

Research Article

Branchial Chamber and Gastrointestinal Tracts Parasites of Fish Species in Benue and Niger Rivers, North Central, Nigeria

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Freshwater fish species are posing health challenges by either serving as host of parasites that are harmful to man and animals. This study was conducted to determine the parasitic profile of the branchial and gastrointestinal tracts of freshwater fish species from Niger and Benue rivers at Lokoja. These fish species are *Tilapia zillii*, *Oreochromis niloticus*, *Clarias* species, *Synodontis schall*, and *Megalops atlanticus*. Fish samples were collected within a period of 12 months, and the species and sex of the fish were identified. The two opercula of each fish were removed and examined for parasites; parasites recovered were preserved in 0.7% physiological saline. Gastrointestinal tracts were removed from each fish, placed in physiological saline, and examined microscopically for parasites. Prevalence of parasites was calculated. The chi-square test was used to compare prevalence of parasites according to sexes, body parts examined, fish species, and parasites species, while the *t*-test was used to compare between gills and intestines of each fish species. The chi-square test was used to determine if any significant difference exists in prevalence between the sexes, body parts, fish species, and parasites species, while the *t*-test was used to determine if any significant difference exists in prevalence between the gills and intestines of each fish species. A total of seven parasites species were harboured in branchial chamber and gastrointestinal tracts of fish species from rivers Niger and Benue: *Clinostomum* sp. (trematode), *Camallanus* sp. (nematode), *Capillaria* sp., *Rhabdochona congolensis* (nematode), *Contraecum* sp. (nematode), *Proteocephalus* sp. (cestode), and *Spinitectus guntheri*. *T. zillii* (81 (95.3%)) had the highest prevalence, while *O. niloticus*, *Clarias* sp., *S. schall*, and *M. atlanticus* had prevalence of 87 (89.7%), 96 (80.0%), 48 (70.6%), and 27 (38.6%), respectively. Out of the total fish samples examined, females (191 (80.3%)) were observed to harbour more parasites than males (148 (73.3%)). The gastrointestinal tracts (287 (65.2%)) significantly harboured more parasites than branchial chamber (52 (11.8%)). Fish species in rivers Niger and Benue are highly infected with parasites. Fish consumers should subject the fish to proper processing before consumption, as some of these parasites are of zoonotic importance.

1. Background

Freshwater environments are exceedingly biodiverse. Freshwater constitutes only 0.8% of the earth's surface area with approximately 0.02% of the habitable volume of the Earth and contains about 30% of vertebrate species [1–3].

The freshwater is essential to human life, leading to humans traditionally dwelling along rivers and wetlands. This proximity of people to these water bodies constitutes declines in freshwater species and quality [4, 5]. The IUCN [6] reported that 24.6% of freshwater species are threatened, while 27.0% fish species is threatened. Series of factors such

as habitat loss, pollution, invasive species, over exploitation, and climate change are responsible for this loss in the freshwater biodiversity and quality [7, 8]. These factors affect the fish species biodiversity and parasite fauna of freshwater environments. Also, the spatial and temporal variability of intermittent rivers is likely to have a major influence on parasite diversity and abundance and on the dynamics of parasitic diseases because of their direct effects on parasite free-living stages and indirect effects on freshwater fishes [3].

Fish are rich source of protein to man and other animals. They contain lipids, mineral oils, and vitamins which have a remarkable impact on the lives of many individual and communities [9, 10]. Fish oils are known to contain omega-3 essential fatty acid which helps for the proper functioning of the brain, heart, and immune system [11]. Fishes interact at the various levels of food chain, thereby influencing the habitat structure [9]. Despite their significance to man, freshwater fish species are known for harbouring parasitic organisms by either serving as intermediate or definitive host of parasites which are harmful to man and animals [12]. These parasitic protozoans and helminths are known to affect the health, growth, and survival of the fish while causing nutrient devaluation, alteration in biology and behaviour, lowering of the immune system, blindness, morbidity, mortality, fecundity reduction, and mechanical injuries [13].

Nigeria is blessed with many freshwater bodies of which rivers Niger and Benue are the two major freshwater bodies cutting across the country from north to south. Series of studies have been conducted on parasites of freshwater fish species in different parts of the Nigeria [14–20]. Little or no study was conducted on the parasites of the branchial chamber of freshwater fish. This study was conducted to investigate the parasitic profile of the branchial and gastrointestinal tracts (GIT) of freshwater fish species from Niger and Benue rivers at Lokoja.

