Sahel Journal of Life Sciences FUDMA (SAJOLS)
September 2024 Vol. 2(3): 42-52
ISSN: 3027-0456 (Print)
ISSN: 1595-5915(Online)
DOI: *https://doi.org/10.33003/sajols-2024-0203-07*

Research Article

Parasites Infestations Status in Fish Species from River Orogodo, a Freshwater Municipal Stream, Southern Nigeria

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ABSTRACT
Parasites are ubiquitous and fish are host to some of these parasites that can be zoonotic. Assessing their status and trends is vital in public health safety, and aquatic ecology. The study aimed to identify parasites, assess the prevalence, identify the infection sites and also determine the variation in infection among sexes in fish from River Orogodo, Agbor, Delta State. A total of 780 fish, comprising 23 species belonging to 12 fish families were collected between September 2014 and August 2019 using cast nets of various mesh sizes and funnel entrance traps. Fishes were identified and examined using standard morphological keys. According to established procedures, parasitological indexes were determined by inspecting various external and internal body parts. The overall prevalence recovered was 196 (25.1%) with twenty-two parasites including larvae stages both from external and internal parts of the fish. These include 5 protozoans *(Microsporidium gen* sp*, Trichodina* spp*, Epistylis* sp*, Crytobia* sp and *Chilodonella* sp*), Myxobolus* sp*,* 5 nematodes *(Procamallanus laevionchus, Camallanus* sp*, Cucullanus* sp*, contracaecum larvae, Rhabdochona* sp*);* 3 acanthocephalans *(Acanthogyrus* sp*, Neoerchinorhynchus* sp *and Acanthocephalus* sp*),* 4 cestodes *(Monobothroides woodlandi, Wenyonia sp, Proteocephalid sp including plerocercoid* larvae*);* 3 digeneans *(Clinostomum sp, Euclinostomum heterostomum, Centrocestus sp,* unidentified metacerceriae in the liver). The study revealed that female fish (32.5%) were more infected than their male counterparts (26.4%). The results indicate that fishes in River Orogodo, Delta State are hosts of various external and internal parasites, which may be of public health and aquacultural importance.

Keywords: Parasite; Fish; Prevalence; Infection sites; River Orogodo; Southern Nigeria

Citation: Oduma, E. O., Ogidiaka-Obende, E. & Eboh, O. J. (2024). Parasites Infestations Status in Fish Species from *River orogodo,* a Freshwater Municipal Stream, Southern Nigeria. *Sahel Journal of Life Sciences FUDMA,* 2(3): 42-52. DOI: *https://doi.org/10.33003/sajols-2024-0203-07*

INTRODUCTION

Fish across different water bodies in Nigeria are diverse and in high demand because of their high protein content. The extensive diversity and endemism found among freshwater fishes align with the diversity and endemicity exhibited by their parasites. This is because parasites are important components of the population structure of a functioning ecosystem (Scholz *et al*., 2018). The high demand for fish for consumption is a pointer to screen for parasitic infections. These parasites may be pathogenic to man, domestic animals and may lead to losses in the aquaculture industry.

Fish have been recognised as definitive hosts to various protozoa and helminth parasites; including cestodes, digeneans, monogeneans, nematodes and acanthocephalans. Fish have also been implicated as intermediate hosts, carrying many larval parasitic forms whose adult stages cause diseases in other vertebrates and man (FAO, 1996; Hoffman, 1999). Investigations of parasites of fishes in various water bodies in Nigeria have been undertaken Anosike *et al*. (1993); Aken'Ova (1999); Okaka and Akhigbe (1999); Akinsanyan *et al*. (2006); Iyayi and Eyo (2008); Onyedineke *et al*. (2010); Ogbeibu *et al*. (2014) and Junaid *et al*. (2023).

The first study on fish parasitism in River Orogodo a municipal stream was about twenty years ago, and the study was centred on intestinal helminths infections of cichlid fish (Nmor *et al*., 2003). Another study focussed on nematode parasites of channid fish (Arimoro and Utebor, 2013). Fish fauna of the River have been identified to consist of thirty-seven fish species belonging to 19 families (Meye 2010; Meye and Ikomi, 2012).

