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Full Length Research Paper

Structure and population dynamics of myxobolus infections in wild and cultured *Oreochromis niloticus* Linnaeus, 1758 in the Noun division (West-Cameroon)

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Myxosporidian parasites of *Oreochromis niloticus* Linnaeus, 1758 from the Noun River at Kouoptamo and the Foumban fish ponds in west Cameroon, were investigated from May 2008 to June 2009. Out of 537 Tilapia (267 cultivated and 270 wild) examined, 64.8% (n=173) specimens from the fish farming and 61.1% (n=165) from the Noun River harbored Myxosporean parasites. A total of ten parasite species were found. *Myxobolus kainjiae*, *Myxobolus sarigi* were scarce in both study sites; *Myxobolus Tilapiae*, *Myxobolus equatorialis* scarce in Foumban and Kouoptamo, respectively. *M. agolus*, *M. brachysporus*, *M. camerounensis*, *M. equatorialis*, *Myxobolus Heterosporus*, *Myxobolus israelensis* were secondary in the two sites. *M. Tilapiae*, *M. equatorialis* appeared secondary in the Noun River and the fish ponds respectively. Myxosporean spores were most encountered in the kidney (61.3 and 49.0%, respectively in cultured and wild fish) and the spleen (50.5% in Foumban and 47.5% in Kouoptamo) but no host sex preference was found. In the Foumban fish farm site, high significant infection rate was observed for *M. tilapiae*, *M. camerounensis* and *M. israelensis* during the rainy season, while in the Noun River, no significant seasonal effect was found. Older hosts were significantly most infected at the fish ponds while youngs Tilapia were most commonly infected in the River.

Key words: Myxosporean, *Oreochromis niloticus*, prevalence, fish-farm, Noun River, Cameroon.

INTRODUCTION

Myxosporean (Myxozoa: Myxosporea) are primarily fish parasite (Fomena et al., 2010; Eiras et al., 2010). With their pathogenic potentials, they can affect growth (Longshaw et al., 2010), reproduction (Obiekezie and Okaeme, 1990) and involve epizooties being able to cause the death of the host (Gbankoto et al., 2001; Feist anand Longshaw, 2005). Economic losses caused by these parasites in aquaculture have been well documented (Barassa et al., 2003; Lom and Dykovà, 2006). According to FAO (2008), fish represents nearly 50% of animal proteins intake of many countries in Africa. In addition, the economic interest of *Oreochromis niloticus* and its generalized use in the development of fish farming projects in Africa, make this species one of most important. In natural environment, parasitism is frequent and the parasitic diseases are expressed only when the conditions of the environment allow the proliferation of the parasites (Odewage and Van As, 1987; Martins et al., 1999). In fish farming medium on the other hand, hosts containment increase the parasitic load, but also maintain the development of parasite life cycle (Hedrick, 1998; Abakar et al., 2007; Milanin et al., 2010). Under natural environment or during farming (Feist and Longshaw, 2006; Eiras et al., 2008), the Genus *Myxobolus* Bütschli, 1882 is the largest group among Myxosporean with approximately 790 valid species (Eiras et al., 2005; Lom and Dykovà, 2006; Umur et al., 2010). Many of these species are potential pathogens of fish. Fomena and

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Bouix (1997) counted ten species of Myxosporean of the genus *Myxobolus* infesting various organs of *Oreochromis niloticus* and Abakar et al. (2007) identified 11 species of the same genus on *Oreochromis niloticus* and *Sarotherodon galilaeus* in Chad. These findings corroborate the idea of Combes (1995) who revealed that pathogenic effect is scarcely due to only one parasitic species.

In Cameroon, studies on Myxosporean fishes parasites are essentially descriptive (Fomena et al., 2008, 2010). Data provided by few authors such as Fomena (1995) in fish ponds, Tombi and Bilong Bilong (2004) and Lekeufack Folefack (2010) in natural environment; highlight aspect of the structure and the population dynamics of this group of parasites.

In this work, we study the structure and population dynamics of Myxosporean that infest *O. niloticus* Linneaus, 1758 under breeding situations (Fish ponds at Foumban) and in nature (River Noun at Kouoptamo) in the western region of Cameroon. The objective of this study is to determine the occurrence of Myxosporean parasites of *O. niloticus* in the two different biotopes. We also investigated the factors (seasonal variation, size and sex of the host) which can influence the parasitic prevalence.

MATERIALS AND METHODS

From May, 2008 to June, 2009, 537 fishes among which 267 taken in the fish ponds of the Zootechnical and Veterinary Training centre of Foumban and 270 captured in the river Noun (tributary of Mbam river) at Kouoptamo were examined. The head quarter of the survey region Foumban (5°43' 54.5''N; 10°54' 09.8''E) and the sampled locality Kouoptamo (5°39' 17'' N, 10°37' 1'' E) belong administratively to the west region of Cameroon (Figure 1). Its climate belongs to the tropical mountain subset characterized by two seasons: a short dry season from November to February and a long rainy season from March to October. The temperatures in this region is definitely lower than in other parts of the country with an annual average varying between 19.8 and 22°C. We can note an oceanic influence resulting in important precipitations in the locality. The mean annual rainfall varies between 1313.7 and 1988.6 mm. The sub highland forest is often degraded by coffee plantations and other food crops (Olivry, 1986). Monthly, Fish were captured during the day and night, using a fish net or fishing canes. Immediately after harvesting, the captured fish were stored in a formalin solution (10%) until further examination. These fishes were identified according to Stiassny et al. (2007). At the laboratory, each fish was measured to the closest millimeter using a slide caliper of the brand Stainless Hardened. The sex was determined after dissection and examination of the gonads based on the work of Obiekezie and Okaeme (1990)

The external (eyes, skin, operculum, fins, scales) and internal organs (gills, liver, intestine, stomach, kidneys, spleen, gall bladder, urinary bladder, ovaries) were first examined macroscopically with the naked eye and then with a Olympus Bo 61 stereoscopic microscope to search for cysts. The smears of the kidneys, spleen, liver and gonad were mounted and examined with objective 100X of the light microscope to search for spores. Cysts found were crushed between slide and cover glass and their content identified with the objective 100X of the microscope Wild M-20.

