Indeed [53], has observed in Ghana a seasonal variation of the genus *Cichlidogyrus* Paperna, 1960 in *Tilapia* sp. with a quasi-disappearance of certain parasites during certain dry months. In addition, in the Yaoundé Municipal Lake (Cameroon) [24], reported the mortality of adult parasites in *H. fasciatus* when water temperatures reach 25-26 °C. As for *C. douellouae*, its infection rate is significantly high in the dry season. As it was stated that host range and host-specificity in *Cichlidogyrus* spp. parasitizing Cichlidae fish is determined by the host's phylogenetic position, rather than by a shared ecological niche [54].

5. Conclusion
In the present study, we revealed that *S. galilaeus* harbored different species of monogeneans over their gills. It also revealed that the effects of the months, the size and the sex of the fish do not have an impact on the infection. Indeed, *S. galilaeus* can be infected by the different species of monogeneans indifferently of the month of the year, the size and the sex of the fish. Moreover, this study indicated that the season has an effect on the parasitism of *C. douellouae*. The information obtained may provide strategies in aquaculture management to reduce potential economic losses of *S. galilaeus* caused by parasitic infection.

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7. References
1. Le Roux LE, Avenant-Oldewage A. Checklist of the fish parasitic genus *Cichlidogyrus* (Monogenea), including its cosmopolitan distribution and host species, African Journal of Aquatic Science. 2010; 35(1):21-36.
2. Boungou M. Diversités des parasites branchiaux (Myxosporidies, Monogènes et Copépodes) de quelques poissons consommés au Burkina Faso: systématique et dynamique du taux d'infestation. Thèse de doctorat unique de l'Université de Ouagadougou. 2007, 147.
3. Boungou M, Kabré GB, Bilong-Bilong CF, Nack J, Sawadogo L. Observations on some monogeneans parasites of *Oreochromis niloticus* (Linne, 1757) (PISCES, Cichlidae) in Burkina Faso (West Africa). RASPA. 2006; 4(3, 4):149 -156.
4. Boungou M, Kabre GB, Marques A, Sawadogo L. Dynamics of population of Five Parasitic Monogeneans of *Oreochromis niloticus* Linné, 1757 in the Dam of Loumbila and possible Interest in intensive pisciculture. Pak. J. Biol. Sci. 2008; 11(10):1317-1323.
5. Rohde K, Heap M, Hayward CJ, Graham KJ. *Calitotyle australiensis* n.sp. and *Calitotyle* sp. (Monogenea, Monopisthocotylea) from the rectum and rectal glands

and *Rugogaster hycholagi* Shell, 1973 (Trematoda, Apisdogastrea from the rectal glands of holocephalans off the coast of southeastern Autralia. Syst. Parasitol. 1992; 21:69-79.
6. Pariselle A, Euzet L. Five new species of *Cichlidogyrus* (Monogenea: Ancyrocephalidae) from *Tilapia brevimanus*, *T. buttikoferi* and *T. cessiana* from Guinea, Ivory Coast and Sierra Leone (West Africa). Folia Parasitol. 1998; 45:275-282.
7. Whittington ID, Cribb BW, Hamwood TE, Halliday JA. Host-specificity of monogenean (platyhelminth) parasites: a role for anterior adhesive areas. Int. J. Parasitol. 2000; 30:305-320.
8. Post G. Animal parasite of fishes. In: T.F.H. (2nd Ed). Neptune City. Textbook of Fish Health. 1987, 159-214.
9. Obiekezie AI, Taege M. Mortalities in hatchery-reared fry of the African catfish, *Clarias gariepinus* (Burchell) caused by *Gyrodactylus groschafti* Ergens, 1973. Bull. Eur. Fish Pathol. 1991; 11(2):82-85.
10. Aloo PAA. Comparative study of helminthes parasites from the fish *Tilapia zillii* and *Oreochromis leucostictus* in Lake Naivasha and Oloidien. J. Helminthology. 2002; 76:95-102.
11. Buchmann K, Lindenstom T. Interactions between monogenean parasites and their fish hosts. Int. J. Parasitol. 2002; 32:309-319.
12. Ogawa K. Impacts of diclidophorid monogenean infections on fishes in Japan. Int. J. Parasitol. 2002; 32(3):373-380.
13. Kirk RS. The impact of *Anguillicola crassus* on European eels. Fish. Manag. Ecol. 2003; 10:385-394.
14. Obiekezie AI. The principal pathogens and diseases of cultured fishes in Nigeria. In: IFS (Eds). Aquaculture in Africa. 1991, 197-207.