Poor environmental conditions, reduced oxygen levels, and increased organic matter contribute to the likelihood of parasite infections in fish (Overstreet, 1997; Laferty and Curtis 2005). Environmental changes, whether driven by human activities or natural forces, can significantly influence parasite burden variability by favouring or hindering specific stages in a parasite species life cycle (Overstreet, 1997; Laferty and Curtis, 2005). These changes can either facilitate or hinder specific phases in the life cycles of various parasite species (Sures and Nachev, 2022). These conditions exist in River Orogodo a typical municipal stream, studies have indicated anthropogenic factors such as wastewater effluents from abattoirs discharged on daily basis into the river (Arimoro and Oganah, 2010). Other factors enhancing parasitic infections in fish are the presence of intermediate hosts, reservoirs and definitive hosts of parasites. These factors may affect the dietary patterns and habits of the fish.

The information on parasitic infections in the cichlids and channid fishes in River Orogodo is not exhaustive because only data on the intestinal helminth were provided. This study therefore report all the taxa of parasites affecting various body parts of the fish in the River.

MATERIALS AND METHODS

Study Area

River Orogodo is a typical rainforest stream that lies between latitudes 05o10'N and 06o20'N and longitudes 006o10' to 006o26'E (Figure 1). The study area has been described (Meye, 2010; Arimoro and Oganah, 2012 and Meye, 2012). At the time of the study, the air temperature ranged from 26^{o}C to 300^{o}C, and the water temperature ranged from 24.3^{o}C to 31.8^{0}C.

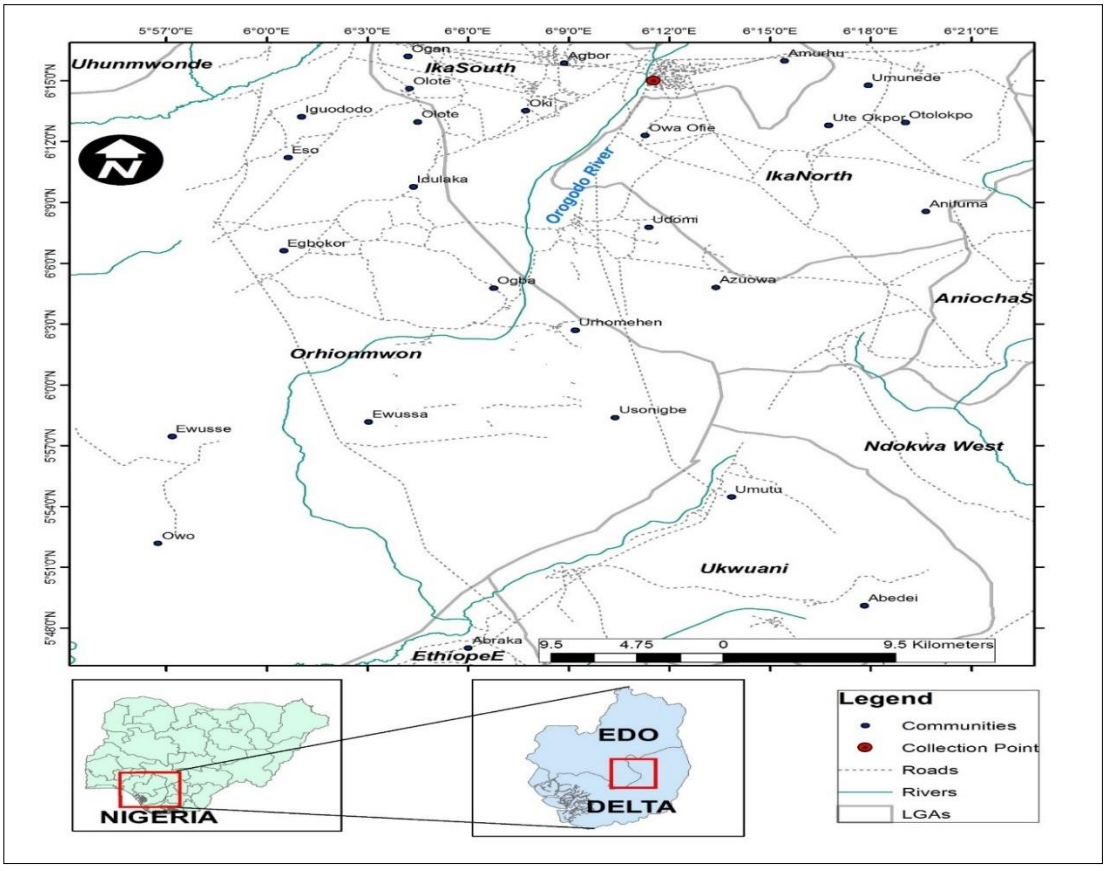

Figure 1: Map of the Study Area (Source:GIS, River Orogodo, Agbor, Delta State)

