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Incidence of parasitic nematodes in *Parachanna obscura* (Gunther, 1861) *in* the Sô River in southern Benin

Anissossé Ignance TOGLA[*1], Bernadin BOUKO1, Tadjida Bienvenu ZANNOU[1], Mireille HOUENOU SEDOGBO[1], Moudachirou IBIKOUNLE[1]

[1]University of Abomey-Calavi, Faculty of Science and Technology, Department of Zoology, Laboratory of Parasitology and Parasitic Ecology, 01 BP 526 Cotonou, Benin
[2]National University of Agriculture, School of Aquaculture, Research Unit in Aquaculture and Fisheries Management, BP 43 Kétou, Benin

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Abstract

This study aims at evaluating the nematode incident on Parachanna obscura in the waters of South Benin. Six hundred and ninety (690) specimens of Parachanna obscura of various sizes were sampled at three sites along the Sô River: Tota, Ahomey, and Ganvié, from November 2018 to October 2019. Three species of nematodes to be known: Spirocamallanus spiralis, Paracamallanus cyathophrynx, Camallanus sp were recorded, and an overall infestation rate of 54.49% to the different nematode species was obtained, with very significant differences (P = 0.000) between the prevalences of these nematode species and this from one site to another. Infestation with different nematode species was possible in all seasons of the year (P=0,000). It is much higher in December (87.71%) and lower in March (21.18%) and varies according to the size classes and weight of the fish. Medium size and medium weight specimens are more infested than others. Although males are more exposed than females, the different infestation rates by sex again show that the sex of the host fish did not influence the distribution of parasite prevalence.

Keywords: *Nematoda parasites- Parachanna obscura- Sô river- South Benin*

1. Introduction

Nematodes include 256 families and more than 40,000 species; it is one of the largest groups in the animal kingdom. Mostly parasites of vertebrates and invertebrates generally live in the cavities (intestine, stomach) in the blood vessels of the tissues of their hosts. Prevalent in freshwater, brackish and marine fish worldwide (Moravec, 1994), these nematodes represent a risk to fish. They can cause lesions at the site of attachment (Paperna, 1982; Rhode, 2005) and cause health problems for humans. Such parasites are nematode Anisakis, which causes either an infection or an allergic reaction due to the substances released by the fish's flesh (Akbar, 2005). Thus, fish parasites and diseases are the most significant setback to aquaculture and its development (Obiekezie and Ekanem, 1995). *Clarias gariepinus*, *Clarias ebriensis*, *Synodontis nigrita*, *S. schall* and *Chrysichthys nigrodigitatus* (Tossavi, 2015), *Sarotherodon melanotheron* (Bouko, 2017) *Oreochromis niloticus* (*Zannou et al.,* 2019) etc. are known to be hosts for parasites and diseases. Because they constitute an essential biotope for developing many parasites.

*Corresponding author's ORCID ID: 0000-0000-0000-0000
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For example, fish species such as Parachanna obscura are known to be infested by nematodes (Oden et *al.,* 2015). On the other hand, the first study on the diversity of metazoan parasites of *Parachanna obscura* (Gunther 1861) from the Sô River in southern Benin reported three nematode species with severe damage to fish. The prevalence of more than 50% indicated a trend of loss of innate defence mechanism as predicted by Parvathi and Karemungikar (2011) in the case of chronic infection. Hence, there is no documented evidence on the incidences of *Parachanna obscura* nematodes in the Sô River and its tributaries. However, fishing for this type of fish has been carried out daily for a very long time with significant economic interest. This study aims at determining the incidence and prevalence of nematode infection in *Parachanna obscura* in the Sô River in southern Benin. The reason is to evaluate its aquaculture potential and take appropriate measures to preserve the health of this species, which is of great interest not only economically but also for human nutrition as regards its animal protein needs without running a significant risk of arthritis.

2-1. Study area

The Sô River is located between 6°24' and 6°32' North latitude and 2°27' and 2°30' East longitude.

