E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 76.37
(GIF) Impact Factor: 0.549
IJFAS 2024; 12(3): 76-83

www.fisheriesjournal.com
Received: 19-02-2024
Accepted: 28-03-2024

Cheikh Mouhamadou Bamba SECK
Department of Animal Biology, Faculty of Sciences and Technics, Cheikh Anta Diop University, Dakar, Senegal

Ephigénie Ndew DIONE
a) Department of Animal Biology, Faculty of Sciences and Technics, Cheikh Anta Diop University, Dakar, Senegal
b) Ecole Normale Supérieure for Technical and Vocational Education, Cheikh Anta Diop University, Dakar, Senegal

Malick DIOUF
Department of Animal Biology, Faculty of Sciences and Technics, Cheikh Anta Diop University, Dakar, Senegal

Corresponding Author:
Cheikh Mouhamadou Bamba SECK
Department of Animal Biology, Faculty of Sciences and Technics, Cheikh Anta Diop University, Dakar, Senegal

Study of some ecological parameters in nematode parasites of freshwater fish in the Senegal and Gambia rivers

Cheikh Mouhamadou Bamba SECK, Ephigénie Ndew DIONE and Malick DIOUF

DOI: https://doi.org/10.22271/fish.2024.v12.i3b.2936

Abstract
This study was conducted in the rivers of Senegal and the Gambia over three consecutive years, during both dry and wet periods. A total of 1216 fish were sampled during this period, with 551 from Gambia and 665 from Senegal. The fish were classified into 29 species. *Chrysichthys maurus* Valenciennes, 1840 is the host fish with the broadest spectrum of parasites, with *Procamallanus* and *Contracaecum* being the most common genera of nematodes. *Chrysichthys maurus* Valenciennes, 1840, *Clarias gariepinus* Burchell, 1822, *Synodontis annectens* Boulenger, 1911, and *Synodontis nigrita* Cuvier et Valenciennes, 1840 exhibit the highest biodiversity indices, which vary depending on the seasons and sex of the fish. The overall prevalence of fish parasites varies by locality and sex. Only *Citharinus citharus* Geoffroy Saint-Hilaire, 1809 shows significant differences in weight and size, with respective values of 6.3e-08 and 0.01653.

Keywords: Fish-Nematodes-Biodiversity Indices-Prevalence

1. Introduction
Globally, fish provide about 16% of the animal proteins consumed (FAO, 2006) [15]. In Senegal, fishery products are the main source of protein for the population, covering 75% of their protein needs. These fishery products are included in many dishes, especially in the composition of the Senegalese national dish (Broutin, 2000) [4].
In the Senegal River, fish are placed at the top of the food pyramid (Anonymous, 2014; PNEEB/TYPHA, 2014) [3]. The ichthyofauna is strongly affected by environmental degradation and especially by the decrease in rainfall (Diouf *et al*., 2021) [12].
The presence of flood depressions in Lower Gambia accounts for the presence of freshwater fish. In Middle Gambia river, about 61 species have been identified. Finally, in Upper Gambia, at an altitude of more than 500 m, we note the presence of a fauna remarkable for its scarcity and originality (Daget, 1960) [7]. The risk, when eating raw fish, even if it is fresh, in good condition, and of good quality, is ingesting a fish infected with parasites and becoming contaminated (Gonzales, 2013) [16]. Among these fish parasites, nematodes are very present in several hosts.
Nematode parasites of freshwater fish have been the subject of several studies worldwide. In Africa, the works of Ibiwoye *et al*. (2005) [19] and Akinsanya and Otubanjo (2005) [1] in Nigeria and those of Moravec and Jirků (2014) [26] in the Central African Republic can be mentioned. In Senegal, there are the works of (Vassiliades 2010, 1970, 1973; Vassiliades & Troncy, 1973; Vassiliades & Petter, 1972; Dione *et al*., 2014) [33, 36, 37, 35, 34, 11].
This manuscrit adds to the many studies already carried out in the Senegal and Gambia rivers. The objective is to analyze the distribution of nematodes in host populations as well as the influence of weight, size, and sex of the fish hosts on nematode infestation in these two watercourses.

