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First records of *Macrogyrodactylus clarii* and six species of *Quadriacanthus* (Monogenea) infecting *Clarias gariepinus* (Burchell, 1822) across four localities in Senegal

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ABSTRACT

This study was conducted from November 2022 to October 2023, in order to contribute to the knowledge of fish parasites biodiversity in *Clarias gariepinus* from Senegalese freshwater. Fish were collected from different sampling sites, including Ndiawdoune (Saint-Louis), Mbao (Dakar), Sadel (Matam) and Gouloumbou (Tambacounda). In the laboratory, fish were identified and dissected, gills are removed and examined under a stereomicroscope. Monogeneans were collected and mounted between slide and coverslip using ammonium picrate-glycerin, then observed under an optical microscope. Measurements of the sclerotized structures of the haptor and the male copulatory organ were carried out to identify monogeneans species. Out of a total of 119 fish collected, 60 were infested with monogeneans, giving a prevalence of 50.42%. The parasitic abundance and intensity were, respectively, 12.15 and 24.1 parasite per fish. Statistics analysis showed that infestation rate of monogeneans varied depending on the sampling location and fish size. Seven species, including six belonging to the genus *Quadriacanthus* and one to the genus *Macrogyrodactylus* were identified. They are *Q. aegypticus* (prevalence 14.29%), *Q. clariadis* (24.37%), *Q. fornicatus* (26.05%), *Q. kearni* (6.72%), *Q. pravus* (15.13%), *Q. ashuri* (0.84%) and *Macrogyrodactylus clarii* (5.88%). These species are reported for the first time in Senegal. This study showed diversity of monogeneans species parasite African catfish *C. gariepinus* in Senegal.

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INTRODUCTION

Clarias gariepinus is a very common fish species in Africa. It is common in Senegal river basins (Paugy *et al.*, 2003). It is considered one of the most important freshwater fish species in Africa (Khalil and Bishai, 1997). Global catfish production is estimated at 7,284,000 tonnes (live weight equivalent) in 2024, accounting for 11 per cent of the total production of the world's main aquaculture species (FAO, 2026). In Senegal, *C. gariepinus* is the second most farmed fish species due to its high fecundity, omnivorous diet, good growth performance, and tolerance to a wide range of environmental conditions (Tine *et al.*, 2021).

However, *C. gariepinus* may harbour pathogens that can cause disease. These pathologies disrupt fish health, reduce zootechnical performance, and lead to high mortality rates in farming or natural environments, and result significant economic losses and, in some cases, infestations of humans and other vertebrates that consume them (Michel, 1989; Simková *et al.*, 2001; Barker *et al.*, 2002). Among the pathogens capable of causing harm to fish are monogeneans. Indeed, they cause losses or growth disturbances in fish (Euzet and Pariselle, 1996), damage to the gill filaments, tissue changes, inflammation, and so on (González-Lanza *et al.*, 1991; Sitjà-Bobadilla and Alvarez-Pellitero, 2009; Mashaly, 2019; Lehmann *et al.*, 2020; McAllister *et al.*, 2023). Furthermore, studies on the monogeneans of fish have proved useful, as they enable the implementation of appropriate preventive measures in the event of an epizootic outbreak, help to elucidate the mechanisms of speciation in these parasites (Pariselle *et al.*, 2003), and allow the biogeographical history of fish to be reconstructed (Barson *et al.*, 2010). Being sensitive to changes in the physico-chemical parameters of water, monogeneans can be used as bioindicators to monitor and assess ecosystem health (Bayoumy *et al.*, 2015; Biswas and Pramanik, 2016).

At the time of writing this study, there are no published data available on the monogeneans of *C. gariepinus* from Senegal, a fish species with significant socio-economic potential. In this context, it became necessary to undertake this study, the main objective is contributed to the knowledge of the specific diversity of monogenean parasites in *C. gariepinus* from Senegalese freshwater.