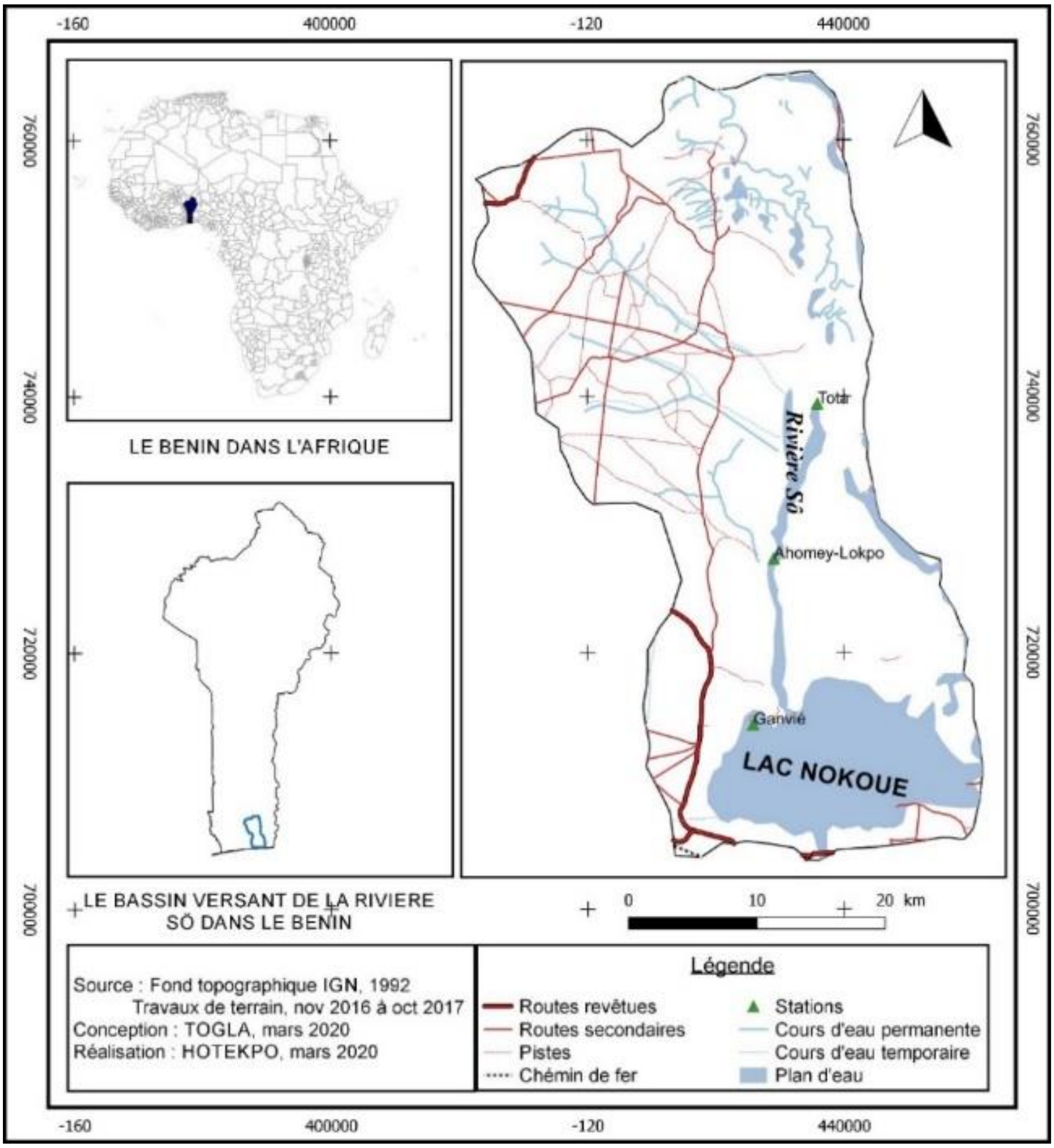

Figure 1: Map showing fish collection sites along the Sô River watershed (Tota, Ahomey, Ganvié)

It is located in the commune of Sô-Ava and has a length of 84.4 km and discharges its waters into the northwestern part of Lake Nokoué at Ganvié (Laleyè 1995). Three sites (Ahomey, Tota and Ganvié) were selected for fish collection (Figure 1). The climate in the region is sub-equatorial with four alternating seasons: a long rainy season (LRS) that extends from March to July, a short dry season (SDS) that extends through August, a short rainy season (SRS) that extends from September to November, and a long dry season (LDS) that extends from December to March.

2-2. Sample collection and Parasitological examination of fish

A total number of 690 specimens of *Parachanna obscura* were collected from November 2018 to October 2019, at a rate of 230 specimens per site. *Parachanna obscura* were purchased live from fishers at three different sites Ahomey, Tota and Ganvié. The total length and weight of the specimens of *Parachanna obscura* ranged respectively from 10 - 45cm and 30 - 400g. At each site, three (3) to five (5) specimens were transported alive to the Laboratory of Parasitology and Ecology of Parasites of the University of Abomey-Calavi, where parasitological analyses were performed at adequate time intervals. The total length of each fish was measured to the nearest 0.1cm using a graduated wooden measuring board. The weight of each fish was taken using a digital scale with a reading accuracy of 0.1g.