Collection and Identification of Fish

Twenty-three fish species namely; *Tilapia zillii*, *Tilapia guineensis, Oreochromis aureus*, *Oreochromis niloticus*, *Chromidotilapia guentheri, Hemichromis fasciatus, Tilapia mariae, Tilapia dageti, Parachanna obscura*, *Parachanna africana, Claria gariepinus*, *Clarias*

anguillaris, *Auchenoglanis occidentalis*, *Gymnarchus niloticus*, *Erpetoichthys calabaricus*, Malapterurus *electricus*, *Gnathonemus petersii*, *Ctenopoma kingslyeae*, *Hyperopisius bebe occidentalis*, *Hepsetus odoe* and *Phractolaemus ansorgei* were sampled from catches of local fishermen and fish sellers for September 2014 to August 2019. The 5-year sampling was done to prevent excessive fish capture and access to a variety of fish species. Fishing gears such as dragnets (1.5-2.5cm stretch mesh size), local traps with funnel entrances containing baits (25cm diameter and 75cm deep) and gill nets (0.5-10.2cm stretch mesh size) were used for fish capture. The fish were transported live in black plastic drums covered with nets. In the laboratory, fishes were identified and confirmed to species levels using the taxonomic keys by Idodo-Umeh (2003). Details of their morphology such as Standard Length (SL) and Total Length (TL) were obtained using a meter rule. The weight of the fish was obtained using an electronic balance (Opra electronic weighing scale AA ISO 9001: 2008) and recorded to the nearest 0.1g. The sex of the fish was determined upon the dissection of the fish to indicate the presence of testes or ovaries.

Examination of fish for Parasites

The external surface (fins, gills and skin) of the fish was examined using a hand lens under a strong light and attached parasites of these areas were carefully detached and placed in petri dishes containing normal saline. The fish were slit open using blunt/sharp scissors from the anal region to the operculum. The abdominal cavity was examined first for encysted parasites. The viscera were removed and all organs such as the liver, gallbladder, spleen, oesophagus, stomach, pyloric caeca/pancreas and intestine were placed in separate petri dishes and beaker containing 0.8 – 0.9% NaCl solution (Scholz *et al*., 2018). Smears were made by teasing these organs apart on a slide. The intestines were cut open in normal saline. The muscles, were filleted, by running a scalper along the backbone. The muscles were cut into thin pieces and placed in normal saline. Parasites were preserved in properly labelled vials. They were processed as follows; protozoans were fixed with absolute methanol in a clean slide and stained with Giemsa. Live nematodes were isolated, counted and fixed in hot 70% alcohol and then preserved in fresh 70% alcohol. Temporary mount of nematodes was made after clearing in lactophenol, cestodes, digeneans and other small helminths were flattened under a cover slip. They were fixed in 5% formol saline and then stained overnight in dilute acetocarmine. Permanent mounts were made in Canada balsam after the worms were dehydrated in alcohol series and cleared in xylene. Acanthocephalans were left overnight in a refrigerator to relax until the proboscis was fully everted. The parasites were identified using taxonomic keys by Lom and Dykova (1992); Khalil *et al*., (1994); Paperna, (1996); Bray *et al*., (2008); Anderson *et al*., (2009); Scholz *et al*., (2018). Fish and parasite specimens were deposited in Biological Science Laboratory, College of Education, Agbor now University of Delta, Agbor, Delta State.

Determination of Parasitological Parameters

The parasitological terms prevalence, intensity and mean intensity was done after Bush, (1997).