MATERIALS AND METHODS

Sampling sites and period

Fish were collected during the sampling period from November 2022 to October 2023, directly from fishermen in four different sampling sites in Senegal. These are Ndiawdoune, Sadel, Gouloumbou and Mbao. QGIS software (Desktop version 3.28.2) was used for visual representation and precise localization of sampling sites (Fig. 1).

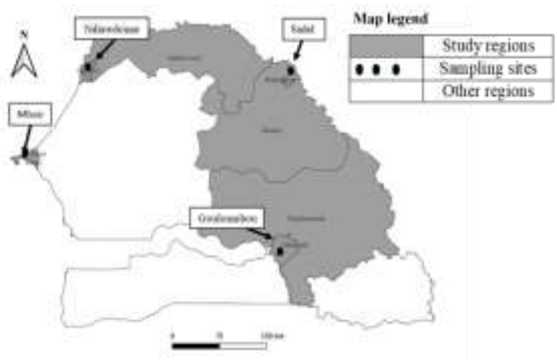

Fig. 1. Map showing the different sampling sites in Senegal

Fish collection and identification

Fish collected were transported directly to the laboratory in insulated coolers containing ice to keep them fresh. Once in the laboratory, they were identified using volume 2 of the manuals of Paugy *et al.* (2003) and the criteria established by Benech *et al.* (1993) for distinguishing between *C. anguillaris* and *C. gariepinus*. After identification, fish were weighed using an electronic balance (Denver Instrument). The total length was measured by ichtyometer. The sex of the fish was determined after evisceration by examining the gonads.

Collection and identification of parasites

Fish were immediately dissected or stored in a freezer at -20°C for later examination. The gills were removed and placed in Petri dishes containing tap water. Parasite search was conducted under incident light using a binocular stereomicroscope (Motic SMZ-140). Monogeneans were detached from the gill filaments using a strong water current and fine needles. They were mounted on a slide in a drop of Ammonium Picrate-Glycerin (Malmberg, 1957). The preparation was then covered with a round coverslip and sealed with Glyceel (Bates, 1997).

Measurements of the sclerotized structures of the haptor and the male copulatory organ of monogeneans were carried out according to Přikrylová and Gelnar (2008) and Francová *et al.* (2017). All measurements (means, minimums and maximums) are given in micrometers (µm). The set of morphometric parameters collected allowed species identification through comparison with descriptions available in the literature (El-Naggar and Serag, 1986; Kritsky and Kulo, 1988; Přikrylová and Gelnar, 2008; Francová *et al.*, 2017). The drawings were made using the Inkscape software (v. 1.4.3).

Epidemiological and statistical analyses

The epidemiological indices used were prevalence (P), abundance (A) and intensity (I) of parasites, derived from formulas established by Bush *et al.* (1997): $P = (N/H) \times 100$, $A = n/H$ and $I = n/N$ where N = infested fish, H = examined fish and n = number of parasites.

Statistical analysis and tests were performed using Excel 2021 (Version 2605) and R-studio software (version 2026.04.0). Fisher's test was used to compare prevalence rates based on fish sex, collection sites and weight and size classes. The Pairewise.fisher was used for pairwise comparisons of prevalences. We used the Shapiro test to examine the distribution of the data. To assess the significance of differences in parasite abundance and intensity, we used the Wilcox test for sex, the Kruskal-Wallis test for collection sites, weight and size classes, and the Pairewise.wilcox test for pairwise comparisons. P-values were considered significant if they were less than 0.05 ($P<0.05$).

Ethical statement

Our practices comply with ethical principles concerning animal collection and handling and adhere to animal welfare regulations of the National Ethics Committee for Health Research (CNERS) of Senegal, and to procedures established by Cheikh Anta Diop University of Dakar (UCAD) for ethical approval of all research involving human and animal participants.

RESULTS

Global parasitic indices of monogeneans

A total of 119 fish of *Clarias gariepinus* were examined, out of them, 60 were parasitized, corresponding to an overall prevalence of 50.42%. A total of 1,446 monogeneans were collected, with, respectively, a parasite abundance and intensity of 12.2 and 24.1 monogeneans per fish.