The various parasitic species were identified according to Lom and Arthur (1989). The sample of studied hosts was grouped by classes of size based on the modified formula of Yule (Mouchiroud, 2002). Prevalence (P) is calculated as being the number of individuals of a host species infested by a parasite species divided by the number of hosts examined for that parasite species: it is often expresses as a percentage (Margolis et al., 1982). Analysis of the status of each parasitic species was made according to Valtomen et al. (1997). Thus, the species are qualified as frequent (or common or principal) if $P > 50\%$. Less frequent (or secondary or intermediate) if $10\% \leq P \leq 50\%$, and scarce (or satellite) if $P < 10\%$. Comparison of parasitic prevalence of the various parasite species was made using the χ^2 test. The security level retained in our analysis is 95%, that is, error probability < 0.05.

RESULTS

Population structure of *Oreochromis niloticus*

The size (LS) of *O. niloticus* (n_1=270 and n_2=267) sampled respectively in Kouoptamo and Foumban varied from 20 to 226 mm in the natural environment, and from 35 to 175 mm in fish pond medium. These fishes were grouped in 3 classes based on size of amplitude 50 mm (Figure 2). The modal class is (70-120) in the two study sites (Foumban and Kouoptamo). Approximately 92.2% (n=249) and 64.8% (n=173) individuals examined respectively in natural environment and in breeding situation belonged to class (70, 120). The sex ratio is skewed toward females (1.03) in fish pond and toward males (0.82) in river Noun.

Species richness and status of parasitic species

Except *Myxobolus nounensis*, which was collected only among hosts captured in the Noun River, the fauna of Myxosporeans collected is identical in fish ponds and in Noun river (Table 1). Therefore, ten species of Myxosporeans have been identified in natural environment while nine species were recorded in breeding fish ponds (Figure 3).

In the two biotopes, the number of parasitic species carried by each individual host varied from 1 to 6 (Figure 4). 37% (that is, 99/267 individuals hosts) at Foumban carried 4 to 6 species of parasites, whereas 49% (that is, 132/270 individuals) of the population of hosts examined in the natural environment were infested by 1 to 3 species of parasites. 38.8 (105/270) and 35.2% (94/267) individuals hosts examined respectively in Kouoptamo and Foumban were free of Myxosporidian.

In the two biotopes, *Myxobolus camerounensis*, *Myxobolus agolus*, *Myxobolus brachysporus*, *Myxobolus israelensis* and *Myxobolus heterosporus* are secondary ($10 \leq P \leq 50\%$). However, *Myxobolus Tilapiae* is scarce ($P < 10\%$) in Foumban and secondary in Kouoptamo, whereas *Myxobolus equatorialis* is secondary in Foumban and rare in Kouoptamo. *M. sarigi* and *M kainjiae* are rare in the two study sites. On the other hand,

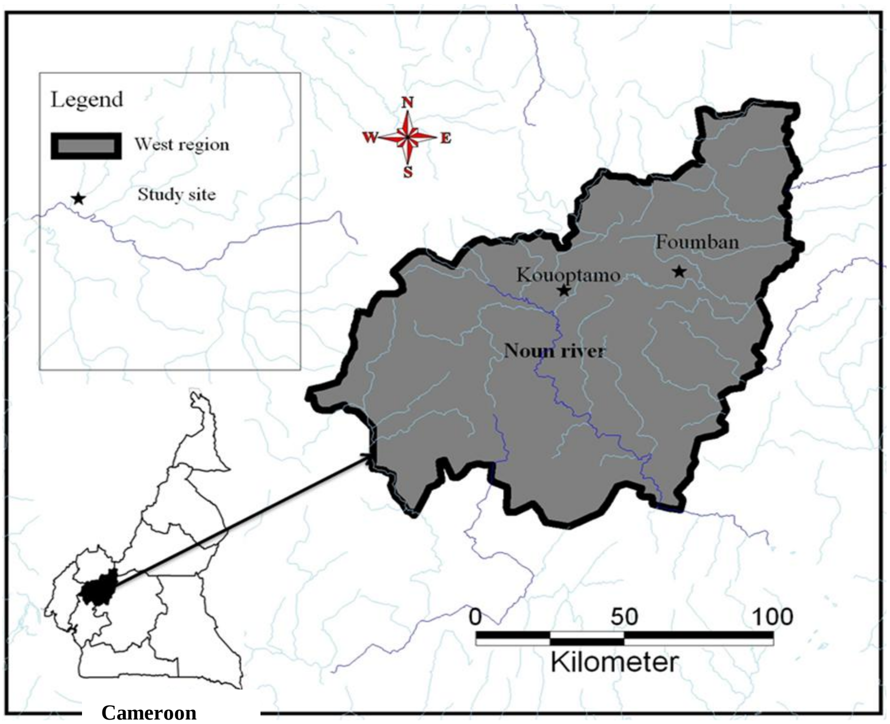

Figure 1. Cameroon map showing the study area.