Materials and Methods
Fish sampling was carried out randomly between 2018 and 2021 during both the rainy and dry

seasons and in two different localities, the Senegal River and the Gambia River. In the Senegal River, the collection point is Richard Toll (16°27′31.96" North latitude and -15°41′38.56" East longitude) and in the Gambia River, it is the locality of Gouloumbou (13°34′58.82" North latitude and 13°41′44.21" East longitude). The fish were preserved in ice and transported to Dakar, to the Cheikh Anta Diop University's general parasitology laboratory. They were identified according to Lévêque *et al*. (1990) [21], and for each specimen, its weight, standard length, total length, and sex were determined.

After dissection, nematodes were collected from the stomach, intestine, rectum, and liver. These parasites (adults and larvae) were fixed in boxes containing 70° ethanol. On each box, the host's name, the date and place of collection, and the organ in which the parasite was found were mentioned. The number of nematodes per site of infestation was also cataloged. A Nikon type light microscope was used to study the nematodes. Ecological terms such as prevalence (P), mean abundance (Am), dominance index (Id), and mean parasitic intensity (Im) were calculated according to Margolis *et al*. (1982) [24].

Microsoft Office Word 2020 and Microsoft Office Excel 2020 software were used for data entry. The R software was used for statistical data analysis and graphical representations. To assess the influence of variables (weight, size, sex, and locality) on prevalence, Fisher's, Shapiro-Wilk, and Wilcox tests were performed.

Each host fish is characterized by a biodiversity index that varies according to the diversity of nematode parasite genera. Thus, the Shannon index (Marcon, 2022) [23], also called the Shannon-Weaver index or Shannon-Wiener index, was calculated for each host according to the following formula:

$$H = -\sum_{i=1}^{s} Pilnpi$$

With
S = total number of species
pi = (nj/N), the proportion of species in the survey.
nj = relative frequency of species j in the sampling unit
N = sum of specific relative frequencies
Log 2 = Natural logarithm

Results

During this sampling period, the number of fish collected totaled 1216, with 715 in the dry season and 501 in the rainy season. In the Senegal River, we sampled 551 fish, while in the Gambia River we had 665 fish.

Between the two localities, the difference in the number of fish obtained is not linked to any factor other than the availability of equipment. The difference between the number of males and the number of females is also not linked to any factor other than chance, as sex is only determined after dissection. The fish species common to both localities are:

Table 1: Fish sampling locations

Fish	Sampling location	
Alestes baremoze Joannis,1835		Gambia River
Brycinus nurse Rüppell,1832		Gambia River
Chrysichthys maurus Valenciennes,1840	Senegal River	Gambia River
Citharinus citharus Geoffroy Saint-Hilaire,1809	Senegal River	Gambia River
Clarias anguillaris Linnaeus, 1758	Senegal River	
Clarias gariepinus Burchell,1822	Senegal River	Gambia River
Cynoglossus senegalensis Kaup, 1858		Gambia River
Gymnarchus niloticus Cuvier,1829	Senegal River	
Hemichromis fasciatus Peters,1857		Gambia River
Heterobranchus bidorsalis Geoffroy Saint Hilaire,1809		Gambia River
Heterotis niloticus Cuvier,1829	Senegal River	
Hydrocynus forskahlii Cuvier,1819	Senegal River	Gambia River
Hyperopisus bebe Günther,1866	Senegal River	
Labeo senegalensis Cuvier et Valenciennes,1842		Gambia River
Marcusenius senegalensis Steindachner,1870		Gambia River
Malapterurus electricus Gmelin, 1789		Gambia River
Mormyrops anguilloides Linnaeus, 1758	Senegal River	Gambia River
Mormyrus rume Valenciennes,1846		Gambia River
Oreochromis niloticus Linné,1757	Senegal River	
Parachanna obscura Günther, 1861	Senegal River	
Polypterus senegalus Cuvier, 1829		Gambia River
Schilbe intermedius Rüppell,1832		Gambia River
Synodontis annectens Boulenger,1911		Gambia River
Synodontis batensoda Rüppell, 1832	Senegal River	
Synodontis clarias Linné,1758		Gambia River
Synodontis nigrita Cuvier et Valenciennes,1840		Gambia River
Synodontis ocellifer Boulenger,1900	Senegal River	Gambia River
Synodontis schall Bloch et Schneider,1801	Senegal River	
Tetraodon lineatus Linnaeus, 1758	Senegal River	

After dissection, the fish were divided into 663 males and 553 females as shown in the following table.

Table 2: Distribution of the Number of Fish by Locality, Sex, and Season.