15. FAO, Fisheries and Aquaculture Department. The state of world fisheries and aquaculture 2008. Food and agriculture organization of the United Nations, Rome. 2009
16. Sures B. The use of fish parasites as bioindicators of heavy metals in aquatic ecosystems; A Review. Aquat. Ecol. 2001; 35:245-255.
17. Dudgeon D, Arthungton AH, Gessner MO, Kawabata Z, Knowloer DJ, Lévêque C *et al*. Freshwater biodiversity: important, threats, status and conservation challenge. Biol. Rev. 2006; 81(2):163-82.
18. ONEA, CASST Rapport technique: Bathymétrie et pose de balises du barrage de Loumbila. ONEA et CASST. 2004, 35.
19. Baijot E, Moreau T, Bouda S. Aspects hydrobiologiques et piscicoles des retenues d'eau en zone soudano-sahélienne: Le cas du Burkina Faso. Ede; Bruxelles : CTA ; CEE. 1994, 250.
20. Malmberg G. On the occurrence of *Gyrodactylus* on Swedish fishes. In: Swedish, with description of species and a summary in English. Skrift. Sodra Sverig. Fiskerifor. 1957, 19-76.
21. Bush AO, Lafferty KK, Lotz JM, Shostak AW. Parasitology meets ecology on its own terms: Margolis *et al*. revisited. J. Parasitol. 1997; 83:575-583.
22. Koskivaara M, Valtonen ET. *Dactylogyrus* (Monogenea) communities on the gill of roach in three lakes in Central Finland. Parasitology. 1992; 104:263-272.
23. Valtonen ET, Holmes JC, Koskivaara M. Eutrophication, pollution and fragmentation: effects on parasite communities in roach (*Rutilus rutilus*) and perch (*Perca fluviatilis*) in four lakes in Central Finland. Can. J. Fish. Aquat. Sci. 1997; (54):572-585.
24. Bilong Bilong CF, Njine T. Dynamique de populations de trois monogènes parasites d'*Hemichromis fasciatus* Peters, 1858 dans le lac municipal de Yaoundé, et intérêt possible en pisciculture intensive. Ann. Fac. Sci. Univ. Ydé I, Série Sci. Nat. et Vie. 1998; 34(2):295-303.
25. Fischerand JR, Paukert CP. Habitat relationships with fish assemblages in minimally disturbed Great Plains regions," Ecology of Freshwater Fish. 2008; 17(4):597-609.
26. Ter Braak CJF, Similauer P. Canoco 4. Cambridge University Press, USA. 2003, 242.
27. Pariselle A. Diversité, spéciation et évolution des monogènes branchiaux de Cichlidae en Afrique de l'Ouest. PhD Thesis: University of Montpellier II, France. 1996, 199.
28. Pariselle A, Bilong Bilong CF, Euzet L. Four new species of *Cichlidogyrus* Paperna, 1960 (Monogenea, Ancyrocephalidae), all gill parasites from African mouthbreeder tilapias of the genera *Sarotherodon* and *Oreochromis* (Pisces, Cichlidae), with a redescription of *C. thurstonae* Ergens, 1981. Syst. Parasitol. 2003; 56:201-201.
29. Sasal P, Morand S, Guegan JF. Parasite species richness for fish of Mediterranean Sea. Mar. Ecol. Progr. Ser. 1997; 149:61-71.
30. Morand S, Poulin R, Hayward C. Aggregative and species co-existence of ectoparasites of marine fishes. Int. J. Parasitol. 1999; 29:663-672.
31. Zharikova TI. The adaptative reactions of the gill ectoparasites of the bream (*Abramis brama*) and the white bream (*Blicca bjoerkna*) onto the anthropologenic factor influence in the Ivan'kovo reservoir. Parasitol. 2000; 34(1):50-55.
32. Galli P, Crosa G, Mariniello L, Ortis M, D'Amelio S. Water quality as a determinant of the composition of fish parasite communities. Hydrobiologia. 2001; 452:173-179.
33. Paperna I. *Onchobdella* n. gen. New genus of monogenetic trematodes (Dactylogyridae, Bychowski, 1933) from cichlid fish from West Africa. Proc. Helminth. Soc. Wash. 1968b; 35(2):200-206.
34. Paperna I. Monogenetic trematodes of the fish of the Volta basin and South Ghana. Bulletin de l'Institut Français d'Afrique Noire. 1969; 31A:840-880.
35. Paperna I. The metazoan parasite fauna of Israel inland water fishes. Bamidgeh. 1964; 16:3-66.
36. El-Naggar MM, Khidr AA. Survey of population dynamics of *Cichlidogyrid* monogeneans from the gills of three Tilapia spp. from Damietta branch of the River Nile in Egypt. Proceedings of the Zoological Society of the Arab Republic of Egypt. 1986; 12:275-286.