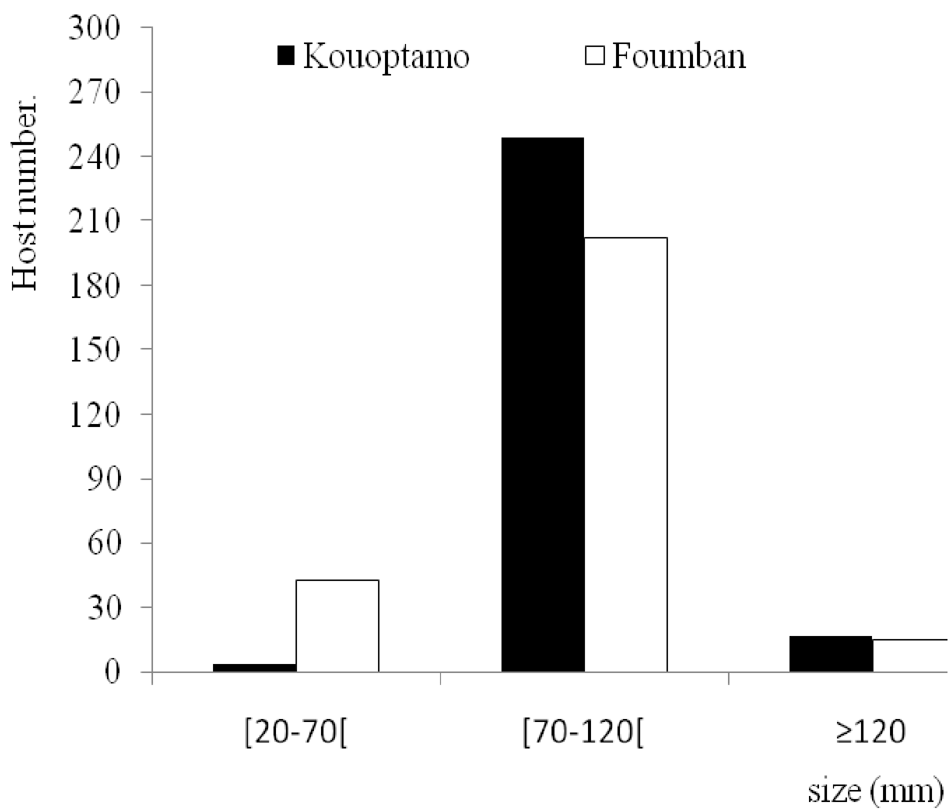

Figure 2. Host distribution (*O. niloticus*) as a function of the host size class at Kouoptamo and Foumban.

Table 1. Comparison of the Myxosporean infection rate (%) in *O. niloticus* at Foumban and Kouoptamo.

Parasite species	Locality			
	Foumban	Kouoptamo	χ^2	P
M. agolus	31.8 (85) **	12.2(33) **	30.1	0.001
M. brachysporus	48.3(129) **	49.3(133) **	0.105	0.827
M. camerounensis	19.5(52) **	16.0(16) **	22.8	0.001
M. heterosporus	40.8(109) **	15.2(41) **	43.83	0.001
M. israelensis	39.0(104) **	16.3(44) **	34.15	0.001
M. equatorialis	15.0(40) **	4.4(12) *	17.04	0.001
M. tilapiae	8.6(23) *	16.7(45) **	7.87	0.005
M. kainjiae	1.9(5) *	1.5(4) *	1.25	0.724
M. sarigi	2.3(6) *	3.4(9) *	0.58	0.445
M. nounensis	0	14.4(39) **	-	-

The rate infections are followed in brackets by the number of hosts species harboring at least one parasitic species of the population examinated. **, secondary species; *, scarce species. statistical analyses is not doing concerning *M. nounensis.*