Localities	Senegal River		Gambia River	
Sexes	Male	Female	Male	Female
Dry Season	189	157	201	168
Rainy Season	119	86	154	142

The number of fish sampled in the dry season is higher than that obtained in the rainy season, a period when fish are scarce. Indeed, with the increase in water levels in the rivers, fishing becomes very difficult in certain areas. This is compounded by the reduction in the number of fishermen during the rainy season due to agricultural activities. After identifying the host fish and the genera of nematode parasites, the results are summarized in the following table 3.

Among the 29 host fish, 13 genera of nematodes were encountered. *C. maurus* is the host with the widest range of nematode parasites, harboring 10 genera of nematodes. It is followed by *C. gariepinus*, which hosts 6 genera of nematodes. *S. annectens* and *S. ocellifer* each present 5 genera of nematodes. *H. forskahlii* and *S. nigrita* each have 4 genera of nematodes. *M. electricus*, *O. niloticus*, *S. clarias*, and *S. nigrita* each host 3 genera of nematodes. *C. anguillaris*, *H. niloticus*, and *S. bentosoda* each present 2 genera of nematodes. The fish *Brycinus nurse*, *C. senegalensis*, *H. fasciatus*, *H. bidorsalis*, *M. senegalensis*, and *M. anguilloides* are each parasitized by a single genus of nematodes. The rest of the fish do not show any parasites. The genus *Multicaecum* and *Capillaria* are found respectively in *H. niloticus* and *M. electricus*. These two genera of nematodes are found only in a single host. Therefore, their frequency is very low among the sampled fish. The genus *Camallanus* and Spiro *Camallanus* are present *in C. maurus* and *C. gariepinus*.

The genus *Cucullanus* is also present only in two hosts, *M. rume* and *O. niloticus*. The frequency is a bit higher with the genus *Falcaustra*, which is present in 3 hosts, and the genera Anisakis and *Paracamallanus*, which are present in 4 hosts each. The most frequent nematode genera in our various fish populations are *Rhabdochona*, *Pro Camallanus*, and *Contracaecum*. *Rhabdochona* is present in 7 fish species, while the genera *Procamallanus* and *Contracaecum* each parasitize 9 different fish.

The following table provides the biodiversity index values for all sampled fish.

A. baremoze, *G. niloticus*, *L. senegalensis*, *P. obscura*, *P. senegalus*, *S. intermedius*, *S. schall*, and *T. lineatus* are not parasitized, therefore their biodiversity index is null. This is also the case for *B. nurse*, *C. citharus*, *C. senegalensis*, *H. fasciatus*, *H. bidorsalis*, *H. bebe*, *M. senegalensis*, *M. anguilloides*, and *M. rume*, which are parasitized by only one genus of nematode.

The other host fish present a biodiversity index that varies according to sex, season, and locality.

Thus, *C. maurus*, *C. gariepinus*, *S. annectens*, and *S. nigrita* show a higher biodiversity index in males. However, *H. niloticus*, *H. forskahlii*, and *S. ocellifer* have a higher biodiversity index in females. The biodiversity index is null in males of *M. electricus*, *O. niloticus*, and *S. clarias*, and in the female of *C. anguillaris*. The most significant biodiversity index according to sex is recorded in males of *C. maurus*.

C. maurus and *H. niloticus* show a higher biodiversity index in the rainy season, while *C. gariepinus*, *H. forskahlii*, and *S. clarias* have a higher biodiversity index in the dry season. *C. anguillaris* shows a null biodiversity index in the dry season, whereas *M. electricus*, *O. niloticus*, *S. annectens*, *S. bentosoda*, *S. nigrita*, and *S. ocellifer* have a null index in the rainy season. *C. maurus* shows the highest biodiversity index in the rainy season.

Species common to both localities, such as *C. gariepinus* and *S. ocellifer*, show a higher biodiversity index in the Senegal River. *C. anguillaris*, *H. niloticus*, *O. niloticus*, and *S. niloticus* have a null biodiversity index in the Gambia River, while *C. maurus*, *H. forskahlii*, *M. electricus*, *S. annectens*, *S. clarias*, and *S. nigrita* show a null biodiversity index in the Senegal River. *C. maurus* again shows the highest biodiversity index in the Gambia River.

The calculation of the prevalence of host fish during the two seasons and in the two sites has resulted in the table 5.