Where:

$$\text{Prevalence (P)} = \frac{No\ of\ infested\ host}{No\ of\ examined\ host} \times 100\%$$

Intensity of Infection (I): is the number of individuals of a particular parasite specie in a single host expressed as a numerical range

Mean Intensity (MI): Is the total number of a particular parasite divided by the number of infected hosts

RESULTS

Out of the 780 fishes examined (Table 1), 196 (25.1%) had parasites. 19 fish species belonging to nine fish families were infected with different taxa of parasites. *P. obscura* had the highest prevalence rate 45.3% (29 out of 64 examined), followed by *C. gariepinus* 43.4% (33 out of 76 examined) and *T. zilli* 41.5% (17 out of the 41 examined). Others are *C. guentheri* (36.1%), *T. mariae* (34.5%), *T. dageti* (34.3%), *O. niloticus*, *A. occidentalis* and *H. fasciatus* with prevalence rate of (31.8%) respectively. The least infected fishes are *E. calabaricus* 5.8% (3 out of 52 examined), *C. macromystax* 7.0% (3 infected out of 43) and *X. nigri* 7.1% (1 infected out of 14). No infection was recorded in *G. petersii*, *C. kingslyeae*, *H. bebe occidentalis* and *P. ansorgei*. The protozoans were the most encountered parasites infecting 16 fish species with a prevalence rate of (9.9%) followed by the nematodes infecting 13 fish species with a prevalence rate of (7.2%), acanthocephalans infecting 11 fish species with prevalence of (4.5%), cestodes infecting 10 fish species with prevalence of (3.1%), digeneans infecting 6 fish species with prevalence of (2.3%) and myxozoans infecting 4 fish species with prevalence of (1.8%).

Results from Table 2, indicate 5 five protozoans namely; *Microsporidium* gen *sp*, *Trichodina gen sp*, *Epistylis* sp, *Crytobia* sp and *Chilodonella* sp were encountered. *Microsporidium* gen sp infected 12 fish species. It had a wide range of infection sites; gills, muscles, skin, stomach, and intestine. *Trichodina* gen sp also infected 12 fish species. *Crytobia sp* was found only in *C. gariepinus*. *Epistylis* sp infected six fish species with the highest prevalence recorded in *A. occidentalis* (13.6%) and lowest prevalence in *H. fasciatus* (1.5%).

Digenians were observed 6 fish species namely; *C. gariepinus, T. zillii*, *C. guentheri*, *P. obscura*, *C. anguillaris* and *G. niloticus* (Table 3). *Euclinostomum heterostomum* infected five fish species; metacercariae of *Centrocestus sp* was found in two fish species whereas *Clinostomum* sp metacercariae infected only *C. gariepinus*. In infections with *E. heterostomum*, *C. anguillaris* recorded the highest prevalence of 8.3% but the highest mean intensity was recorded in *P. obscura*. An unidentified metacercariae was found in the liver of *G. niloticus*.

All cestodes were observed in the intestine of their host except for plercercoid larva which was found in both the visceral cavity and intestine (Table 4). *Proteocephalid* sp was recovered from seven fish species with *O. niloticus* having the highest prevalence of 4.5% and the least prevalence in *C. gariepinus* (1.3%). All four fish species infected with *Wenyonia* sp were all of the family cichlidae. *Monobothrium* sp infected two cichlids and one catfish; *T. zillii*, *T. mariae* and *M. electricus*.

Among the three acanthocephalan parasites observed, *Acanthogyrus* sp infected nine fishes, *Neoechinorhychus* sp and *Acanthocephalus* sp infected two fishes (Table 5). All acanthocephalan infections occurred in the intestine except for *Acanthogyrus* sp observed in the gills of *P. obscura*. Its highest prevalence was recorded in *T. zillii*.

Table 6 indicates that five nematodes namely; *Camallanus* sp, *Procamallanus laevionchus*, *Cucullanus* sp, *Rhabdochona* sp and the third stage larva of Contracaecum sp infected fishes in this study. They were all recovered from their host's intestine however, the third stage larva of Contracaecum sp larvae was found in the muscles and visceral cavity of *P. obscura* and specifically in the intestinal walls of *C. gariepinus*. All but *Rhabdochona* sp did not infect *P. obscura*. The highest intensity rates for *Camallanus* sp, *Procamallanus* and Contracaecum larvae were observed in *P. obscura*. Female fishes of *P. obscura* and *C. guentheri*, had significant (<0.05) higher prevalence of (60.6% and 50.0%) than their male counterparts (29.0% and 20.7) Table 7.