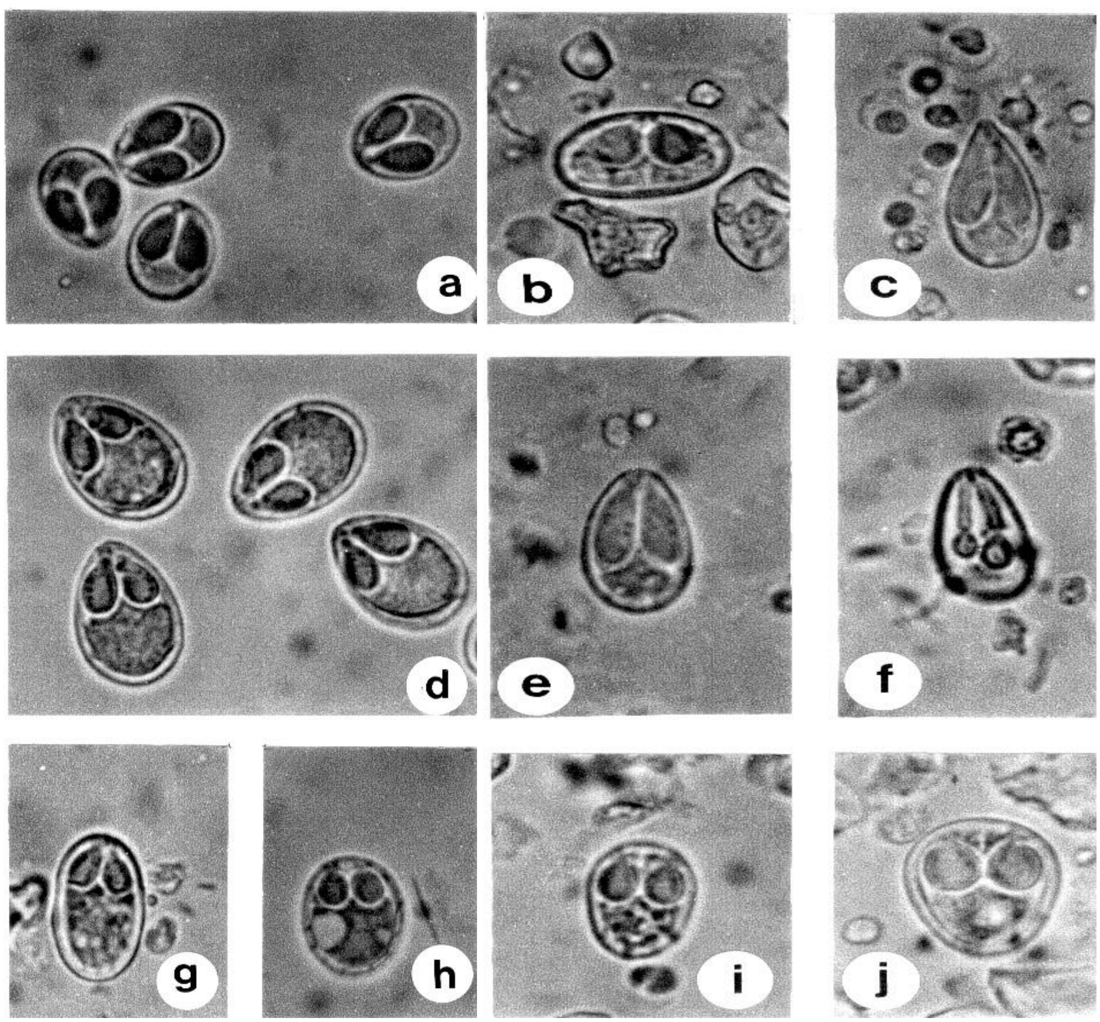

Figure 3. Spores of different species of Myxobolus studied. a: *Myxobolus agolus* (X 1500); b: *M. brachysporus* (X 1500); c: *M. heterosporus* (X 1500); d: *M. camerounensis* (X1500); e: *M. israelensis* (X 1500); f: *M. equatorialis* (X 1500); g: *M. tilapiae* (X 1500); h: *M. kainjiae* (X 1500); i: *M. sarigi* (X 1500); J: *M. nounensis* (X 1500).

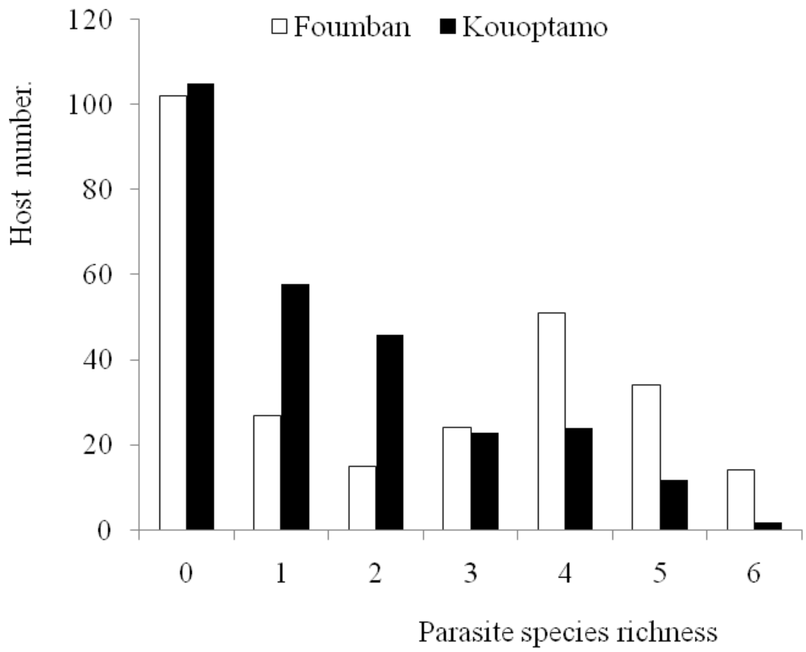

Figure 4. Host distribution (*O. niloticus*) as a function of the Myxosporean species richness.

Table 2. Percentage of parasitize organs by Myxosporean in wild and cultured *O. niloticus* at Foumban/kouoptamo; *M. Myxobolus.*

Parasite species	Parasitize organs									
	Gill	Liver	Gonad	Operculum	Skin	Spleen	Kidney	eyes	χ^2 Value	P Value
M. agolus	1.8/0	2.7/2.7	0/0	0/11	0/0	22.2/8.3	34.6/10.8	0/0	χ^2= 46.7	P< 0.001
M. brachysporus	0/0	3.1/2.7	0/0	0/0	0/0	43.8/40.0	51.9/40.9	0/0	χ^2= 2.38	P= 0.12
M. camerounensis	23.7/4.0	0/0	0/0	1.5/3.3	11.1/0	0.4/0.4	0.9/0.8	26,9/0	χ^2=32.36	P< 0.001
M equatoriais	0/0	0/0	0/0	0/0	0/0	5,8/4.2	10.0/3.1	0/0	χ^2=7.49	P=0.06
M. heterosprus	0/0	2.2/1.6	0/0	0/0	0/0	29.2/12.8	39.0/15.4	0/0	χ^2=40.0	P< 0.001
M. israelensis	0/0	3.6/1.2	0/0	0/0	0/0	32.9/13.9	39.4/14.7	0/0	χ^2=51.4	P< 0.001
M. kainjiae	0/0	0/0	2.5/1.3	0/0	0/0	0/0	0/0	0/0	χ^2=1.22	P= 0.26
M. sarigi	0/0	0/0	0/0	0/0	0/0	0.8/1.9	1.7/1.9	0/0	χ^2= 1.7	P= 0.18
M. tilapiae	0/0	0/0	0/0	0/0	0/0	2.1/9.4	4.8/11.6	0/0	χ^2=21.0	P< 0.001

M. nounensis is secondary and is present only in the River Noun.

Comparison of infestations rates of *Oreochromis niloticus* in the two study sites.