For species common to both rivers, the results show that prevalence varies from one species to another. Thus, *C. maurus* shows a null prevalence in the Senegal River, whereas in the Gambia River its prevalence varies according to sex, season, and locality. Indeed, the species presents the highest prevalence among females in the rainy season. *C. citharus* has a null prevalence in the Gambia River during the rainy season for both sexes. This is also where the species records the highest value for both sexes. In the Senegal River, the fish is parasitized throughout the year and in all individuals, but with values much lower than those of the Gambia River. *C. gariepinus* shows a maximum prevalence in the dry season in the Senegal River for both sexes and a null prevalence for both sexes in the same season in Gambia. The species is parasitized in the rainy season in both localities, with a higher prevalence among males of the Gambia River. In *H. forskahlii*, only males in the dry season show a null prevalence. Indeed, in both localities, among all individuals and throughout the year, the species is parasitized, and its prevalence is much higher among individuals of the Gambia River. *S. ocellifer* is sampled only during the rainy season in both rivers. Its prevalence is higher in Gambia. *M. anguilloides* and *B. nurse* are parasitized only in the Gambia River, in the rainy season, and among female individuals. *A. baremoze* shows a null prevalence in both localities, throughout the year, and for both sexes.

Regarding fish species sampled only in the Senegal River, *C. anguillaris* and *H. bebe* are parasitized only in the dry season, unlike *O. niloticus* and *S. batensoda*, which are parasitized in the rainy season. *H. niloticus* is parasitized throughout the year, but its prevalence is higher among females in the dry season. *G. niloticus*, *S. schall*, and *T. lineatus* show a null prevalence. For fish species found only in Gambia, *C. senegalensis*, *M. electricus*, *S. annectens*, and *S. nigrita* are parasitized only in the dry season, while *H. bidorsalis*, *M. senegalensis*, and *M. rume* are parasitized in the rainy season. *M. electricus* and *M. rume* show the highest prevalences. *H. fasciatus*, *L. senegalensis*, *P. senegalus*, *S. intermedius*, and *S. clarias* have a null prevalence.

The results of tests on the relationship between the weight and size of host fish on prevalence yield the table 6.

Table 3: Distribution of Nematode Genera According to Host Fish

Genera of Nematodes Hosts	*Multicaecum*	*Cithariniella*	Para *Camallanus*	Pro *Camallanus*	*Rhabdochona*	*Contracaecum*	*Anisakis*	Spiro *Camallanus*	*Spinitectus*	*Falcaustra*	*Capillaria*	*Cucullanus*	*Camallanus*
Brycinus nurse					■								
Chrysichthys maurus		■	■	■	■	■	■	■	■	■			■
Citharinus citharus		■											
Clarias anguillaris			■	■									
Clarias gariepinus			■	■		■	■	■					■
Cynoglossus senegalensis									■				
Hemichromis fasciatus						■							
Heterobranchusbidorsalis			■										
Heterotis niloticus	■					■							
Hydrocynus forskahlii					■	■	■		■				
Hyperopisus bebe									■				
Marcusenius senegalensis				■									
Malapterurus electricus					■				■		■		
Mormyrops anguilloides						■							
Mormyrus rume												■	
Oreochromis niloticus						■	■					■	
Synodontis annectens		■		■	■				■	■			
Synodontis batensoda				■		■							
Synodontis clarias		■		■	■								
Synodontis nigrita		■		■					■				
Synodontis ocellifer		■		■		■			■	■			

Table 4: Distribution of biodiversity indices in fish hosts

Fish Hosts	Shannon Biodiversity Indices					
	Sex		Season		Locality	
	Male	Female	Dry	Rainy	Senegal	Gambia
Brycinus nurse	0	0	0	0	0	0
Chrysichthys maurus	1.46	1.2	0.24	1.38	0	1.73
Citharinus citharus	0	0	0	0	0	0
Clarias anguillaris	0.57	0	0	0.49	0.49	0
Clarias gariepinus	1.26	0.7	1.07	0.31	1.03	0.23
Cynoglossus senegalensis	0	0	0	0	0	0
Hemichromis fasciatus	0	0	0	0	0	0