Table 1: Distribution of Parasite Taxa in Fishes from River Orogodo

Fish Species	No Examined	Total Number Infected (%)	Number Infected (%)					
			Protozoa	Myxozoa	Nematode	Digenea	Cestodes	Acanthocephalan
T. zilli	41	17 (41.5)	06 (14.6)	0 (0)	02 (4.9)	02 (4.9)	02 (4.9)	07 (17.1)
T. guineensis	8	02 (25.0)	02 (25.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
T. mariae	55	19 (34.5)	09 (16.4)	0 (0)	01 (1.8)	0 (0)	07 (12.7)	04 (7.3)
T. dageti	35	12 (34.3)	05 (14.3)	0 (0)	02 (5.7)	0 (0)	01 (2.9)	06 (17.1)
O. aureus	21	4 (16.8)	02 (9.5)	0 (0)	01 (4.8)	0 (0)	0 (0)	01 (4.8)
O. niloticus	22	07 (31.8)	03 (13.6)	0 (0)	01 (4.5)	0 (0)	04 (18.2)	01 (4.5)
C. guentheri	61	22 (36.1)	10 (16.4)	2 (3.3)	08 (13.1)	03 (4.9)	01 (1.6)	04 (6.6)
H. fasciatus	66	21 (31.8)	13 (21.7)	0 (0)	07 (10.6)	0 (0)	0 (0)	05 (7.6)
A. occidentalis	22	7 (31.8)	03 (13.6)	0 (0)	03 (13.6)	0 (0)	0 (0)	01 (4.5)
P. obscura	64	29 (45.3)	01 (1.6)	8 (12.5)	17 (26.6)	03 (4.7)	02 (3.1)	01 (1.6)
P. africanna	25	4 (16.0)	0 (0)	3 (12.0)	01 (4.0)	0 (0)	01 (4.0)	0 (0)
C. gariepinus	76	33 (43.4)	15 (19.7)	01 (2.2)	09 (11.8)	09 (11.8)	01 (2.2)	4 (5.3)
C. anguillaris	28	04 (14.3)	01 (3.6)	0 (0)	02 (7.1)	01 (3.6)	0 (0)	0 (0)
C. macromystax	43	03 (7.0)	02 (4.6)	0 (0)	0 (0)	0 (0)	01 (2.2)	0 (0)
E. calabaricus	52	03 (5.8)	03 (5.8)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
M. electricus	45	06 (13.3)	1 (2.2)	0 (0)	0 (0)	0 (0)	04 (8.9)	1 (4.5)
C. kingsleyeae	25	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
G. niloticus	05	1 (20.0)	0 (0)	0 (0)	0 (0)	1 (20.0)	0 (0)	0 (0)
H. odoe	07	1 (14.2)	0 (0)	0 (0)	01 (14.2)	0 (0)	0 (0)	0 (0)
P. ansorgei	53	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
H. bebe occidentalis	4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
G. petersii	8	0 (0)	0(0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
X. nigri	14	01 (7.1)	01 (7.1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

Total	780	196 (25.1)	77 (9.9)	14 (1.8)	55 (7.2)	19 (2.4)	24 (3.1)	35 (4.5)

Table 2: The prevalence (%) of Protozoa and myxozoan parasites in fishes from River Orogodo, Agbor

Parasite	Host Specie	Site of Infection	Infected	%
Microsporidium gen sp	*T. zillii*	Gills, muscles, gonads	3	7.3
	T. guineensis,	Gills, muscles	2	25.0
	T. dageti	Gills, muscles	2	5.9
	T. mariae	Gills, muscles	4	7.2
	O. aureus	Gills, muscles	1	4.8
	H. fasciatus,	Gills, muscles	3	4.5
	C. guentheri	Muscles	3	4.9
	P. obscura	Stomach, Intestine	1	1.6
	C. gariepinus	Stomach, Intestine	2	2.6
	C. macromystax	Stomach, Intestine	1	2.3
	E. calabaricus	Viscera cavity	3	5.8
	M. electricus	Stomach, Intestine	1	2.2
	X. nigri	Visceral cavity	1	7.1
Crytobia sp	*C. gariepinus*	Stomach, Intestine	4	5.3
Chilodonella sp	*A. occidentalis*	Gills	1	4.5
	C. gariepinus	Gills	1	1.3
Trichodina gen sp	*T. zillii*	Gills	1	2.4
	O. niloticus	Gills	3	13.6
	T. dageti	Gills	1	2.9
	T. mariae	Fins, skin	5	9.1
	O. aureus	Skin	2	9.52
	H. fasciatus,	Skin	11	16.7
	C. guentheri	Gills	7	11.5
	P. obscura	Skin, gills	1	1.6
	P. africana	Skin, gills	1	4.0
	C. gariepinus	Gills	2	2.6
	C. macromystax	Gills	1	8.3
	M. electricus	Gills	1	2.3
Epistylis sp	*A. occidentalis*	Gills	3	13.6
	T. zillii	Gills	2	4.9
	T. dageti	Gills	2	5.9
	H. fasciatus,	Skin	1	1.52
	C. gariepinus	Gills	2	2.6
	C. anguillaris	Gills	1	8.3
Myxobolus	*C. guentheri*	Gills	2	3.3
	H. fasciatus,	Skin	5	7.6
	A. occidentalis	Gills	1	4.5
	P. obscura	Skin, gills	8	12.5
	P. africana	Skin, gills	3	12.0