Difference between the prevalence of *M. brachysporus* (χ^2=0.105; P=0.82), *M. sarigi* (χ^2=0.58; P=0.44) and *M. kainjiae* (χ^2=1.25; P=0.72) in the natural environments and the fish ponds are statistically not significant. *M. agolus*, *M. camerounensis*, *M. equatorialis*, *M. heterosporus* *M. tilapiae*, and *M. israelensis* have statistically different rates of infestation (P < 0.001) between the two study sites. *M. nounensis* was not found in Foumban (Table 1).

Parasitism according to the infected organs

The various species of Myxosporean infest the same organs in the two biotopes except *M. camerounensis* (collected on the skin and eyes) and *M. agolus* found in the gills of *O. niloticus* in fish ponds (Table 2). The highest prevalence was observed in the kidneys (61.3 and 49.0%, respectively in fish ponds and natural

Table 3. Infection rate (%) of Myxosporean parasite in *O. niloticus* as a function of the size class at Foumban and Kouoptamo.

		Size class				
Parasites species	**Localities**	**(20-70)**	**(70-120)**	**≥ 120**	**χ^2**	**P**
M. agolus	Foumban	30.6	25.0	71.4	29.53	0.001
	Kouoptamo	50.0	11.2	13.3	5.6	0.061
M. brachysporus	Foumban	66.7	40.8	714	16.75	0.001
	Kouoptamo	100	51.0	40.0	6.4	0.04
M. camerounensis	Foumban	22.2	17.3	28.6	19.33	0.001
	Kouoptamo	0.0	7.3	1.7	2.88	0.24
M. equatorialis	Foumban	11.1	14.3	22.0	2.2	0.33
	Kouoptamo	0.0	2.9	10.0	5.6	0.56
M. heterosporus	Foumban	2.8	0.5	11.4	16.11	0.001
	Kouoptamo	50.0	16.0	15.0	3.4	0.18
M. israelensis	Foumban	69,9	31.1	57.1	19.33	0.001
	Kouoptamo	50.0	16.0	15.0	3.4	0.18
M. kainjiae	Foumban	0.0	2.6	0.0	1.84	0.34
	Kouoptamo	25.0	3.9	0.0	8.09	0.18
M. sarigi	Foumban	2.8	0.5	11.4	16.16	0.001
	Kouoptamo	25.0	3.9	0.0	8.09	0.18
M. tilapiae	Foumban	2.8	9.7	8.6	1.85	0.4
	Kouoptamo	100	13.6	21.7	22.5	0.001

M, Myxobolus; ddl= 2.

environment) and in the spleen (50.5% in Foumban and 47.5% in Kouoptamo). Variation of the rates of infestation according to the infested organs (gills, skin, spleen, gonad, operculum, kidney, eyes and liver) shows a statistically significant difference in Foumban (χ^2=274.20; *P< 0.01*) and in Kouoptamo (χ^2=427.4; *P<0.001*). *M. camerounensis* with 4 organs (gills, operculum, kidneys and spleen) parasitized in natural environment and 6 organs (gills, operculum, kidneys, spleen, skin and eyes) infested in fish ponds is the species which presents the largest spectrum of target organs in the two biotopes. The parasitic rates of infestation are statistically higher (χ^2=8.48; P=004) in the organs of *O. niloticus* in fish ponds than in the natural milieu. *M. agolus* (χ^2= 46.7; *P<0.001*); *M. heterosporus* (χ^2=40.0; *P<0.001*) and *M. israelensis* (χ^2=51.4; *P<0.001*) presents the highest prevalence in the kidneys and spleen of *O. niloticus* in fish pond than in natural environment. On the other hand, *M. tilapiae* show a higher percentage of infestation (χ^2= 21.0; *P<0.01*) in natural environment than in fish pond in these same organs. The gills of *O. niloticus* are parasitized by *M. camerounensis* in Foumban (χ^2=28.4; *P<0.01*) than in Kouoptamo. In the two situations, the rare species *M. kainjiae*, infests only the gonads whereas the majority of species following the example of *M. brachysporus*, *M. israelensis*, *M. heterosporus*, *M. tilapiae*, *M. sarigi* and *M. equatorialis* infect two organs (kidneys and spleen).

Parasitism according to the size of the host

The parasitic infection rates are statistically not significant (χ^2=3.38; ddl= 2; P=0.18) in the various size of classes in natural environment (Table 3). In breeding situation on the other hand, the bigger fish (LS≥ 120mm) are generally infested (χ^2=5.84 ddl=2; P=0.054) than small hosts and those of intermediate size. The comparison of the various sets of class between the two sites shows that the parasitic rates of infection are significantly higher