Heterobranchus bidorsalis	0	0	0	0	0	0
Heterotis niloticus	0.36	0.68	0.51	0.63	0.58	0
Hydrocynus forskahlii	0.24	0.83	0.86	0.5	0	0.81
Hyperopisus bebe	0	0	0	0	0	0
Malapterurus electricus	0	1.02	0.98	0	0	0.98
Marcusenius senegalensis	0	0	0	0	0	0
Mormyrops anguilloides	0	0	0	0	0	0
Mormyrus rume	0	0	0	0	0	0
Oreochromis niloticus	0	0.83	0.88	0	0.65	0
Synodontis annectens	0.9	0.71	0.82	0	0	0.82
Synodontis batensoda	0	0	0.54	0	0.54	0
Synodontis clarias	0	0.89	0.55	0.27	0	0.37
Synodontis nigrita	0.8	0.41	1.17	0	0	0.49
Synodontis ocellifer	0.42	0.58	0.62	0	0.29	0.27

Table 5: Distribution of overall prevalences in fish hosts

Fish Hosts	**Global prevalences**							
	Senegal River				**Gambia River**			
	Rainy Season		**Dry Season**		**Rainy Season**		**Dry Season**	
	Males	**Females**	**Males**	**Females**	**Males**	**Females**	**Males**	**Females**
Brycinus nurse	0	0	0	0	0	100	0	0
Chrysichthys maurus	0	0	0	0	14.81	18.81	0	16.66
Citharinus citharus	20	11.11	3.44	5.88	0	0	100	100
Clarias anguillaris	17.39	12.5	0	0	NS	NS	NS	NS
Clarias gariepinus	16.66	5.55	100	100	20	6.25	0	0
Cynoglossus senegalensis	NS	NS	NS	NS	0	0	0	50
Heterobranchus bidorsalis	NS	NS	NS	NS	7.69	0	NS	NS
Heterotis niloticus	6.25	40	33.33	45	NS	NS	NS	NS
Hydrocynus forskahlii	3.12	3.03	0	9.09	45.45	21.42	0	21.73
Hyperopisus bebe	NS	NS	0	9.09	NS	NS	NS	NS
Malapterurus electricus	NS	NS	NS	NS	0	0	0	100
Marcusenius senegalensis	NS	NS	NS	NS	0	33.33	NS	NS
Mormyrops anguilloides	NS	NS	NS	0	NS	NS	0	7.69
Mormyrus rume	NS	NS	NS	NS	0	100	0	0
Oreochromis niloticus	0	0	0	25	NS	NS	NS	NS
Synodontis annectens	NS	NS	NS	NS	NS	NS	22.85	1.09
Synodontis batensoda	NS	NS	26.66	33.33	NS	NS	NS	NS
Synodontis nigrita	NS	NS	NS	NS	NS	NS	60	41.66
Synodontis ocellifer	NS	NS	0	15.38	NS	NS	30.76	60

NS: Not Sampler

Table 6: Results of weight and size tests on the prevalence of fish hosts

Hosts	WEIGHT		SIZE	
	P-value	Conclusions	P-value	Conclusions
Chrysichthys maurus	0.7	Not significant	0.2206	Not significant
Citharinus citharus	6.3e-08	Very significant	0.01653	Significant
Clarias anguillaris	0.5637	Not significant	1	Not significant
Clarias gariepinus	0.6063	Not significant	0.9734	Not significant
Heterotis niloticus	0.5018	Not significant	0.4195	Not significant
Hydrocynus forskahlii	0.445	Not significant	0.0815	Not significant
Oreochromis niloticus	-	-	0.7788	Not significant
Synodontis annectens	0.6065	Not significant	0.4169	Not significant
Synodontis batensoda	1	Not significant	0.006152	Not significant

These results indicate that only *C.citharus* shows a highly significant conclusion for weight and significant for size. The other parasitized species present non-significant results.

Discussion

The results of this study primarily indicate that the biodiversity of nematodes in sampled host fish is low. Only *C. maurus* and *C. gariepinus* present index values above 1 throughout the year. These two species of host fish would be more exposed to different communities of nematode parasites than others. Their bodies would offer better conditions for the development of various genera of nematodes.

Furthermore, the study of relationships between host fish and different communities of nematodes shows that prevalence is an ecological parameter that varies based on several criteria. Indeed, age, sex, size, type of food, lifestyle, geographical and seasonal distribution of the host population over time and space can determine or influence the parasitic fauna of many species or groups of hosts. This has been reported by other authors. Thus, Sinare *et al*. (2021) [31] showed that the difference in the number of nematode parasites of *C. anguillaris* between two collection localities was significant. Daoui and Chaheb (2021) [8] made a similar observation, highlighting that this parameter plays a very important role in the coexistence between hosts and parasites. Moreover, Debenedettie *et al*. (2019) [9] found prevalence influenced by three factors length, origin, and season in 9 species of fish from the Atlantic and Mediterranean.