Parasitic indices according to sampling sites

Fish collected at Gouloumbou, Mbao and Sadel were the most parasitized by monogeneans, with respective rates of 100%, 83.3% and 72.1%, whereas those collected in the fishing village of Ndiawdoune were the least infested, with a rate of 9.8%.

Parasite abundance and intensity followed the same trend according to sampling sites. They were very low at Ndiawdoune ($A = 0.2$; $I = 2$), while they were higher at Sadel ($A = 9.7$; $I = 13.5$), Mbao ($A = 26.7$; $I = 32$) and Gouloumbou ($A = 45.5$; $I = 45$) (Fig. 2). Statistical tests showed that the differences observed between sites were significant, with a p-value < 0.005 for the prevalences, abundances and intensities.

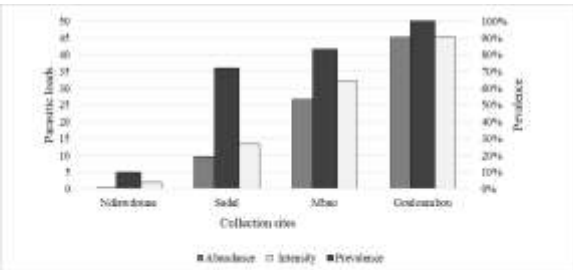

Fig. 2. Parasitic indices of monogeneans according to sampling sites

Parasitic indices according to sex

Males were more infested, with a prevalence of 56.91%, whereas females showed a prevalence of

43.09%. Males showed much higher parasite abundance and intensity, with 17.6 and 31.3 monogeneans per fish, respectively. In female hosts, parasite abundance and intensity were 5.3 per examined fish and 12.5 per infested fish, respectively (Fig. 3). However, this difference was not significant (p-value = 0.2 for prevalences and 0.08 for abundances and intensities).

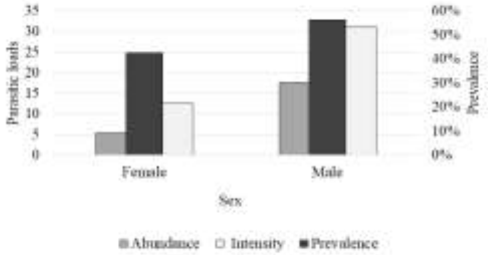

Fig. 3. Parasitic indices of monogeneans according to sex

Parasitic indices according to weight classes

Fish in the 200–350 g weight class and those weighing ≥350 g were the most affected by monogeneans, with rates of 95.5% and 100%, respectively. In contrast, fish weighing <200 g were the least affected by parasites (Fig. 4).

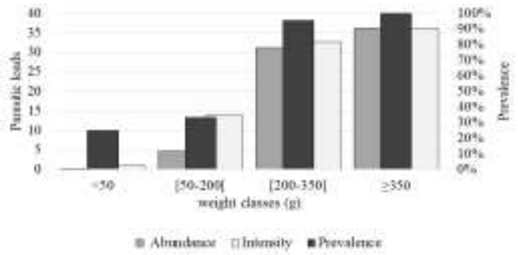

Fig. 4. Parasitic indices of monogeneans according to weight classes

Fish weighing between [200–350[g and those weighing ≥350 g showed parasite abundance of 31.2 and 36.2 per fish, respectively, and a parasite intensity of 32.7 and 36.2 per fish, respectively. In contrast, fish weighing less than 200 g showed very low parasite loads (Fig. 4). Statistical tests revealed a significant difference between prevalences and parasite loads among different weight classes, with a p-value < 0.005.

Parasitic indices according to size classes

Fish whose size ranged between 300–400 and 400–500 mm were the most infected, with respective rates of 92.9% and 100%. However, smaller fish ranging between 100–200 and 200–300 mm showed lower infestation rates of 20% and 34.3%, respectively (Fig. 5).