Each specimen was dissected, and the intestine was removed, put in Petri dishes and covered with 0.85% physiological saline solution and then inspected for nematodes. The whole fish was examined thoroughly, and the worms carefully extracted using a LEICA S8APO binocular loupe. The nematodes present in the fish were carefully collected and passed through hot alcohol (this allows better identification of the different parts of the parasite) before being placed on slides for microscopic examination and then isolated, counted, and their number recorded. Some nematodes were preserved in Gilson's liquid. The adult nematodes were measured with a measuring ruler. In contrast, the larvae and some particular characteristics of the adults were measured under the microscope, using the stage and the ocular micrometre.

2.3. Statistical analysis

Indices such as Prevalence (P), Abundance (Ab) and Mean Intensity (MI) were calculated according to Bush et al. (1997) to determine the balance of species within a community, the level of succession, the influence of extreme factors, the influence of the environment and finally to explain the extent of the parasite population in the hosts. Chi-square test was used to signify the variability or not of prevalence between male and female hosts, sampling sites and periods were carried out with MINITAB version 17. The results were considered significant at 95% level ($p < 0.05$).

3. Results

3.1 Calculation of pest indices

3.1.1 Variation in overall infestation rates by host species

The examination of six ninety (690) specimens of *Parachanna obscura* reveals an infestation rate of 54.49% to the different species of nematodes and allowed to identify in each of the three studied sites of the Sô river three (3) species of nematodes, namely: *Spirocamallanus spiralis*, *Paracamallanus cyathophrynx*, *Camallanus sp* with the parasitic prevalence, average intensity and parasitic abundance of each nematode species identified grouped in table 1 below.

Table 1: Prevalence (P), Mean Intensity (MI) and Abundance (Ab) of *Parachanna obscura* nematode infestation in the Sô River at Ahomey, Tota and Ganvié.

Epidemiological parameters Species of Nematodes	P (%)			Int			Ab		
	Ahomey	Tota	Ganvié	Ahomey	Tota	Ganvié	Ahomey	Tota	Ganvié
Spirocamallanus spiralis	8,26	10	16,52	2,39	4	3,03	0,23	0,51	**0,47**
Paracamallanus cyathophrynx	10,21	26,69	16,65	4,46	4	4,89	1,56	1,71	**1,22**
***Camallanus* sp**	16,52	20,43	12,17	1,75	4,43	0,6	0,028	0,17	0,017

The species *Paracamallanus cyathophrynx* and *Camallanus sp* had higher or lower infestation rates in the three sites studied. The species *Spirocamallanus spiralis* only had a higher or lower rate in Ganvié. The highest prevalence of nematode infestation was obtained at the Tota site (26.69) with *Paracamallanus cyathophrynx* and the lowest prevalence (8.26) *Spirocamallanus spiralis* species at the Ahomey site. According to our results, *Parachanna obscura* are more infested with *Paracamallanus cyathophrynx.* The average intensities calculated for each site generally exceed three parasites per infected fish. It means that the fish may harbour more than three (3) individuals of each nematode species collected. Mean abundances were more significant than one for fish infested with *Paracamallanus cyathophrynx* and less than 1 for the other two nematode species *Spirocamallanus spiralis* and *Camallanus sp,* at the three sites.

According to the sites, the lowest infestation rate was recorded in Ahomey (40%), and the highest was observed in Tota (69.13%). The statistical test applied for shows a significant difference between the infestation rates according to the sites shown in the following table 2.

Table 2: Infestation rates by site

Sites	Ahomey	Tota	Ganvié
Parasites	92	159	125
Prevalence (%)	40	69,13	54,34
χ2 (p-Value)	39,355 (0,000)		

3.1.2 Variations in overall nematode infestation rates by month

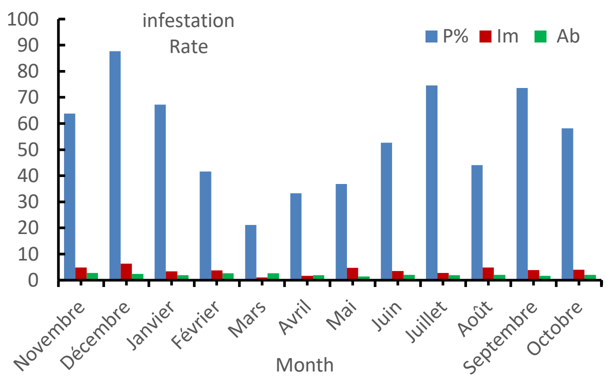

Figure 2: Histogram of parasitic indices as a function of month

The infestation rate of *parachanna obscura* to different species of nematodes found is variable according to the months. It is low from February to May and high from September to December. The highest prevalence was recorded in December (87.71%) and the lowest in March (21.18%). The average intensities exceed one parasite per fish. According to each month, the statistical test shows a significant difference between the overall distribution of different nematode species (P=0.000). Thus, the abundance or not of nematodes is a function of time and the distribution of each nematode species is as shown in the different figures 3,4 and 5.