Table 3: The Prevalence (%), Mean intensity (MI) of Digenean parasites in fishes from River Orogodo, Agbor

Parasite	Host Specie	Site of Infection	Infected	%	MI
*Clinostomum sp**	*C. gariepinus*	Muscles, skin	8	10.5	6.7
*E. heterostomum**	*T. zillii*	Gills	2	4.9	4.5
	C. guentheri	Gills	1	1.6	3.0
	P. obscura	Gills, muscles, visceral	2	3.1	9.0
	C. gariepinus	Gills, muscles	1	1.3	3.0
	C. anguillaris	Gills	1	8.3	3.0
Centrocestus sp	*P. obscura*	Gills	3	4.7	4.7
	C. guentheri	Gills	3	4.1	3.5
Unidentified Metacercariae	*G.niloticus*	Liver	1	20.0	1.0

*****metacercariae

Table 4: The Prevalence (%), Mean intensity (MI) of cestodes in fishes from River Orogodo, Agbor

Parasite	Host Specie	Site of Infection	Infected	%	MI
Wenyonia sp	*T. mariae*	Intestine	3	5.4	1.0
	T. dageti	Intestine	1	2.9	1.0
	C. guentheri	Intestine	1	1.6	1.0
	O. niloticus	Intestine	1	4.5	1.0
Monobothrium woodlandhi	*T. zillii*	Anterior intestine	2	4.9	3.5
	T. mariae	Intestine	1	1.8	2.0
	M. electricus	Intestine	1	2.2	1.0
Proteocephalid sp	*T. mariae*	Intestine	2	3.6	1.0
	O. niloticus	Intestine	1	4.5	1.0
	P. obscura	Intestine	2	3.1	1.0
	P. africana	Intestine	1	4.0	1.0
	C. gariepinus	Intestine	1	1.3	1.0
	C. macromystax	Intestine	1	2.3	1.0
	M. electricus	Intestine	2	4.4	1.0
*Plerocercoid**	*T. mariae*	Visceral cavity/intestine	2	4.0	1.5
	O. niloticus	Intestine	1	4.5	1.0
	M. electricus	Intestine	1	2.2	1.0

*Cestode larvae

Table 5: The Prevalence (%), mean intensity (MI) of Acanthocephalan parasites in fishes from River Orogodo, Agbor

Parasite	Host Specie	Site of Infection	Infected	%	MI
Acanthogyrus sp	*T. zillii*	Stomach, intestine	7	17.1	3.3
	T. mariae	Intestine	4	7.2	3.8
	T. dageti	Intestine	4	11.8	3.0
	O. aureus	Stomach	1	4.8	2.0
	O. niloticus	Intestine	1	4.6	4.0
	C. guentheri	intestine	4	6.6	3.0
	H. fasciatus	intestine	2	3.0	4.0
	P. obscura	Gills	1	1.6	2.0
	M. electricus	Intestine	2	2.2	3.5
Acanthocephalus sp	*T. dageti*	Intestine	2	5.9	3.5
	H. fasciatus	Intestine	3	4.6	3.0
Neoechinorhynchus	*A. occidentalis*	Intestine	1	4.6	2.0
	C. gariepinus	Intestine	3	3.9	2.7

Table 6: The Prevalence (%), mean intensity (MI) of Nematode parasites in fishes from River Orogodo, Agbor