37. Přikrylová I, Matějusová I, Musilová N, Gelnar M, Harris PD. A new *gyrodactylid* (Monogenea) genus on gray bichir, *Polypterus senegalus* (Polypteridae) from Senegal (West Africa). J Parasitol. 2009; 95(3):62-67
38. Kaouachi N, Boualleg C, Bensouilah M, Marchand B. Monogenean parasites in Sparid fish (*Pagellus genus*) in eastern Algeria coastline. Afr. J Microbiol. Res. 2010; 4:989-993.
39. Tombi J, Akoumba JF, Bilong Bilong CF. The monogenean community on the gills of *Oreochromis*

niloticus from Melen fish station in Yaounde, Cameroon. Int. J Mod. Biol. Res. 2014; 2:16-23.
40. Ibrahim MM. Variation in parasite infracommunies of *Tilapia zillii* in relation to some biotic and abiotic factors. Int. J Zool. Res. 2012; 8(2):59-70.
41. Blahoua KG, N'Douba V, Tidiani K, N'Guessan KJ. Variations saisonnières des indices épidémiologiques de trois monogènes parasites de *Sarotherodon melanotheron* (Pisces: Cichlidae) dans le lac d'Ayamé (Côte d'Ivoire). Sci. Nat. 2009; 6(1):39-47.
42. Gutiérrez PA, Martorelli SR. Hemibranch preference by freshwater monogeneans a function of gill area, water current, or both? Folia Parasitologica. 1999; 46:263-266.
43. Simkova A, Verneau O, Gelnar M, Morand S. Specificity and specialisation of congeneric Monogeneans parasitizing Cyprinid fish. Evolution. 2006; 60:1023-1037.
44. Sasal P, Trouvé S, Müller-Graf C, Morand S. Specificity and host predictability: a comparative analysis among monogenean parasites of fish. J. Anim. Ecol. 1999; 68:437-444.
45. Cable J, Tinsley RC, Harris PD. Survival and embryo development of *Gyrodactylus gasterostei* (Monogenea: Gyrodactylidae). Parasitology. 2002; 124:53-68.
46. Bilong Bilong CF, Tombi J. Hétérogénéité du système branchial de *Barbus martorelli* (Poisson Cyprinidae) et modèle de croissance. J.C.A.S. 2004; 4(3):211-218.
47. Combes C, Jourdane J. Taxonomy, Ecology and Evolution of Metazoan Parasites. 1st Edn. University of Perpignan Press, Perpignan. 2003, 380-396.
48. Le Roux LE, Avenant-Oldewage A, Walt van der FC. Aspects of the ecology of *Cichlidogyrus philander* collected from *Pseudocrenilabrus Philander philander* from the Padda Dam, Gauteng, South Africa. Afr. Zool. 2011; 46:103-116.
49. Rohde K. Ecology of marine parasites. An introduction to marine parasitology, 2nd Ed. Cab International, Wallingford, Oxon, 1993.
50. Silan P, Birgi E, Louis C, Clota F, Mathieu A, Giral L. Aquaculture and ichtyoparasitology : Action in vitro of nitroxinil (anthelmintique) on *Diplectanum aequans*, gill parasite Monogeans of *Dicentrarchus labrax*. Rec. Méd. Vét. 1996; 172:401- 407.
51. Bilong-Bilong CF, Tombi J. Temporal structure of a component community gill parasites of *Barbus martorelli* (Roman) (freshwater Cyprinidae) in the Centre province, Cameroon. Cam. J. Biochem. Sc. 2005; 13:9-18.
52. Obiekezie AI, Taege M. Mortalities in hatchery-reared fry of the African catfish, *Clarias gariepinus* (Burchell) caused by *Gyrodactylus groschafti* Ergens, 1973. Bull. Eur. Fish Pathol. 1991; 11(2):82-85.
53. Prah SK. Observation on parasitic infection in freshwater fish in Ghana. In: Obeng, L.E., Ed. Academy of Sciences. Man-made lakes, the Accra Symposium. Accra University Press for Ghana. 1969; 261-268.
54. Pariselle A, Van Steenberge M, Snoeks J, Volckaert FAM, Huyse T, Vanhove MPM. Ancyrocephalidae (Monogenea) of Lake Tanganyika: Does the Cichlidogyrus parasite fauna of *Interochromis loocki* (Teleostei, Cichlidae) reflect its host's phylogenetic affinities? Contributions to Zoology. 2015; 84(1):25-38.