3.1.2.1 Variations in *Spirocamallanus spiralis* infestation rates as a function of month

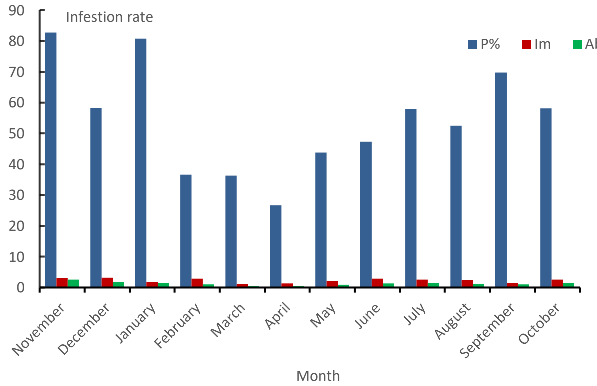

Figure 3: Histogram of parasite indices of spirocamallanus spiralis as a function of the month (P%**:** Prevalence; Ab: Average abundance; Im: Average intensity)

The rate of infestation of *Parachanna obscura* by the species *spirocamallanus spiralis* according to the Months is variable. For this nematode species, the low rates are only recorded in February and April and the high rates from May to January with a rate going from 50 to nearly 80%. During the sampling period, more individuals of this species are found in the infected *Parachanna obscura.* According to the month, there is a statistically significant difference between the distribution of this species (χ2 = 36.015; p-Value= 0.0000). Therefore, the abundance of this nematode species could be time-dependent.

3.1.2.2 Variations in *Paracamallanus cyathophrynx* infestation rates as a function of Month

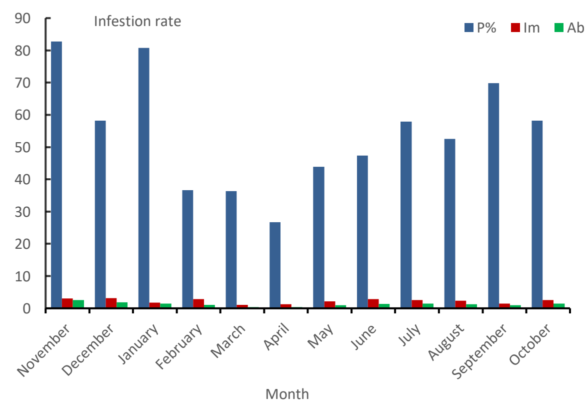

Figure 4: Histogram of parasite indices of Paracamallanus cyathophrynx as a function of the month.

Parachanna obscura is most infested by the species *Paracamallanus cyathophrynx* during November and December and least infested in February and March. The average intensities exceed one parasite per fish. The statistical test applied shows a significant difference between prevalences among months (χ2 = 79.471; p-Value= 0.0000). Therefore, the distribution of *Paracamallanus cyathophrynx* could be a function of time.

3.1.2.3 Variations in *Camallanus sp* infestation rates as a function of Month

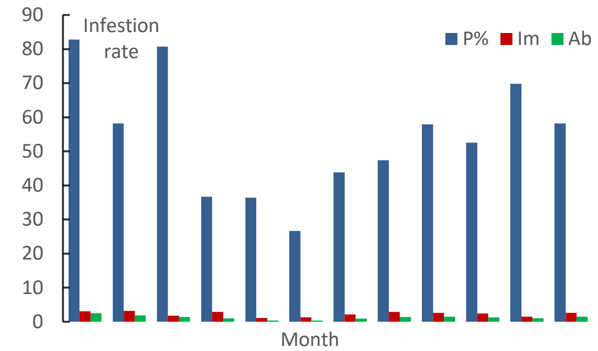

Figure 5: Histogram of parasite indices of Camallanus sp as a function of month

The infestation rate of *parachanna obscura* by *camallanus* sp is variable, with high rates only recorded in October to January. The highest rate in December, and the most reliable rate is in February and March. The average intensities exceed one parasite per fish over the whole period. The difference is significant between the prevalences from month to month (χ2 = (57.896; p-Value= 0.0000). Therefore, the distribution of *Camallanus sp* could be a function of time.

3.2 Variations in overall infestation rates by size class

The variation of the overall infestation rates according to size classes is shown in Figure 6.