Parasite	Host Specie	Site of Infection	Infected	%	MI
Camallanus	*T. zillii*	Intestine	2	4.9	4.5
	T. mariae		1	1.8	5.0
	T. dageti		2	5.7	4.0
	O. aureus		1	4.8	3.0
	O. niloticus		1	4.5	3.0
	C. guentheri		5	8.2	4.7
	P. obscura		2	3.1	9.0
	H. odoe		1	14.2	4.0
	C. gariepinus		4	5.3	5.4
Cucullanus sp	*C. guentheri*	Intestine	3	4.9	4.3
	H. fasciatus		7	10.6	8.0
	P. obscura		2	3.1	4.5
	C. gariepinus		3	3.9	5.0
	A. occidentalis		2	9.1	4.5
Procamallanus laevionchus	*P. obscura*	Intestine	12	18.6	8.1
	C. anguillaris		1	8.3	4.0
*Contracaecum larvae**	*P. obscura*	Visceral cavity, muscles	3	4.7	12.2
	P. africana	Visceral cavity, muscles	1	4.0	6.0
	C. gariepinus	Intestinal wall	1	1.3	8.0
	C. anguillaris	Intestinal wall	1	3.6	9.0
Rhabdochona sp	*C. gariepinus*	Intestine	1	1.32	3.0

*Third stage larva

Table 7: The Prevalence of Parasitic Infections in Relation to Fish Sex

	Male		Female		P
Fish Specie	**No Examined**	**Infected (%)**	**No Examined**	**Infected (%)**	**Value**
T. zillii	20	8 (40.0)	21	9 (42.3)	0.866
T. guineesis	4	2 (50.0)	4	0 (0)	0.102
T. mariae	27	10 (37.0)	28	9 (32.1)	0.912
T. dageti	20	9 (45.0)	15	3 (20.0)	0.123
O. aureus	8	1 (12.5)	13	3 (23.1)	0.549
O. niloticus	10	1 (10.0)	12	6 (50.0)	0.065
Chromidotilapia sp	29	6 (20.7)	32	16 (50.0)	0.017*
Hemichromis sp	36	10 (27.8)	30	11 (35.5)	0.440
A. occidentalis	11	2 (18.2)	11	5 (45.4)	0.170
P. obscura	31	9 (29.0)	33	20 (60.6)	0.011*
P. africana	15	3 (20.0)	10	1 (10.0)	0.504
C. gariepinus	42	20 (47.6)	34	13 (38.2)	0.418
C. macromystax	12	1 (8.3)	16	2 (12.5)	0.635
C. anguillaris	20	3 (15.0)	23	1 (4.3)	0.160
E. calabaricus	28	2 (7.1)	24	1 (4.2)	0.646
M. electricus	25	3 (12.0)	20	3 (15.0)	0.769
Hepsetus odoe	5	1 (20.0)	2	0 (0)	0.494
Gymnarchus sp	4	1 (25.0)	1	0 (0)	0.312
X. nigri	9	0 (0)	5	1 (20.0)	0.164
P. ansorgei	28	0 (0)	25	0 (0)	0
H. occidentalis	2	0 (0)	2	0 (0)	0
G. petersii	6	0 (0)	2	0 (0)	0
Total	405	92 (23.0)	375	104 (28.5)	0.106

Prevalence in parentheses

*There were significant differences ($P < 0.05$) in prevalence rates between male and female *P. obscura* and *C. guentheri*

DISCUSSION

The parasites observed in this study corroborate other studies from several other freshwater bodies in Nigeria (Adebambo, 2020). The overall prevalence 25.1% was low when compared to 60.66% and 57.55% report by Nmor *et al*. (2003); Arimoro and Utebor (2013) from the same river. The low prevalence recorded in this study could be attributed to the clearing of debris/dredging activities that took place before the time of this study. According to Sures (2004); and Kelly *et al*. (2010), high environmental debris levels may significantly contribute to fish parasitism by potentially compromising host defense mechanisms and increasing the population densities of suitable intermediate or final hosts.

The highest prevalence rates were in *P. obscura* and *C. gariepinus.* These prevalence rates in *P. obscura* and *C. gariepinus* may be attributed to their omnivorous and microphagous feeding habits (Idodo-Umeh, 2003; Chondhury and Dick, 2000). An examination of diet of different fish species of subtropical and tropical freshwater fish indicated the most helminth fauna was found in fishes with mixed diets which included invertebrates and fishes (Chondhury and Dick, 2000). Akinsanya *et al*. (2006) emphasized that adult *P. obscura* are solitary feeders with a diet comprising both terrestrial and aquatic fishes, as well as frogs and tadpoles.