This last point is related to the ecological parameter considered in this study. Indeed, the prevalence of our specimens is higher in the dry season in the Senegal and Gambia rivers. This could be explained by an increase in river levels and available food for fish during the rainy season, which seems to reduce infestation rates. Furthermore, the increase in temperature and significant evaporation in the waters during the dry season would favor an increase in the rate of parasitism. Similarly, the decrease in food resources exposes fish to consuming all sorts of food, thus increasing the risks of infestation. Our results confirm those of Sinare *et al*. (2021) [31], indicating that during the dry season, the reduction in water surface leads to contacts among different hosts, as well as those found *in Otolithoides pama* from the Bay of Bengal (Priyanka *et al*. 2019) [30] and *Mugil cephalus* in Senegal (Dione *et al*. 2014) [11].

However, the opposite has been reported by other authors (Olivero-Verbel *et al*. 2013, Sinare *et al*. 2021) [29, 31]. Ibiwoye *et al*. (2005) [19] note a high infestation of fish at the beginning of the rainy season due to their weakening during hibernation.

Weight and/or size of the hosts can influence the prevalence of certain hosts. Indeed, the Fisher test indicates for *C. citharus* a p-value = 6.3e-08, highly significant for weight, and a p-value=0.01653, significant for size. This influence of weight and size on this ecological parameter has been noticed in a catfish, *Sciades proops* (Carvallho *et al*. 2015) [6]. In his work, Al-Zubaidy (2009) [2] reported a positive correlation of infection by larvae of *Contracaecum sp.* with the length and weight of fish.

In *Otolithoides pama* from the Bay of Bengal, larger fish showed higher prevalence values (Kassem *et al*. 2015) [20]. This could be since heavier fish consume more food that may contain parasites. Hassani-Smail (2015) [18] reported a significant relationship between prevalence and size in *Hysterothylacium aduncum*. This relationship is not verified in most of our host fish species. Our results corroborate those of Sinare *et al*. (2021) [31] and Mujtaba *et al*. (2018) [27], according to whom, the number of nematodes is not related to the size or weight of the hosts. Moreover, Enyidi and Eneje (2015) [14] showed a decrease in prevalence with an increase in size in farms.

This increase in infestation would be due to the longevity of fish and especially their diet. Indeed, with age, by consuming various organisms such as crustaceans and intermediate hosts of nematodes, fish increase their risk of infestation. This was reported in the works of Bussmann and Ehrich (1979) [5], Ibiwoye *et al*. (2005) [19], Valero *et al*. (2006b) [32] and Dougnon *et al*. (2012) [13]. The effect of time on fish infestation was also shown in *Stizostedion vitreum* by Muzzall *et al*. (1990) [28] and on *Piaractus mesopotamicus* by Dias *et al*. (2004) [10]. Other authors even indicate that an increase in prevalence would be influenced by an increase and growth of the internal organs of the hosts leading to an increase in infection surfaces (Hagras *et al*. 1995) [17]. According to Mbokane *et al*. (2015) [25], an increase in fish size allows for an increase in space and food resources for parasites.

However, for some researchers, size and weight may or may not be related to parasitism. This is the case with Luque (1996) [32] in his work on marine sciaenid fish.

Acknowledgments

We would first like to thank the fishermen who accompanied us during the sampling periods. Then, we warmly thank Professor Cheikh Tidiane BA and Professor Ngor FAYE for their unconditional support. Finally, our thanks to all the staff of the Laboratory of General Parasitology and the Evolutionary Biology, Ecology and Ecosystem Management Laboratory of the department of Animal Biology of the Faculty of Science and Technology of Cheikh Anta Diop University of Dakar.