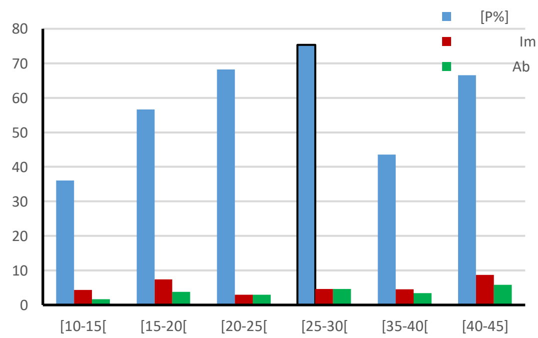

Figure 6: Histogram of parasitic indices according to size classes

The results of the infestation rates show the variability of the parasite indices according to the size classes. The values recorded are between 36 and 75.34% of prevalence. The lowest infestation rate was observed in the specimens of the class [10-15[. While the highest infestation rate was recorded in specimens with size ranging from 20-30cm.

Regarding the average intensity, it usually exceeds three parasites per infected fish. The statistical test applied shows a significant difference between the different size classes ($\chi2$ = 50.361; p-Value= 0.0000). Therefore, an infestation could be a function of fish size.

3.3 Variations in overall infestation rates by weight class

The infestation rates show the variability of parasite indexes according to weight classes. The values recorded are between 30 and 71.02% prevalence. The highest infestation rates are found in fish weighing between 100-310 g, which are generallyconsidered medium weight fish, and the lowest rates are recorded in low weight fish [30-100[and high weight fish [310-380].

The difference between infestation rates from one weight class to another is significant ($\chi2$ = 60.20; p-Value= 0.0000). Parasite loads exceeded two parasites per examined and infected fish. The distribution of parasite indices for each nematode species by weight class is presented in Table 3.

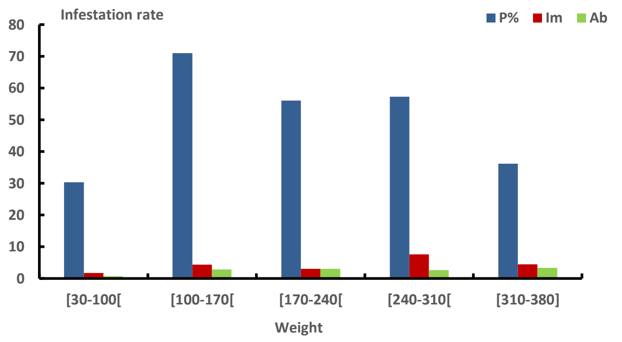

Figure 7: Histogram of parasitic indices as a function of weight.

Table 3: Distribution of nematode species by weight

Nematode species	*Spirocamallanus spiralis*			*Paracamallanus cyathophrynx*			*Camallanus sp*		
Parasitic indicators	**P%**	**Im**	**Ab**	**P%**	**Im**	**Ab**	**P%**	**Im**	**Ab**
[30-100[	11,25	1,5	0,5	**81,74**	5,3	2	0 ,80	3,1	1,1
[100-170[	**30,83**	4	1,4	**40,59**	3,3	2	**40,97**	5,3	2,2
[170-240[	19,58	2	0,7	18,80	4,6	2	**25,21**	5,3	1,7
[240-310[	27,91	3,3	0,9	17,71	4	1	18,05	3	2,5
[310-380]	10,41	4,6	2	14,71	7,1	2,1	7,73	4	1,8

The infestation rates of Spirocamallanus spiralis seem to be highest in fish weighing between 100 and 170g. In contrast, Paracamallanus cyathophrynx seems to be more infested in fish, weighing between 30 and 170g. In comparison, Camallanus sp, this nematode species, seems to be preferred in fish weighing between 100 and 170g, generally of medium weight.

3.3.5 Variations in infestation rates by sex across sites

The results show that the parasite indices vary according to the sex of the fish examined but overall, this difference is not significant ($\chi2$ = 1.503; p-Value = 0.220). Indeed, males have the highest infestation rates (P=35.07%). Parasite loads exceeded one parasite per infested fish for both sexes. According to each site, males seem to be more infested than females, and the difference between prevalence rates is significant at the Ahomey site ($\chi2$ = 16.242; p-Value = 0.000); however, these differences are not significant at the Tota and Ganvié sites (Table 4).

Table 4: Overall nematode infestation rates by gender

Sites	Global		Tota		Ahomey		Ganvié	
Sexes	F	M	F	M	F	M	F	M
Parasites	134	242	32	58	81	78	47	78
Prevalence (%)	19,42	35,07	13,97	25,21	35,21	33,91	20,43	33,91
χ2 (p-Value)	1,503 (0,220)		0,332(0,565)		**16,242(0,000)**		0,681(0,409)	

3.3.5.1 Variations in overall nematode infestation rates by sex

The three nematodes collected seem to infest more males of Parachanna obscura than females, but this difference is not significant. However, the highest rates were obtained with Paracamallanus cyathophrynx with a rate of 35.07% in male Parachanna obscura and 18.11% in females, while the lowest rates were obtained with Spirocamallanus spiralis with a rate of 21.15% in male Parachanna obscura and a rate of 13.62% in females (Table 5).