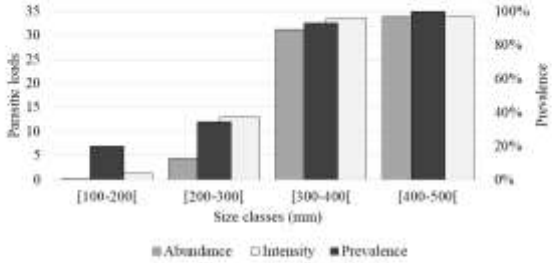

Fig. 5. Parasitic indices of monogeneans according to size classes

Fish measuring between 300–400 and 400–500 mm showed parasite abundance, respectively, of 31.2 and 33.9 monogeneans per fish, and an intensity of 33.6 and 33.9 monogeneans per fish, respectively. In contrast, fish measuring between 100–200 and 200–300 mm showed low abundances (0.3 and 4.4, respectively) and parasite intensities (1.3 and 13, respectively) (Fig. 5). Statistical tests revealed a significant difference in the prevalences and in the abundances and intensities among the considered size classes, with a p-value < 0.005.

Specific diversity of monogeneans

Observation of morpho-anatomical criteria, obtained measurements (Table 1&2) and comparison with species previously described in the literature for the examined host fish allowed the identification of seven species belonging to two genera. These include the genus *Quadriacanthus* with six species: *Q. aegypticus* El-Naggar and Serag, 1986, *Q. ashuri* Kritsky and Kulo 1988, *Q. clariadis* Paperna, 1961, *Q. fornicatus* Francová and Řehulková, 2017, *Q. kearni* El-Naggar and Serag, 1985 and *Q. pravus* Francová and Řehulková, 2017 (Fig. 6-11); and the genus *Macrogyrodactylus* with one specie, *M. clarii* Gussev 1961 (Fig. 12).