2. Methods

2.1. Study Area. The study was carried out in Lokoja, Kogi State, Nigeria. It lies between latitude 7°40'N–8°10'N and longitude 6°40'E–7°10'E. Lokoja is a city situated at the confluence of Niger and Benue rivers having extensive flood plains with numerous perennial ponds and marshes on both banks of the rivers before and within the confluence. The vegetation along the rivers comprises mainly of wooded savannah grassland with shrubs and trees. The climate of the area consists of two seasons, the dry season and wet season. The wet season begins toward the end of March and ends towards the end of October or early December, while the dry season begins in November and lasts until late March. The annual rainfall ranges between 1016 mm and 1700 mm and mean daily temperature ranges between 25°C and 29°C [21]. Three (3) sampling sites were selected along the rivers: Irenedu village—along Lokoja-Koton-Karfe road (Niger River), Mozum village—located on the eastern bank (Benue River), and Chintaco village—downstream of the confluence (Figure 1).

2.2. Ethical Approval and Consent to Participate. This study follows guidelines for the care and use of experimental animals established by the Animal Care and Use Committee of the Kogi State University, Anyigba, Nigeria, for the purpose of control and supervision of experiments on animals.

2.3. Collection of Fish Samples. Fish samples were collected within a period of 12 months (May 2019–April 2020), with the aid of artisanal fishers using cast and gill nets of various mesh sizes. The fish were collected on ice and transported to the laboratory for subsequent analysis. The fish samples were identified using texts standard keys [22, 23].

2.4. Sex Determination. The sex of each fish was determined by physical observation of the urogenital papillae. It is long or distended in male, while in female, it is round and reddish in the matured ones. The sex was confirmed by internal examination after dissection to expose the paired testes in the males and paired ovaries in the females [24].

2.5. Examination of Fish for Parasites. The two opercula of each fish were removed, and their inner sides were examined under the dissecting microscope. Recovered parasites were placed in 0.7% physiological saline; thereafter, the gills were dissected out, placed in Petri dish containing physiological saline, and examined with the aid of a dissecting microscope. Parasites found were noted, removed, and preserved in 4% formalin for further identification and classification.

The GIT was removed from each fish and placed in a Petri dish containing physiological saline for examination as stated above.

2.6. Identification of Parasites. The detected parasites were identified according to their morphology using a stereomicroscope. Standard keys for identification of fish parasites were used [25, 26].

2.7. Statistical Analysis. Prevalence of parasites was estimated through the following formula:

$$\text{Prevalence (\%)} = \frac{\text{Number of fish host infected}}{\text{Total number of fish host examined}} \times 100. \quad (1)$$

The chi-square test was used to determine if any significant difference exists in prevalence between sexes, body parts, fish species, and parasites species, while the *t*-test was used to determine if any significant difference exists in prevalence between the gills and intestines of fish species examined. Analysis was performed using the Statistical Package for Social Science version 21.0 (SPSS Inc., Chicago, IL) at $p < 0.05$.