Table 5: Infestation rates of nematode species by sex

Species	***Spirocamallanus spiralis***		***Paracamallanus cyathophrynx***		***Camallanus sp***	
Sexes	F	M	F	M	F	M
Parasites	94	146	125	242	115	234
Prevalence (%)	13,62	21,15	18,11	35,07	16,66	33,91
χ2 (p-Value)	**5,067(0,025)**		0,067(0,796)		0,143(0,705)	

Discussion

Parasite analysis of 690 specimens of *Parachanna obscura*, showed the presence of parasitic nematodes in the viscera (digestive tract: intestines, stomach, liver and gonads), in two encapsulated and elongated forms. The nematodes have prickles on the scolex and cling firmly to the intestinal mucosa, causing lesions to reach the blood vessels. In case of heavy infestation, they can cause anaemia in the host due to their hematophagy nature and the digestive tract's necrosis. According to Oden (2015), even if the presence of parasitic nematodes in the gut of fishes does not have dramatic effects on the host, their overpopulation and obstruction of the digestive tract of the fishes could probably lead to severe feeding and growth problems. This point was also made during this study when some of the *Parachanna obscura* specimens examined had bloated, gas-filled bellies. In these fishes, the digestive tract was almost empty of food but filled with impressively large and long nematodes.

Contrary to Oden (2015), the nematodes were extracted from the muscles, the gut and gills of the fish; this study extracted nematodes only from the digestive tract. However, Oden did well to point out the preponderance of nematodes in the gut showing that the gut is truly the most preferred site by nematodes. We fully agree with the author when he points out that the high concentration of nematodes in the digestive tract of *Parachanna obscura* gave a clear indication of the preference of the digestive tract to any other site of attachment. This could therefore be justified by the abundance and availability of food in this region. Indeed, parasites generally prefer the digestive tract for various reasons, such as the digestive tract serving as a perfect hiding place for these nematodes and the porous nature of the gut wall, allowing easy attachment to nematodes. In the same vein, Moravec (2000) and Ibiwoye, et *al.* (2006) also discussed the preference of the digestive tract by nematodes. They reveal that nematode larvae may have penetrated the mucosal wall and created passages in the muscles and blood vessels to accumulate in the digestive tract of the fishes, sometimes causing lesions, haemorrhage and bloating of the abdomen. Such a journey between the different compartments of the organism would indeed be possible only with larvae because the adults will have great difficulty making it.

Moreover, this justifies the fact that Oden (2015) found only nematode larvae in the gills and muscles and helps us to clarify the absence of nematodes in the gills and muscles in this study. Indeed, we encountered only mature nematodes during this study. The high concentration of nematodes in the digestive tract is also possible because the fish ingested nematode eggs during feeding, which once hatched will remain in the gut lumen due to the abundance of food.

Oden (2015) identified two species of nematodes (Neocamallanus sp and Paracamallanus cyathopharynx). This study identified three nematodes: Spirocamallanus spiralis, Paracamallanus cyathophrynx, and Camallanus sp. thus, expanding the inventory of nematodes can infest *Parachanna obscura.* Several scientific authors have already described the Nematode species found in the present study in Benin (Tossavi, 2010; Houenou, 2019) but little reported in *Parachanna obscura.* The infestation rate of 54.49% to the different nematode species obtained is close to the average prevalence (53.9%) obtained by Oden in 2015 with an average intensity of 8 nematodes per fish and similar to the results of Tossavi (2010) on *Heterobranchus longifilis* (55.55%). In Malaysia, Rahman and Bakri (2008) reported a much higher prevalence of nematode infestation of *Parachanna obscura* (73.2%) than that reported in this study, showing that *Parachanna obscura* is a preferred host of nematodes. Furthermore, it is essential to point out that this infection rate above 50% can be hazardous. This indicates a tendency for loss of innate defence mechanism as predicted by Parvathi and Karemungikar (2011) in the case of chronic infection. Several factors may determine the distribution of fish parasites. The prevalence, intensity and abundance of fish infection in the environment may be related to the diet of *Parachanna obscura*, their life span, mobility throughout life, and a variety of habitats encountered, population density and size attained. The infestation rate of 54.49% to the different nematode species obtained may be justified by the omnivorous and microphagous feeding habits of *Parachanna obscura. Compared to that obtained by Oden (2015), the low average intensity obtained in this study may* be due to the low pollution or more or less acceptable quality of the Sô river water. Among the nematode species recorded in this study, the species *Paracamallanus cyathophrynx* has the highest prevalence and is a species often encountered in the majority of nematode studies. This finding is similar to that of Houenou, 2019 on *C. gariepinus.* Indeed, Houenou's work shows that of the eleven metazoan parasite species identified, nematodes (*P. cyathopharynx* and *Pr. laevionchus*) have the highest prevalence. Of the 828 individuals of parasites recorded, i.e., nearly 40% of the total abundance, *P. cyathopharynx* represents the dominant species in the environment. Among the parasitic species of *C. gariepinus*, *P. cyathopharynx* presents the highest prevalence (40.77%) and parasite abundance (1.98). Houenou (2019) justifies this high prevalence by a low host specificity towards the adult stage of this nematode species, making it capable of infecting different genera and species of fish. The availability in the environment of different hosts necessary for the completion of the life cycle of these parasites could also constitute, for the author, a favourable factor (Amaré *et al.,* 2014). These hosts include piscivorous fish and man as definitive host and gastropods and fish as intermediate hosts (Yanong, 2002).