Table 1. Measurements of collected *Quadriacanthus* species

Species	*Q. clariadis*	*Q. aegypticus*	*Q. kearni*	*Q. fornicatus*	*Q. pravus*	*Q. ashuri*
Localities	Gouloumbou, Sadel and	Gouloumbou and	Sadel	Gouloumbou, Sadel and	Gouloumbou and Sadel	Gouloumbou
Measurements (µm)	Mbao			Mbao		
Bd	561.8 (426-796) n=12	570.8 (300-866) n=9	726.0 (488-1338) n=9	459.6 (364–672) n=15	469.7 (385–543) n=7	604.3 n=1
Bw	66.4 (40-92) n=11	58.9 (30-99) n=9	72.7 (33-120) n=9	73.8 (51-95) n=15	69.3 (36–88) n=7	64.3 n=1
Pl	33.2 (22-44) n=4	47.1 (23-75) n=5	60.0 (32-97) n=6	38.7 (28-58) n=5	-	45.1 n=1
Hl	78.2 (64-106) n=7	66.9 (47-86) n=11	80.0 (52-93) n=9	74.5 (59–92) n=13	80.0 (58–98) n=6	77.3 n=1
Hw	102.0 (73-129) n=7	77.2 (43-99) n=11	93.7 (75-125) n=9	87.1 (66–107) n=13	99.9 (82–120) n=6	118.2 n=1
Val	27.0 (24-29) n=16	34.2 (21-52) n=15	28.5 (23-36) n=11	26.6 (24-30) n=18	39.8 (36-55) n=10	30.0 n=1
Vac	0.8 (0.6-1.7) n=16	1.1 (0.7-1.6) n=15	1.2 (0.9-1.4) n=11	0.8 (0.6-1,1) n=18	0.8 (0.6-1,7) n=10	0.7 n=1
Vbtl	10.7 (8-15 n=16	9.9 (7-12) n=15	8.7 (6-12) n=11	11.2 (9-16) n=18	6.6 (5-9) n=10	6.9 n=1
Vasl	7.0 (5-10) n=16	8.3 (6-13) n=16	9.5 (7-13) n=10	7.1 (5-10) n=17	90 (6-11) n=10	10.8 n=1
Vbcl	54.1 (49-63) n=17	38.9 (33-57) n=16	52.9 (38-71) n=11	48.9 (45–53) n=17	47.5 (38-68) n=10	25.0 n=1
Dal	45.7 (41-49) n=17	42.9 (35-62) n=16	53.9 (44-72) n=11	34.0 (31-39) n=17	43.2 (36-63) n=10	30.8 n=1
Dac	1.1 (0.8-1.7) n=17	1.1 (0.9-1.4) n=16	1.1 (0.7-1.4) n=11	1.0 (0.7-1.6) n=17	1.0 (0.9-1.2) n=10	0.8 n=1
Dtl	4.7 (3–7) n=17	3.1 (1-4) n=16	3.7 (2–6) n=11	11.0 (9–14) n=17	2.5 (2–4) n=10	4.6 n=1
Dsl	15.5 (11–19) n=17	17.0 (11-28) n=16	38.0 (28-53) n=11	10.8 (7-13) n=17	14.6 (11-20) n=10	16.1 n=1
Bbl	55.5 (47–61) n=17	46.1 (28-73) n=15	66.4 (51-90) n=10	51.9 (36-64) n=16	51.4 (44-50) n=10	40.7 n=1
Bbw	25.8 (20–30) n=17	26.7 (17-42) n=15	30.7 (20-42) n=11	27.2 (22-33) n=16	24.4 (20-31) n=10	8.5 n=1
Mdbt	12.4 (10–15) n=17	12.9 (8-22) n=15	17.3 (11-26) n=11	10.1 (8-13) n=17	12.0 (10-16) n=10	8.3 n=1
Dbpl	12.1 (7-15) n=15	15.2 (9-22) n=13	14.7 (8-20) n=9	11.0 (6-14) n=10	16.0 (11-24) n=7	-
Lmco	34.8 (38-66) n=3	58.3 (42-80) n=9	78.1 (62-104) n=7	31.3 (22-40) n=2	26.5 n=1	42.2 n=1
Vl	-	35.6 n=1	49.4 (34-73) n=3	-	-	-

Bd: Body Length; Bw: Body width; Pl: Pharynx length; HL: Haptor length; Hw: Haptor width; Val: Ventral anchor length; Vac: Ventral an-chor curvature: Vbtl: Ventral bar tip length; Vasl: Ventral accessory sclerite length; Vbcl: Ventral bar component length; Dal: Dorsal anchor length; Dac: Dorsal anchor curvature; Dtl: Dorsal tip length; Dsl: Dorsal sclerite length; Bbl: Back bar length; Bbw: Back bar width; Mdbt: Median dorsal bar thickness; Dbpl: Dorsal bar process length; Lmco: Male copulator organ length; Vl: Vagina length; n: number of measure-ments.

Table 2. Measurements of *Macrogyrodactylus clarii*. n: number of measurements

Measured elements	Measurements (µm)
Body length	2738.2 (2115-3233.34 ; n=5)
Body width	386 (324.9-444.5 ; n=3)
Length of the hamulus	408.1 (346.11-550.5 ; n=5)
Length of the root of the hamulus	107.6 (85.2-138.1 ; n=5)
Length of the hamulus stem	354.1 (304.3-456.8 ; n=5),
Length of the tip of hamulus	170.6 (143.2-224.2 ; n=5)
Back bar length	15.8 (11.4-28.4 ; n=5)
Back bar width	73.9 (60.8-115.7 ; n=5)
Length of the ventral bar	131.4 (102.2-197.5 ; n=5)
width of the ventral bar	96 (89.7-108.6 ; n=5)
Anterolateral arm length	26.9 (22.3-33.5 ; n=5)
Length of posterior central arm	55 (39.3-70.9 ; n=5)
Length of rod 1 (r1) of the ventral bar	171.7 (134.8-239.8 ; n=5)
Length of rod 2 (r2) of the ventral bar	112.8 (106.3-122.2 ; n=4)
Total length marginal hook	109 (96.7-142.3 ; n=5)
Marginal hook rod length	91.1 (81.48-117.5 ; n=5)
Marginal sickle hook length	17.8 (15.4-23.6; n=5)
Proximal sickle width	13.4 (11.3-17.1 ; n=5)