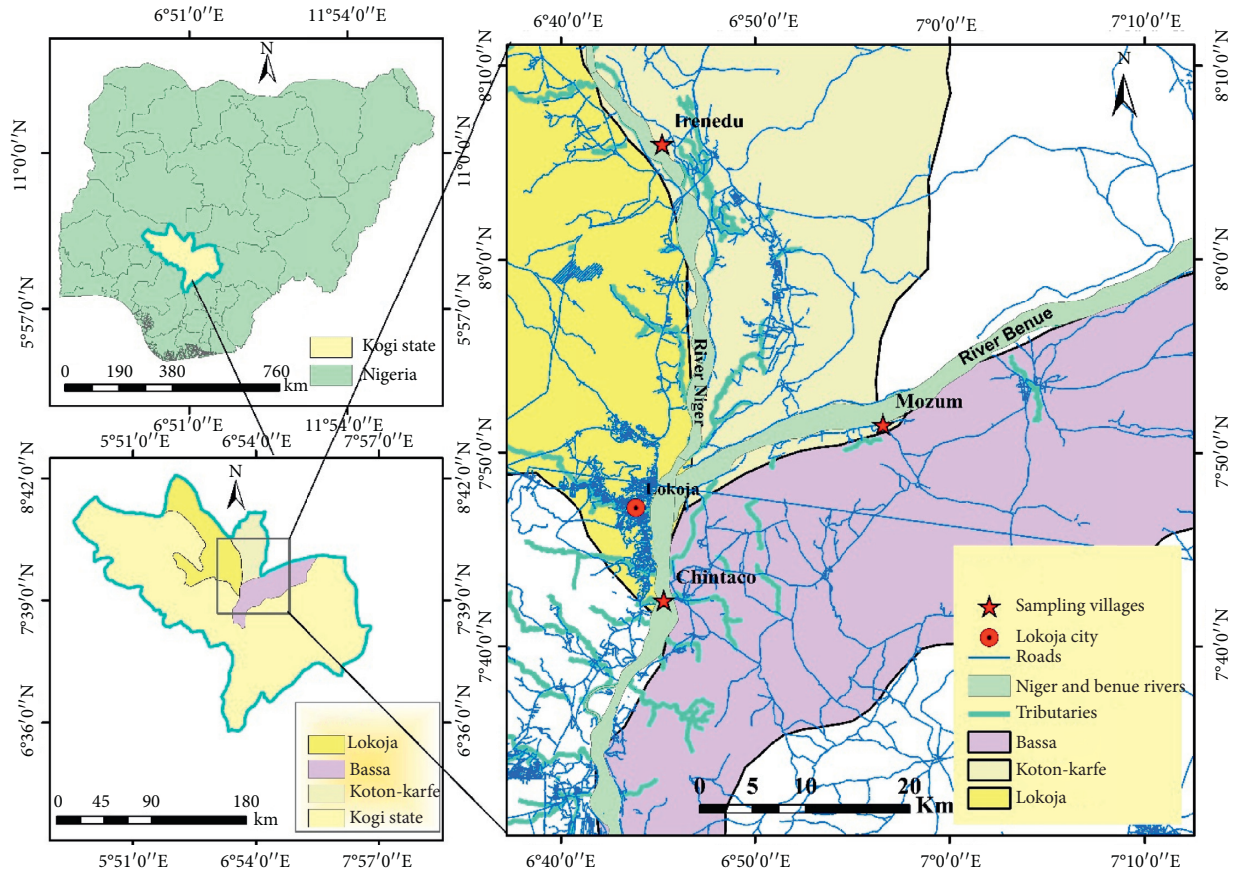


FIGURE 1: Map of sampling villages in the study area. Source: GIS unit, Geography Department, Kogi State University, Anyigba.

3. Results

3.1. Prevalence of Parasites in Fish Species in Rivers Niger and Benue, Lokoja. A total of seven (7) parasites species were found in five (5) fish species (*Clarias* sp., *Tilapia zillii*, *Oreochromis niloticus*, *Synodontis schall*, and *Megalops atlanticus*) examined from rivers Niger and Benue at Lokoja. These parasites were *Clinostomum* sp. (trematode) (Figure 2(a)), *Camallanus* sp. (nematode) (Figure 2(b)), *Capillaria* sp. (nematode) (Figure 2(c)), *Rhabdochona congolensis* (nematode) (Figure 2(d)), *Spinictectus guntheri* (Figure 2(e)), *Contracaecum* sp. (nematode) (Figure 2(f)), and *Proteocephalus* sp. (cestode) (Figure 2(g)).

A total of 440 fish samples were examined for parasites from both rivers. A total of 339 (77.0%) were observed to harbour parasites. *Tilapia zillii* harboured the highest number of parasites with a prevalence of 81 (95.3%), followed by *Oreochromis niloticus* (87 (89.7%)), *Clarias* sp. (96 (80.0%)), and *Synodontis schall* (48 (70.6%)), while *Megalops atlanticus* (27 (38.6%)) harboured the least parasites (Table 1). Comparison of the prevalence among the fish species examined revealed a significant difference ($p \leq 0.05$).

Comparison of parasites harboured by the fishes revealed a significant difference ($p \leq 0.05$) in their occurrence. *Contracaecum* sp. (18.0%) was the most prevalent parasite followed by *Camallanus* sp. (12.5%), *Capillaria* sp. (10.5%), *R. congolensis* (8.6%), and *Clinostomum* sp. (8.2%), while *Proteocephalus* sp. (4.1%) was the least prevalent (Table 2).

In terms of the occurrence of the various parasites in fish species examined, *Contracaecum* sp. was the most prevalent parasite in *Clarias* sp. (23.3%), *O. niloticus* (21.8%), *S. guntheri* (27.1%) in *T. zillii* and *S. schall* (17.6%), while *Camallanus* sp. and *S. guntheri* had equal prevalence of 10% in *M. atlanticus*. *Proteocephalus* sp. was the least occurring fish parasite in all the fish species examined, *Clarias* sp. (5.8%), *T. zillii* (3.5%), *O. niloticus* (6.2%), *S. schall* (2.9%), and *M. atlanticus* (0.0%) (Table 3). Comparison of the prevalence of parasites in individual fish species revealed a significant difference ($p \leq 0.05$) in *Clarias* sp., *T. zillii*, *O. niloticus*, and *S. schall*, while there was no significant difference ($p > 0.05$) in *M. atlanticus* (Table 3).