Monitoring of infestation rates in *parachanna obscura over* twelve months reveals a monthly variation in these rates. The highest nematode infestation rate was recorded from November to December and from May to August, periods that correspond respectively to the Great Dry Season and the period from the end of the Great Rainy Season to the end of the Little Dry Season in southern Benin. These results are similar to those of Mebrouk Nawal and Merar Sabiha (2016), who obtained higher nematode prevalence rates in December (83.3%) and April (61%). However, this result crossed with the previous result of this same study where the parasitic prevalence according to the different seasons indicates that the infestation rates of metazoans are much higher in rainy seasons than in dry seasons three sampled sites raises a contradictory and paradoxical finding. This inconsistency between dry and rainy seasons in nematode infestation in *parachanna obscura was* also observed by Moravec and Scholz (1991), who studied the seasonal dynamics of certain nematode species. The authors stated that the maturity of nematodes could be associated with the variation of the temperature in the locality and the maturity cycles of its intermediate hosts. Indeed, the correlation of Physico-chemical parameters with the prevalence of the leading parasitic groups of *parachanna obscura in the* same year showed that the measured parameters significantly influence the distribution and abundance of nematodes. The nematodes showed a strong interaction with these parameters. At Ganvié, conductivity, salinity, TDS and pH were negatively correlated with nematodes but positively correlated with temperature. In Tota, conductivity is negatively correlated with nematodes, while in Ahomey, salinity negatively influences nematodes. This correlation could justify the difference in the prevalence of nematode infestation obtained between the three surveyed sites, Ahomey (40%), Ganvié (54.34%) and Tota (69.13%). In reality, the main factors governing nematode populations are temperature and humidity in the environment (Anderson, 1992). From November to December, when we obtained the highest infestation prevalence of each nematode species, the temperature of the Sô River was about 28°C, and from May to July, when we obtained slightly lower prevalence than in November and December, the temperature of the Sô River went from 28°C to 28.7°C. These observations agree with Anderson's (1992) findings that nematodes can develop and maintain their populations over different ranges of considerable temperature and humidity and respond differently to the same environmental variable during different life cycle phases.

The infestation rate according to size class showed that specimens between 15-30 cm (juveniles) were more infested than 35-45 cm (adults), which were also more infested than 10-20 cm (alevins). A similar observation was reported by Gale (2006) in the study of the helminth parasite fauna of *Parachanna obscura* in Nigeria, where 21-25 cm fish had low prevalence, while a complete absence of parasites was observed in 26-30 cm fish. The lack of correlation observed between nematode infection and the size of *Parachanna obscura* is very different from what is reported by many authors. Indeed, Mebrouk Nawal and Merar Sabiha (2016) obtained higher prevalence in 9.6 and 12.1cm class specimens. Similarly, the work of Oden (2015) also revealed a 100% prevalence in 10-15cm specimens and the lowest prevalence in 22-27cm specimens. Our result contradicts the finding of Violante-Gonzalez et *al.* (2010) and then Munoz and Zamore (2011), whose work indicates that parasite richness is positively correlated with host size. For these authors, a large fish is more likely to have been exposed to parasites for a long time. Therefore, large fish are likely to carry several species of parasites or have a higher abundance of parasites than small fish. These authors support the fact that large (older) fish have had more time to accumulate parasites than small (younger) fish. Considering the time spent in the environment, we agree with these authors that sizes ranging between 35 to 45 cm (adult are more infested than sizes ranging between 10 to 20 cm (alevin) specimens.