Acanthocephalans and cestode parasites, were mostly observed among the cichlid fishes. A similar observation have been made by Nmor *et al*. (2003). Cichlids diverse dietary habits, characterized by their consumption of invertebrates, small fish, and plant material, increases the likelihood of them ingesting intermediate hosts that carry developmental stage of numerous cestode and acanthocephalan parasites.

Protozoans were the most encountered parasites. Most fish protozoans have a direct life cycle, allowing them to rapidly increase in number (Buchmann, 2015). The presence of *Trichodina* spp in 12 fish species may be attributed to their ability to parasitize a variety of hosts and several trichodinid specie have been documented in cichlids, cyprinids, gobiids, poecilids, and ornamental fish Enyidi and Uwanna (2019) and Maciel *et al*. (2018). The high infection rate of trichonids in the gills than in the skin could be attributed to the fish handling. There is a likelihood that some of the skin trichodinids may have detached from the skin during examination thus leading to low intensity. *Microsporidium* spp was found in the gills, intestine, stomach, intestine, muscles of

different fish species. *Microsporidium* spp occupy a wide range of fish parts; it has been found in the gills, muscles, kidney, liver, brain of carp fish in India (Rajendran *et al*., 2018). The presence of *Crytobia sp* in the stomach of *C. gariepinus* could be attributed to the fish feeding habits of the fish (Okoye *et al*., 2016).

Myxobolus spp was found in the skin, muscles, stomach and intestine of *P. obscura* whereas Akinsanyan and Minasau (2016) recovered *Myxobolus* spp from the intestinal tract of *P. obscura*. But Molnar (2002) stated that a large number of species belong to gill parasites of fish.

The trio of *Procamallanus* sp, *Camallanus* sp and *Cucullanus* sp observed in this study have previously been reported by Arimoro and Utebor (2013). The nematode preference for the intestine could result in overcrowding effects leading to the blockage of the intestine and bloating may follow. This study observed the presence of contracaecum third-stage larvae in the flesh and visceral of *P. obscura* which was not reported by Arimoro and Utebor (2013).

Trematodes observed in the study were *Clinostomum* sp*, Euclinostomum heterostomum* and *Centrocestus* sp. *E. heterostonum* and *Centrocestus sp* were found in the gills, and Clinostomum was found in the skin. Shareef and Abidi (2015) reported trematode metacercariae infects more than one tissue/organ in the fish hosts. This study is the first report of trematodes in fishes from the river. The river is the major source of water for grazing cattle, which are usually accompanied by *Egreta egreta* which is a definitive host of these trematodes. The availability of molluscan and another invertebrate host of these digenean trematodes could help to simplify the transmission of these trematodes known to have complex life cycles (Arimoro *et al*., 2007; Arimoro and Ikomi, 2008).

The acanthocephalans reported in this study have previously been reported among cichlid fishes except for *Octinospinoferiodes sp* (Nmor *et al*., 2003) which was not encountered. Both *Wenyonia sp* and *Monobothrium sp* were found in the guts of cichlid fishes, corroborating findings from Nmor *et al*. (2003). These parasites can be found in a wide range of fish families particularly the cichlids (Adebambo, 2020).

Female fishes had a higher overall prevalence of parasites compared to males. This trend aligns with previous findings in cichlid fishes Nmor *et al*. (2003). Key findings in this trend were observed in *P. obscura* and *C. guentheri*. A similar observation was made by Osho (2017) in *P. obscura* from the Ogun River in Southwest Nigeria whereas Oden *et al*. (2015) reported a higher prevalence of nematode infections among the male *P. obscura* in Cross River systems. Sex-linked parasitism has been explained as resulting from differences in reproductive investment by male and female fish. Karvonen and Lindström (2018) stated that female fishes are more susceptible to parasitic infections due to physiological changes from reproduction, which weaken their immune systems, and behavioural patterns like congregating during spawning (Simkova *et al*., 2008; Karvonen and Lindström 2018; Abd-ELrahman *et al*., 2023).

CONCLUSION

Parasites infecting fish from River Orogodo Delta State are diverse and infect both external and internal parts of the fish. This finding underscores the importance of monitoring and research to understand the ecological and health implications of these parasites.

Conflicts of Interest Statement: The authors declare that they have no conflict of interest.

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