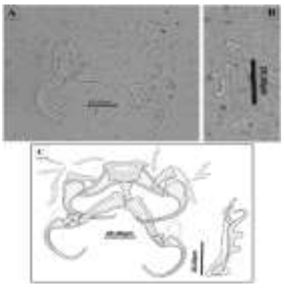

Fig. 6. *Quadriacanthus aegypticus*; A: Photomicrograph of haptor; B: Photomicrograph of MCO; C: Sclerotized structures

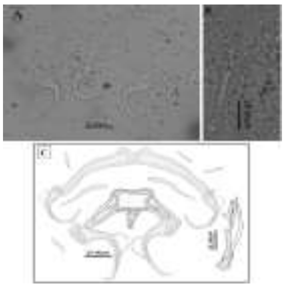

Fig. 7. *Quadriacanthus clariadis*; A: Photomicrograph of haptor; B: Photomicrograph of MCO; C: Sclerotized structures

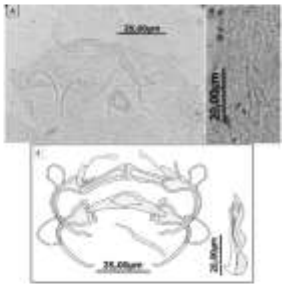

Fig. 8. *Quadriacanthus ashuri*; A: Photomicrograph of haptor; B: Photomicrograph of MCO; C: Sclerotized structures

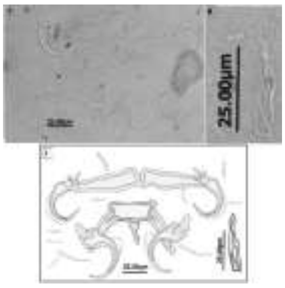

Fig. 9. *Quadriacanthus fornicatus*; A: Photomicrograph of haptor; B: Photomicrograph of MCO; B: Sclerotized structures

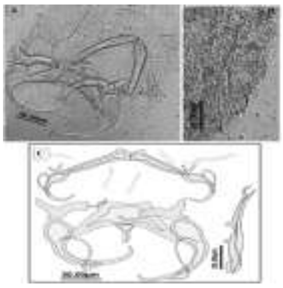

Fig. 10. *Quadriacanthus kearni*; A: Photomicrograph of haptor; B: Photomicrograph of MCO; C: Sclerotized structures

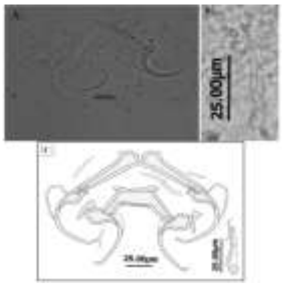

Fig. 11. *Quadriacanthus pravus*; A: Photomicrograph of haptor; B: Photomicrograph of MCO; C: Sclerotized structures

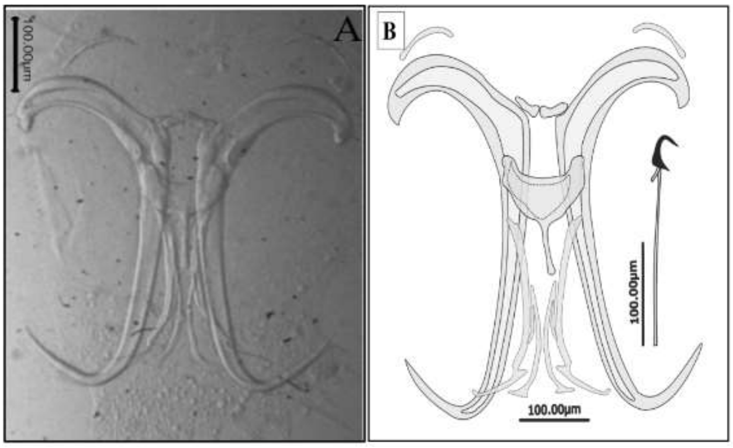

Fig. 12. *Macrogyrodactylus clarii*; A: Photomicrograph of haptor; B: Sclerotized structures