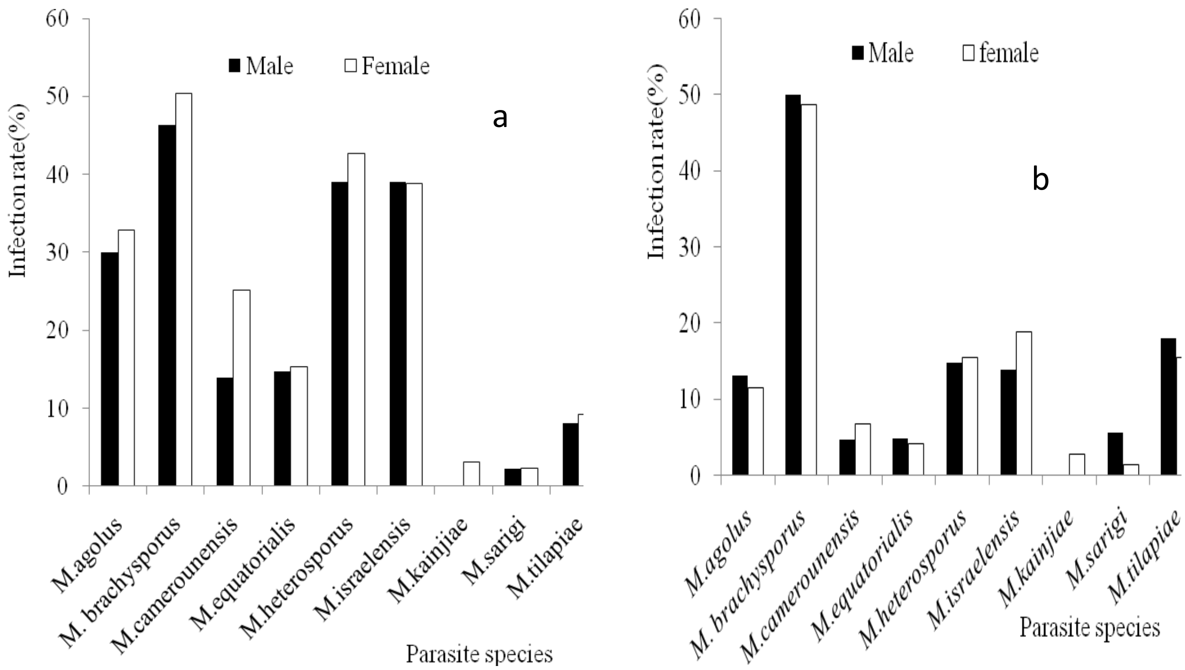

Figure 5. Parasitism (%) as a function of the sex of *O. niloticus* at Foumban (a) and Kouoptamo (b).

(*P<0.001*) among the bigger fish in fish pond than in the natural environment. *M. agolus* (χ^2=32.9; *P<0.001*); *M. brachysporus* (χ^2=8.7; P=0.003); *M. heterosporus* (χ^2= 27.9; P<0.001) *M. israelensis* (χ^2=18.5; *P<0.01*) and *M. sarigi* (χ^2=7.15; P=0.007) infest mostly the bigger fish in fish ponds than in the natural environment. *M. agolus* (χ^2=5.6; P=0.06); *M brachysporus* (χ^2=6.4; P=0.04), *M. israelensis* (χ^2=16. 06; *P<0.001*) and *M. sarigi* (χ^2=22.5; *P<0.001*) infest preferentially young fishes in the River noun than in fish ponds.

Parasitism according to the sex of the host

The various species of Myxosporean collected parasitize indifferently the males and females in fish pond (χ^2= =2.461; P= 0.117) than in natural situation (χ^2= 0.508; P= 0.476) (Figure 5). The hosts of the two sexes are statistically (*P<0.001*) more parasitized in the fish ponds than in River Noun by *M. camerounensis*, *M. israelensis*, *M. brachysporus*, *M. agolus* and *M. equatorialis*. In addition, *M. brachysporus, M. sarigi* and *M. kainjiae* have statistically comparable rates of infestation between the males and the females of *O. niloticus* in the two study sites.

Parasitism according to seasons

In the fish ponds basins of Foumban, the rates of infestation of the various parasitic species are generally higher (χ^2=5.84; P=0.16) in the rainy season than in the dry season (Figure 6). In natural environment (in Kouoptamo), the influence of the season on parasitism is not significant (χ^2=0.27; P=0.604). In Foumban, *M. tilapiae* presents a higher percentage of infestation (χ^2=4.0; P=0.27) during the dry season, whereas the rates of infestation of *M. camerounensis* (χ^2=6.12; P=0.013) and *M. israelensis* (χ^2=4.91; P=0.27) are higher in the rainy season. The following species, *M. agolus, M. heterosporus, M. brachysporus, M. sarigi, M. kainjiae* and *M. equatorialis* present statistically identical prevalence in both seasons. In Kouoptamo, the parasitic prevalence is statistically comparable in the two seasons, except for *M. israelensis* (χ^2=5.71; P=0.017) whose rates of infestation are high during the rainy season. A comparison between the study sites shows that the rate of infestation of *M. equatorialis* is higher in the fish pond basin than in River Noun during the rainy season (χ^2=8.09; P=0.004) as well as in the dry season (χ^2=11.13; *P<0.01*). On the contrary, *M. tilapiae* in the natural milieu parasitizes more fish than in breeding situation during the rainy season (χ^2=7.86; P=0.005) as well as in the dry season (χ^2=4.69; P=0.49).