References

1. Akinsanya B, Otubanjo OA. Helminth parasites of *Clarias gariepinus* (Clariidae) in Lekki Lagoon, Lagos, Nigeria. Revista de Biología Tropical. 2005;54(1):93-99.
2. Al-Zubaidy AB. Prevalence and densities of

Contracaecum sp. larvae in *Liza abu* (Heckel, 1843) from different Iraqi water bodies. Journal of King Abdulaziz University: Marine Sciences. 2009;20:3-17.
3. Anonymous. Situation de reference de la biodiversité dans les zones de peuplement en Typha; c2014. p. 50.
4. Broutin C, editor. Aperçu de la filière halieutique au Sénégal. Groupe de recherche et d'échanges technologiques; c2000. p. 6.
5. Bussmann B, Ehrich S. Investigations on infestation of blue whiting (*Micromesistius poutassou*) with larval *Anisakis* sp. (Nematoda: Ascaridida). Archiv für Fischereiwissenschaft. 1979;29:155-165.
6. Carvallho RPS, Takemoto RM, Melo CM, Jeraldo VLS, Madi RR. Structure of the parasite infracommunity of *Sciades proops* from the Japaratuba River Estuary, Sergipe, Brazil. Brazilian Journal of Biology. 2015;75(4):906-913.
7. Daget J. La faune ichtyologique du bassin de la Gambie. Bulletin de l'Institut Fondamental d'Afrique Noire XYII. skr. A. 1960;8(2):612-613.
8. Daoui S, Chaheb K. Etude bibliographique de la charge parasitaire des poissons famille des Cichlidae. Université de Biskra; c2021.p. 62.
9. Debenedetti ÁL, Madrid E, Trelis M, Codes FJ, Gómez FG, Durán SS, Fuentes MV. Prevalence and risk of anisakid larvae in fresh fish frequently consumed in Spain: An overview. Fishes. 2019, 4(13).
10. Dias PG, Furuya WM, Pavanelli GC, Machado MH, Takemoto RM. Carga parasitária de *Rondonia rondoni* Travassos, 1920 (Nematoda, Atractidae) e fator de condição do armado, *Pterodoras granulosos* Valenciennes, 1883 (Pisces, Doradidae). Acta Scientiarum: Biological Sciences. 2004;26(2):151-156.
11. Dione EN, Diouf M, Fall J, Bâ CT. Seasonal and spatial distribution of nematode larvae of the genera *Anisakis* and *Contracaecum* (Anisakidae) in two populations of *Mugil cephalus* (Mugilidae) from Saloum and Senegal Rivers. Journal of Biology and Life Science, 2014, 5(1).
12. Diouf PS, Kebe M, Bousso T, Diadhiou HD, Gaye AB. Plan directeur de développement forestier: pêche et aquaculture continental. 2021;2:33.
13. Dougnon J, Montchowui E, Daga FD, Houessionon JT. Cutaneous and gastrointestinal helminth parasites of the fish *Synodontis shall* and *Synodontis nigrita* (Siluriformes, Mochokidae) from the lower Ouémé Valley in South Benin. Research Journal of Biological Sciences. 2012;7(8):320-326.
14. Enyidi U, Uwanna P. Parasites of African catfish *Clarias gariepinus* and *Oreochromis niloticus* polycultured in earthen ponds. Aquaculture Studies. 2019;19(2):81-89.
15. FAO. State of food and agriculture. Food agriculture series No. 37. Rome, Italy; c2006.p. 103.
16. Gonzales S. Risque d'infection parasitaire par des poissons crus cas de l'anisakidose et de la bothriocephalose. Thèse pour diplôme d'Etat docteur en pharmacie; c2013.p. 13.
17. Hagras AEM, El-Naggan MM, Mansour MFA, El Naggar AM. Influence of age, length and sex of the catfish *Clarias lazera* on infestation with six monogenean parasites. Mansoura Science Bulletin (Biological Sciences); c1995, 22(2).
18. Hassani-Smail MM. Inventaire des nématodes des poissons gadidés : *Phycis blennoides* (Brünnich, 1768) et *Phycis phycis* (Linné, 1758) du littoral oranais (ouest algérien). Thèse présentée pour l'obtention du diplôme de Doctorat en Sciences; c2015.p. 199.
19. Ibiwoyei TLI, Sule AM, Okomoda JK, Agbontale JJ. Investigation of nematode *Eustrongylides* larvae infections in mudfish *Clarias gariepinus* and *C. anguillaris* from Bida floodplain of Nigeria. New Bussa, Niger State, Nigeria; c2005. p. 520-529.