Species-specific prevalence of identified monogeneans

Among the identified monogenean species, *Q. fornicatus* and *Q. clariadis* were the most frequently encountered, with prevalences of 26.05% and 24.37%, respectively, followed by *Q. pravus* and *Q. aegypticus*, with prevalence rates of 15.13% and 14.29% respectively.

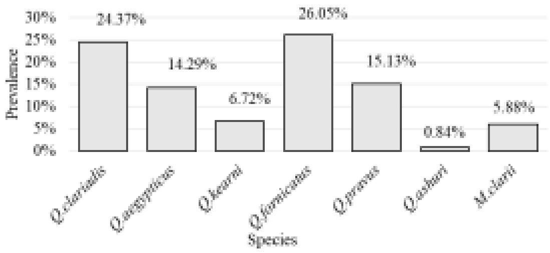

Fig. 13. Prevalence according to identified species

Infestations with *Q. kearni, M. clarii* and *Q. ashuri* were less common, affecting only 6.72%, 5.88% and 0.84% of the fish examined, respectively (Fig. 13).

DISCUSSION

The objective of this study was to contribute to the knowledge of the specific diversity of monogenean parasites of the freshwater African catfish *Clarias gariepinus* in Senegal. An overall monogenean prevalence of 50.4%, with an abundance of 12.2 monogeneans per fish and a parasitic intensity of 24.1 per fish were obtained during this study. In Egypt, Abdel-Latif *et al.* (2009) reported a prevalence similar to ours (56%) during their study on *C. gariepinus*; however, Nack *et al.* (2022) in Cameroon reported a higher prevalence (76.92%).

Gado *et al.* (2017) and Mahmoud *et al.* (2018) found much lower monogenean prevalences in Egypt, with 34% and 22%, respectively. The parasitic intensity reported by Nack *et al.* (2022) in Cameroon was lower than ours, with fewer than 10 individuals per infested fish. These differences in infestation rates among studies may be related to sample size, applied methodologies, as well as variations in ecological conditions. Indeed, environmental conditions can positively influence infestation rates by accelerating parasite life cycles and increasing parasitism, but they can also have negative effects and be fatal to certain parasite species (Eissa *et al.*, 2006).

We observed that the different study sites were not equally affected by monogeneans, and the difference in infestation among sites was significant (p-value < 0.005). The Sadel, Mbao and Gouloumbou sites were the most affected, with respective rates of 72.1%, 83.3% and 100%.

Fish collected in the fishing village of Ndiawdoune showed a much lower infestation rate (9.8%).

Differences in prevalence among sampling sites may also be explained by variations in water composition. These sites are geographically distant and experience different climatic conditions. Same observations were reported in previous studies (Bayoumy *et al.* 2015; Biswas and Pramanik 2016). The low prevalence observed at Ndiawdoune despite the hight number of examinted fish, could be explained by its proximity to the Diama dam near Saint-Louis, a coastal region characterized by saline waters. The slight salinity of river water due to saltwater intrusion near the dam could explain the low prevalence of monogeneans, making conditions less favorable for parasite development. Indeed, studies such as those by Mooney *et al.* (2008) and Marchiori *et al.* (2015) have shown that water salinity can influence the dynamic of monogenean infestation in their hosts. Differences in prevalence may also be related to fish size. Indeed, our results shows that smaller fish are less susceptible to monogenean infestation than larger fish; moreover, specimens collected at Ndiawdoune were smaller in size.