DISCUSSION

This work carried out in a natural environment (River Noun) and in breeding situation (Fish pond basin), show in both cases a polyparasitism of fish by Myxosporean. The parasite species *M. nounensis* is present only in River Noun where it was originally described

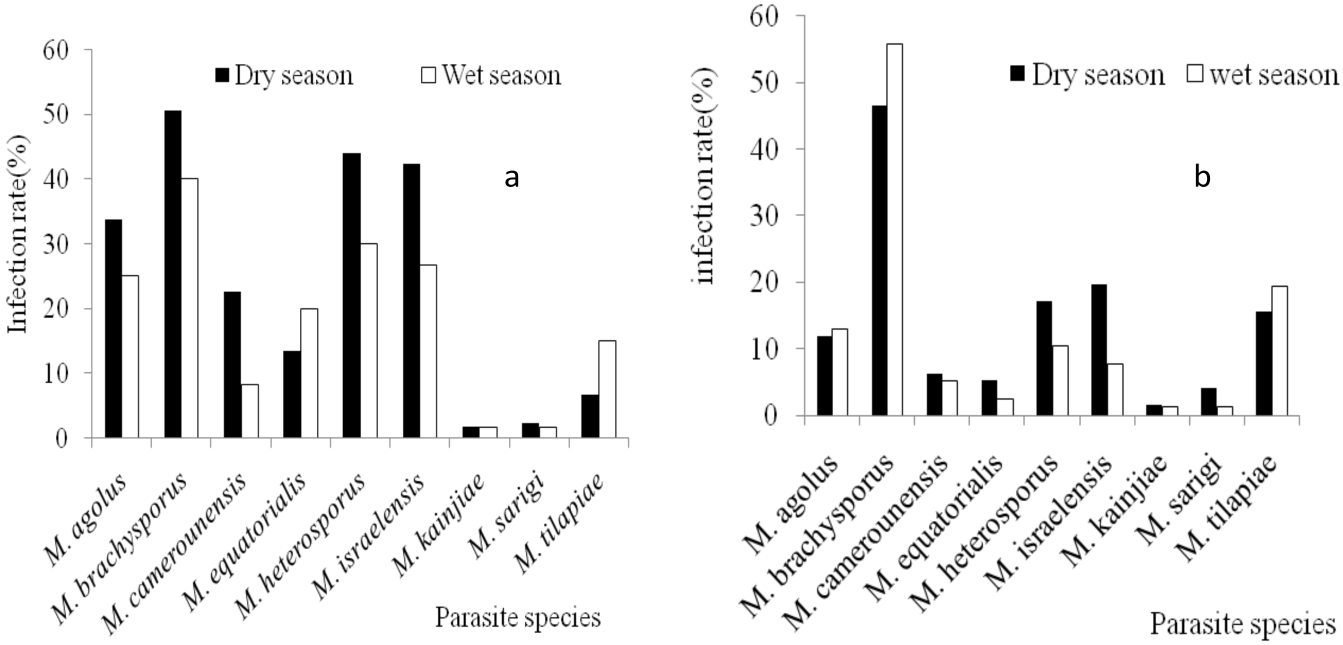

Figure 6. Parasitism (%) as a function of the season in *O. niloticus* at Foumban (a) and Kouoptamo (b).

(Fomena and Bouix, 2000). All other parasite species: *M. camerounensis*, *M. agolus, M. brachysporus, M. israelensis, M. heterosporus, M. kainjiae, M. sarigi, M. equatorialis* and *M. tilapiae* are common in both biotopes. The presence of *M. nounensis* only in River Noun could be explained by the fact that this medium may provide better eco-climatic conditions for the development of this parasite and could facilitate the contact between the infesting stages of this Myxosporean and the host fish (El-Tantawi, 1989). The various species of parasites recorded in Foumban and Kouoptamo were already documented in the same host, in the same organs by Obiekezie and Okaeme (1990) in Nigeria, Fomena and Bouix (1997) in Cameroon and Abakar et al. (2007) in Chad. The identified parasites present to a certain degree the same status in the two sites.

It results from our work that no parasitic species appeared frequent (Prevalence > 50%), whereas studies undertaken in Israel (Landsberg, 1985), in Nigeria (Obiekezie and Okaeme, 1990) and in Chad (Abakar, 2006) show that *M. agolus*, *M. brachysporus* and *M. heterosporus* are frequent in the Cichlidae *O. niloticus* and *S. galilaeus*. Poulin (2006) thinks that parameters (prevalence, intensity, abundance) traditionally used to qualify populations of parasites or the severity of the parasitic infection is prone to variations. For a given species of parasite, the proportion of the infested hosts is not fixed through its geographical distribution range. The status of parasitic species varies according to environmental conditions (El-Tantawi, 1989) and hosts species (Brummer-Korvenkontio et al., 1991).

The rates of infection of some collected species of Myxosporidian are higher in the fish ponds than in the River Noun. Our results corroborate those of Alvarez Pellitero and Sitjà Bobadilla (1989) and Sitjà Bobadilla and Alvarez Pellitero (1990) who in their work, showed that the rate of infestation of *Ichthophomus* sp and *Ceratomyxa* sp are higher in a breeding medium than in a natural environment. On the other hand, Sitjà Bobadilla and Alvarez Pellitero (1993) show that the rate of infestation of *Sphaerospora dicentrarchi* is higher in fish resulting from the natural environment as compared to the hosts from fish pond. These authors explain this situation by the age of fishes (They worked on old hosts) and the fact that the infesting stages of this parasite would be more viable in natural environment than in fish pond medium. Euzet and Pariselle (1996) think that, the pathogenic effect of the parasites under natural conditions is reduced, consequence of the balance established during the evolution in the host-parasite system. Indeed in the fish pond medium, the confinement of hosts, the presence of the muddy vase, the weak oxygenation which is at the origin of an increased sensitivity to the parasites attacker and the low depth of the basins would favor the transmission of the parasites (Obiekezie and Okaeme 1990; Fomena, 1995; Barassa et al., 2003; Tombi and Bilong Bilong, 2004).