20. Kassem HH, Bowashi SM. Prevalence of anisakid nematode larvae infecting some marine fishes from the Libyan coast. Journal of the Egyptian Society of Parasitology. 2015, 45(3).
21. Lévêque C, Paugy D, Teugels GG, editors. Faune des poissons d'eaux douces et saumâtres d'Afrique de l'Ouest. Editions de l'ORSTOM Paris;. Tome 1; c1990. p. 386.
22. Luque JL. Distribución y asociaciones interespecíficas en las comunidades de metazoarios ectoparásitos de peces esciénidos del Perú. Revista de Biología Tropical. 1996;44:387-394.
23. Marcon E. Mesures de la biodiversité. World Wide Web electronic publication; c2022. Available from: https://github.com/EricMarcon/MesuresBioDiv2.
24. Margolis L, Esch GW, Holmes JC, Kuris AM, Schad GA. The use of ecological terms in parasitology (Report of an Ad Hoc Committee of the American Society of Parasitologists). The Journal of Parasitology. 1982;68(1):131-133.
25. Mbokane EM, Theron J, Luus-Powell WJ. Seasonal occurrence of some larval stages of endoparasites in three cyprinids from the Nwanedi-Luphephe dams, the Limpopo River System. Helminthologia. 2015;52(3):229-235.
26. Moravec F, Jirků M. *Rhabdochona* spp. (Nematoda: Rhabdochonidae) from fishes in the Central African Republic, including three new species. Institute of Parasitology, Biology Centre ASCR. Folia Parasitologica. 2014;61(2):157-172.
27. Mujtaba EKS, Abuelgasim IA. Parasites of *Oreochromis niloticus* from Nubia Lake, Sudan. Journal of Aquatic Science and Marine Biology. 2018, 1(2).
28. Muzzall PM, Sweet RD, Milewski CL. Occurrence of *Diplostomum* sp. (Trematoda: Diplostomatidae) in pond-reared walleyes from Michigan; c1990. p. 53-56.
29. Olivero-Verbel JV, Arroyo BS, Manjarrez GP. Parasites and hepatic histopathological lesions in lisa (*Mugil incilis*) from Totumo marsh, North of Colombia. Revista MVZ Córdoba. 1990;18(1):3288-3294.
30. Priyanka RN, Mohammad RR, Joyshri S, Rashadul Islam SM. Prevalence and intensity of *Contracaecum* sp. in jew-fish (*Otolithoides pama*). Scholars Journal of Agriculture and Veterinary Sciences. 2019;10:1-10.
31. Sinare Y, Boungou M, Kangoye MN, Kabre GB. Modèle de distribution des nématodes chez le poisson chat (*Clarias anguillaris* (Linnaeus, 1758)) dans deux réservoirs du Burkina Faso (Afrique de l'Ouest). International Journal of Biological and Chemical Sciences. 2021;15(3):1015-1029.
32. Valero A, Paniagua MI, Hierro IR, Diaz V, Valderrama MJ, Benítez FJ. Anisakid parasites of two forkbeards (*Phycis blennoides* and *Phycis phycis*) from the Mediterranean coasts of Andalucia (Southern Spain). Parasitology Research. 2006;55(1):1-5.
33. Vassilades G. Un nouveau *ParaCamallanus* (Nematoda; Camallanidae), chez un poisson Clariidae de Sangalkam (Sénégal). Annales de Parasitologie (Paris) 2010;4:441-

448.
34. Vassiliades G, Petter AJ. *Camallanus ctenopomae* n. sp. (Nematoda; Camallanidae), parasite de *Ctenopoma kingsleyae* Gunther (Poisson; Anabantidae) au Sénégal. Annales de Parasitologie (Paris). 1972;3:383-389.
35. Vassiliades G, Troncy PM. Description de *Falcaustra tchadi* n. sp. (Nematoda; Katblaniidae) parasite de *Distichodus brevipinnis* (Poisson; Citbarinidae) du Tchad. Annales de Parasitologie (Paris). 1973;3:489-495.
36. Vassiliades G. Un nouveau *ParaCamallanus* (Nematoda; Camallanidae), chez un poisson Clariidae de Sangalkam (Sénégal). Annales de Parasitologie (Paris). 1970;4:441-448.
37. Vassiliades G. Nématodes parasites de *Distichodus rostratus* Poisson Citharinidae du lac de Guiers (Sénégal). Annales de Parasitologie (Paris). 1973;3:469-475.