Nevertheless, the 100% prevalence of infestation in sizes ranging from 10-15 cm obtained by Oden (2015) contradicts the theory of exposition time to parasites in the environment. Although Oden stated that damage and prevalence shows a strong correlation with age, the fry suffered more damage than adult ones. The author instead sees that young and adult *parachanna obscura,* which have already acquired strong immunity against infection, will be less infected than fry with still low immunity. Because of these contradictions, one could agree with Oden (2015) when he states that the prevalence of *parachanna obscura* infestation does not necessarily depend on the size of the fish within the limit of the samples analysed. Our results could be justified because specimens of sizes ranging between 35 to 45 cm (adults) had more time to accumulate parasites than fry. Therefore, were more infested than specimens of 10 to 20 cm (fry), and that specimens of 15 to 30 cm (juveniles) are more infested than 35 to 45 cm (adults) and 10 to 20 cm (fry) because they would have spent most of their energy for high immunity in sexual activity or reproduction. Indeed, young fish are likely to be more sexually active than fry and older fish. For Poulin (1996) or

Ibrahim and Soliman (2011), the higher prevalence and intensity in juveniles may be related to the investment in reproduction (Gbankoto et *al.* 2003). The high prevalence recorded in the sizes ranging between 15-30 cm may be related to the omnivorous and microphagous feeding habits of young *parachanna obscura*. When they become young, they feed on insect larvae, earthworms, tadpoles, shrimps, small fish, and other aquatic animals that harbour parasites, and 15-30 cm (young) specimens may be doubly infested.

According to the weight class, the parasitic indices of each nematode species show that *Spirocamallanus spiralis* and *Camallanus sp.* infect more fishes with a weight between 100 to 170g and, *Paracamallanus cyathophrynx* more fishes from 30 to 170g with a high prevalence of infestation of 81.74% in fishes with a weight between 30 to 100g. The infestation rate by weight of these nematode species may increase due to the abundance in the area reported by Houenou (2019). Its presence in all seasons in the environment and the availability of different hosts necessary for the completion of its life cycle (Amaré *et al.* 2014). The low host specificity of this nematode species allowed it to infect different genera and species of fishes. Knowing the damage caused by this worm nematode species, small fishes with immunity not yet acquired may be easy exposed to attacks by this worm nematode species. The infestation rates of *parachanna obscura as a* function of its weight show that fish weighing between 100 and 170g are the most infested, presenting a significant difference from one class to another. The study conducted by Tossavi (2010) on *Clarias gariepinus* presents a similar result. *Clarias gariepinus* with a weight between 150-200g is the most infected, followed by those with a weight between 50-100g and the least infected those in the 250-300g range. Based on the size/weight relationship, these results can be related to the prevalence by size, to say that fish weighing between 30 and 100g are generally young fish. Therefore, their high prevalence may be related to their omnivorous and microphagous feeding habits.

For this reason, they are exposed to parasite infestation more than fry and adult. Besides being sexually more active, these young fish will spend a large part of their energy to have a strong immunity in reproduction. They may therefore become easy prey to nematodes. The different infestation rates by sex obtained again show that the sex of the host fish did not influence the distribution of parasite prevalence. Whether globally or according to each nematode species and even according to sites, *parachanna obscura* males show higher infection rates than females. Houenou (2019) also reported higher parasite prevalence in male *C. gariepinus* and reports that this observation is in agreement with those of Akinsaya (2010) and Allumma and Idowu (2011).

Similarly, similar results have been reported in many freshwater fishes (Aloo et *al.* 2004). These authors believe that the main reason for these differences may be related to the physiological state of the host and these feeding habits. Indeed, the immaturity and, more precisely, the physiological state of female fishes could be a limiting factor to a massive infestation. During the reproduction period, females are subjected to a loss of energy and keep alive; *Parachanna obscura* females can even digest nematodes for food. According to Benhassine (1978), fish migrate through various biotope and endure significant variation. Thus their parasite fauna would be much more affected by their movement.

On the other hand, fish that migrate without changing environment would be less affected because the variations of the environment's Physico-chemical conditions are absent or of very weak amplitudes. It could indeed happen during the reproduction of *Parachanna obscura* where females are probably more confined to their territory to protect the eggs. At the same time, males could cross different habitats with different conditions in search of food. Besides, the differences in infestation prevalence between male and female fish may be due to a food preference expressed either by the quality of food or the quantity of food consumed (Emere, 2000). However, this difference could be due to the progressive weakening of male's immune resistance, which favours infection by parasites (Rohde and Hayward 1993). Also, males are likely to be more infected by parasites during periods of investment in gonad development (Simokova et *al*. 2005).

Conclusion

Infestation of different nematode species was possible in all seasons of the year but much higher from September to December and varies according to the size classes and weight of the fish. Although males were more exposed than females, the sex of the host fish did not influence the distribution of parasite prevalence. Because of the high prevalence identified and the damage recorded, further studies on the effect of the different nematode species should guide the research community on the potential damage to a fish farm and the likely prophylactic measures to be considered.

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