3.2. Sex-Specific Prevalence of Parasites in Fish Species.

The occurrence of parasites in sexes of fish species examined is presented in Table 4. Overall sex-specific prevalence of the parasites in the fish species examined revealed no significant difference ($p > 0.05$). Females had a prevalence of 80.3% (191 fish) higher than males with prevalence of 73.3% (148 fish) (Table 4). In *Clarias* sp., 32 (66.7%) males and 64 (88.9%) females harboured parasites, and the comparison between sexes revealed a significant difference ($p \leq 0.05$) in this species. There was no significant difference between sexes of *T. zillii*, *O. niloticus*, *S. schall*, and *M. atlanticus*, 42 (95.5%) males and 39 (95.1%) females in *T. zillii*, 44 (88.0%) males and 43 (91.5%) females in *O. niloticus*, 32 (62.5%) males and 36 (77.8%) females in *S. schall*, and 10 (35.7%) males and 17 (40.5%) females in *M. atlanticus*.

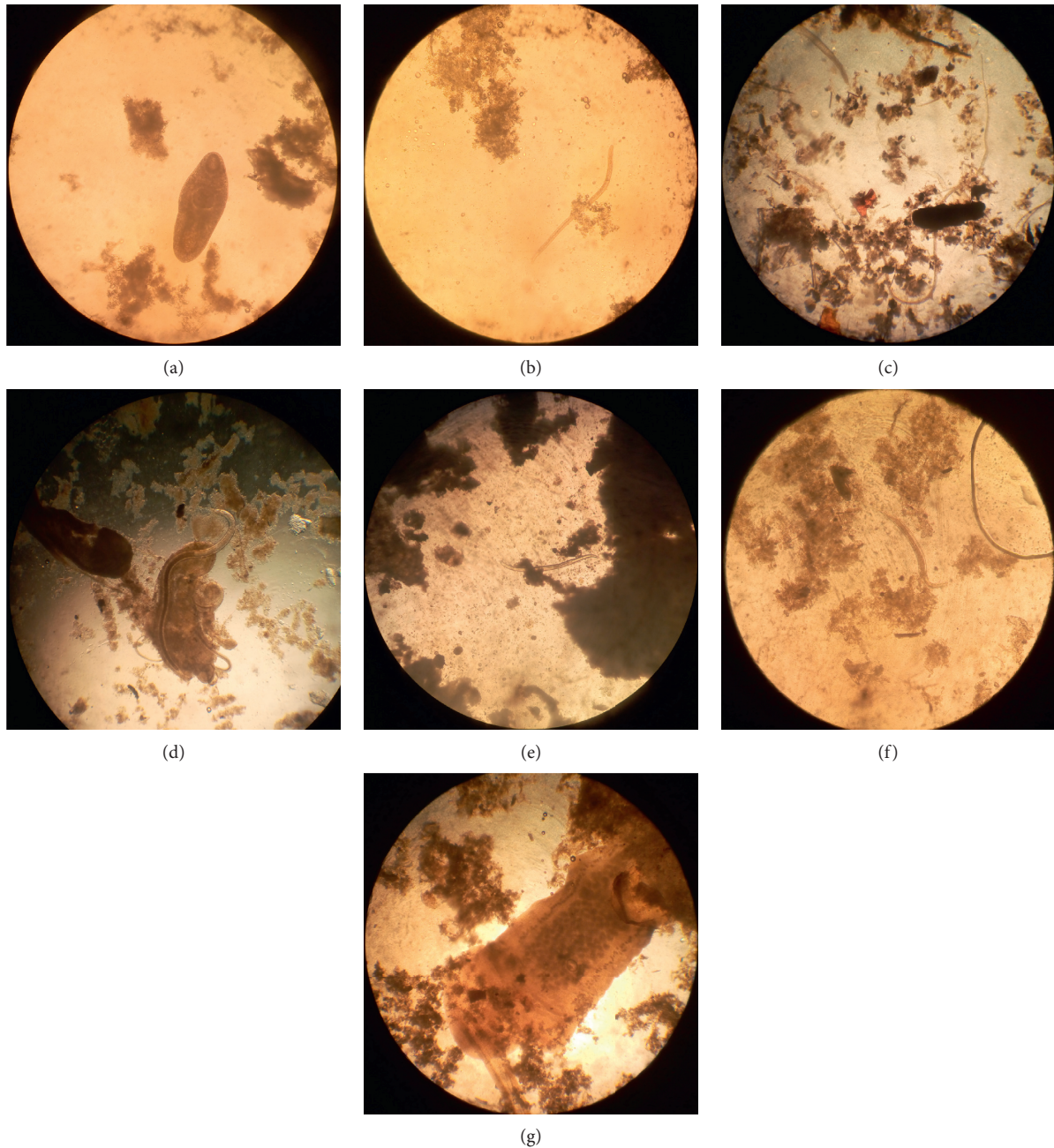


FIGURE 2: Parasites observed in fish species from rivers Niger and Benue. (a) *Clinostomum* sp. (Trematoda: Digenea), (b) *Camallanus* species (nematode), (c) *Capillaria* sp. (nematode), (d) *Rhabdochona congolensis* (nematode), (e) *Spinitectus guntheri*, (f) *Contracaecum* sp. (nematode), and (g) *Proteocephalus* sp.

TABLE 1: Prevalence of parasites of fish species in rivers Niger and Benue at Lokoja.

Fish species	Number examined	Number positive (%)	Number negative (%)	Chi-square	df	<i>p</i> value
<i>Clarias</i> sp.	120	96 (80.0)	24 (20.0)	85.560	4	<0.001*
<i>Tilapia zillii</i>	85	81 (95.3)	4 (4.7)			
<i>Oreochromis niloticus</i>	97	87 (89.7)	10 (10.3)			
<i>Synodontis schall</i>	68	48 (70.6)	20 (29.4)			
<i>Megalops atlanticus</i>	70	27 (38.6)	43 (61.4)			
Total	440	339 (77.0)	101 (23.0)			

*Significant at $p \leq 0.05$.

TABLE 2: Parasites in fish species in rivers Niger and Benue at Lokoja.

Parasites	Number of fish examined	Number positive (%)	Number negative (%)	Chi-square	df	p Value
<i>Clinostomum</i> sp.	440	36 (8.2)	404 (91.8)	58.418	6	<0.001*