In natural environment as in breeding situation, the various parasitic species infest indifferently the males and females. Our results agree with those of Fomena (1995) which did not note any influence of sex on the parasitism of *O. niloticus* in the various species of Myxosporean in fish ponds station of Melen in Yaoundé. Based on the same predictions, Özer (2003) reveals that there is no difference of infestation with respect to the sex in *Gasterosteus aculeatus* by *Sphaerospora elegans* and *Myxobilatus gasterostei* in Turkey. However, authors such as Viozzi and Flores (2003); Milanin et al. (2010) think that concerning Myxosporidiosis, the prevalence is independent of the sex of the host. On the other hand, Tombi and Bilong Bilong (2004) revealed that *M. njinei* parasite of *Barbus martorelli* (Cyprinidae) infests preferentially females than males. According to Sakiti (1997) and Gbankoto et al. (2003), parasitic infections often present higher prevalence in males than in females. According to Poulin (1996), the elevated level of testosterone secreted by the males can involve under certain conditions an immune depression making these individuals more vulnerable to parasitism. A good knowledge of the biology of parasites and their various hosts would make it possible to better explain the parasitism of Myxosporean with respect to sex.

In nearly all cases, parasitic species found in *O. niloticus* (Cichlidae) in natural environment and in breeding are present in their hosts during all the study period. At Foumban, the rates of parasitic infestation are higher in the rainy season and generally low in the dry season. On the other hand, no statistically appreciable fluctuation of parasitism is observed for the wild populations of hosts. Our results are close to those of Sitjà Bobadilla and Alvarez Pellitero (1993) who showed that in Spain, the rate of infestation of *S. dicentrarchi*, parasite of *Dicentrarchus labrax* varies with seasons in the fish pond basins, whereas in natural environment these authors do not note a difference between the percentages of infestation according to seasons. In this work, seasons do not seem to have an influence on Myxosporean in the natural environment. This remark corroborates many observations already made by authors such as Fomena (1995) on *M. camerounensis*, parasite of *O. niloticus*, in Cameroon; Gbankoto et al. (2001) on *Myxobolus* sp and *M. zillii*, gills parasites of *Tilapia zillii* and *Sarotherodon melanotheron melanotheron* in Benin and Milanin et al. (2010) on *M. oliveirai*, parasite of *Brycon hilarii* (Characidae) in Brazil. However, our results are contrary with those of Gbankoto et al. (2003) who note a seasonal difference of the infestation of *Tilapia zillii* by *M. heterosporus* in Benin.

During wet season, the higher water temperature and the presence of muddy vase are the major factors affecting the prevalence of both myxosporean and their definitive host (Tubifex tubifex). According to Özer et al. (2002), mud substract allow rapid growth and multiplication of Oligochaete. Therefore, during wet season, annelids Oligochaete are very abundant and their infecting stages (actinospores) multiply rapidly, a situation which is favorable to fish infection (Abakar et al., 2007).

The spectrum of target organs of the various studied species of Myxosporean varies from 1 to 6 in O*. niloticus* in the two mediums. Abakar (2006) showed that the spectrum of organs colonized by *O. niloticus* and *S. galilaeus* in Chad varies from 1 to 5. *M. camerounensis* appeared as the species having a broad spectrum of organs colonized in this work. We found *M. camerounensis* spores or cyst in six organs in fish pond medium and in four organs in the natural environment. Abakar et al. (2007) found this species infesting six different organs in O*. niloticus* and *S. galilaeus*. According to Obiekezie and Okaeme (1990), Myxosporean of *Tilapia* have a general distribution in tissues. In addition, Alvarez Pellitero and Sitjà Bobadilla (1989) think that spores of the various species of Myxosporean can disperse in the kidneys and other internal organs via blood, causing severe infections. The kidneys and the spleen are organs that are most frequently infested. These results are close to those of Fomena (1995) and Abakar et al. (2007). The kidneys and the spleen may be the site of predilection for certain species of Myxosporean. These organs according to Fomena (1995) constitute the sites of initiation of the developmental cycle for many species of Myxosporean. In addition, Alvarez Pellitero and Sitjà Bobadilla (1989) think that the capacity of Myxosporean to locate itself in a given tissue or cavities of fish could have an influence on the type of damage which these parasites cause to their hosts. The gills constitute one of the organs of predilection in Myxosporean (Lekeufack Folefack, 2010) mean while, the massive infestation of this organ by *M. camerounensis* in the fish pond basin in Foumban, could be at the origin of the reduction in the respiratory capacity of the host. In the same regard, Gbankoto et al. (2001) reveal that this situation would affect its reproductive success negatively.

The rate of infestation of almost all disease-causing agents does not vary statistically between the various sets of classes. The percentage of infestation of the various parasites species is higher in breeding condition than in natural environment in old fish. In natural environment on the other hand, younger hosts are more threatened by certain parasitic species. According to Tombi and Bilong Bilong (2004), the parasitic load is high among hosts of small size host compared to those of big size. On the other hand, Sitjà Bobadilla and Alvarez Pellitero (1993) revealed a progressive increase in the infection of *D. labrax* by *S. dicentrarchi* with the age of the host in agreement with a weak pathogenicity of the parasite. These authors explain this situation by the effect of parasites accumulation in organs with age. In the fish ponds at Foumban, the young hosts would succumb more quickly to the infections because of confinement. According to Lom and Dykovà (1992), young fish are more susceptible to Myxosporean and certain infections decrease with host age.

This study had showed a polyparasitism of *O. niloticus* both in the Noun River and the fish ponds ecosystem in Cameroon. In general, fishes are more infected by Myxosporean when cultured than in Wild environment. This study raised the necessity to pay more attention concerning Myxosporean parasite of fish in a fish farm station because of the hosts confinement. In addition, further investigation for these Myxosporean species is necessary to determine the real effect of these parasites on the health of the hosts.

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