The Mbao stream is fed by runoff water often mixed with wastewater, which may favor the development of monogeneans. Similarly, all fish collected at Gouloumbou were infested with monogeneans, with a prevalence of 100%. Ongoing investigations may, in the near future, reveal the factors promoting this high level of parasitism. However, physicochemical parameters may further explain differences in monogenean infestation among sampling sites as shown by Mashaly *et al.* (2020).

Our results show that sex has no influence monogenean infestation in the fish collected, these observations are similar to those of Bichi and Yelwa (2010) in Nigeria and Mahmoud *et al.* (2018) in Egypt, who reported that sex does not influence gill parasite infestation rates.

However, other authors have reported that infestation depends on fish sex. Tachia *et al.* (2012) in Nigeria reported higher infestation rates in males (65.12%) than in females (34.89%), explaining this difference by the fact that males are known to engage more in hunting and feeding activities. In contrast, in Cameroon, Nack *et al.* (2022) observed higher prevalences in females (100%) than in males (63%). They attributed these differences to increased food intake by females during egg development, which may increase the risk of infestation (Mahmoud *et al.*, 2018).

Analysis of infestation according to fish weight shows that large fish (weight ≥200 g, length ≥300 mm) are more infested than small fish (weight <200 g, length <300 mm). Statistical tests showed significant differences among weight and size classes (p-value < 0.05).

Therefore, weight and size influence infestation rates. Similarly, fish weight and size also influence parasite loads (p-value < 0.05). In Cameroon, Nack *et al.* (2022) made a similar observation. According to these authors, long-term exposure to pathogens may increase the probability of infestation. Moreover, larger fish offer a greater surface area for parasite attachment compared to smaller fish (Nack *et al.*, 2018). Poulin (2006) added that the increase in parasitic indices with fish size may be linked to parasite accumulation over the host's lifetime and to changes in diet. Conversely, Mahmoud *et al.* (2018) reported that smaller fish are more sensitive to gill parasites than larger fish, attributing this phenomenon to the underdeveloped immune system of smaller fish.

The six monogenean species identified in this study have been reported in *C. gariepinus* elsewhere in the world by several authors (Paperna 1961, 1979; El-Naggar and Serag 1986; Kritsky and Kulo 1988; Khalil and Mashego 1998; Barson *et al.* 2010; Nack *et al.* 2022).

However, it is important to note that this is the first report of these parasites in Senegal. This represents a new geographical distribution, making Senegal a new area of occurrence for these parasites. Our study is the first to record the genus *Quadriacanthus* in Senegal.

Regarding the genus *Macrogyrodactylus*, *M. congolensis*, *M. heterobranchii*, *M. polypteri* and *M. simentiensis* were previously reported in Senegal by Přikrylová and Gelnar (2008). In the present study, *Macrogyrodactylus clarii* was identified for the first time in *C. gariepinus* in Senegal.

Our results also show that the presence of a given monogenean species does not prevent the development of other monogenean species within the same host individual, as several cases of co-infestation were observed at all sampling sites.

CONCLUSION

This study was undertaken to contribute to the knowledge of the specific diversity of monogenean parasites in *C. gariepinus* from Senegalese freshwater.

The obtained results provide data on epidemiological parameters and, in particular, on the specific diversity of monogenean parasites of *Clarias gariepinus* in Senegal.

The infestation rate varying according to sampling sites. Larger fish were more infested by monogeneans than smaller fish.

A total of seven monogenean species (six species of the genus *Quadriacanthus* and one species of the genus *Macrogyrodactylus*) were reported for the first time in Senegal, representing a new area of distribution for these parasites.

This study contributes to a better understanding of the parasitic fauna of African catfish, widely used in aquaculture; however, further investigations are warranted. It would therefore be useful to explore other parasite groups such as trematodes, nematodes, cestodes, crustaceans and myxosporidians, which have been collected and are currently under study. In addition, studies incorporating seasonal sampling should be conducted to observe the effects of physico-chemical parameters of sampling sites and to help assess the impact of environmental factors on infestation rates.

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