<i>Camallanus</i> sp.	440	55 (12.5)	385 (87.5)			
<i>Capillaria</i> sp.	440	46 (10.5)	394 (89.5)			
<i>Rhabdochona congolensis</i>	440	38 (8.6)	402 (91.4)			
<i>Contracaecum</i> sp.	440	79 (18.0)	361 (82.0)			
<i>Proteocephalus</i> sp.	440	18 (4.1)	422 (95.9)			
<i>Spinitectus guntheri</i>	440	67 (15.2)	373 (84.8)			
Total	440	339 (11.0)	2741 (89.0)			

*Significant at $p \leq 0.05$.

3.3. *Prevalence according to Body Parts Examined.* Comparison of the prevalence of gills infected with parasites to that of the intestines revealed a highly significant difference ($p \leq 0.05$) in all the fish species. In all the fish species observed, the intestines harboured more parasites than the gills. A total of 287 (65.2%) intestines had parasites, while 52 (11.8%) gills had parasites. In the fish species, 68.3%, 78.8%, 77.3%, 58.8%, and 32.9% intestines and 11.7%, 16.5%, 12.4%, 11.8%, and 5.7% gills in *Clarias* sp., *T. zillii*, *O. niloticus*, *S. schall*, and *M. atlanticus* harboured parasites, respectively (Table 5).

3.4. *Prevalence of Parasites according to Sample Locations.* Fish samples were collected from three different landing sites along rivers Niger and Benue at Lokoja, Chintaco, Irenedu, and Mozum. Fish samples from Mozum had the highest prevalence of 79.3% (115 fishes), followed by those from Irenedu with 78.2% (111 fish), while those from Chintaco had the least with 73.9% (113 fish). There was no significant difference ($p > 0.05$) in the prevalence of parasites among the locations (Table 6).

In terms of the fish species, *T. zillii* harboured the highest number of parasites in the three locations, Mozum (96.8%), Chintaco (96.4%), and Irenedu (92.3%), while *M. atlanticus* harboured the least number of parasites in the three locations with prevalence of 37.0% (Chintaco), 78.2% (Irenedu), and 79.3% (Mozum). Significant variation ($p \leq 0.05$) exists in the prevalence of the parasites in the fish species examined from the three locations (Table 7).

4. Discussion

This study showed a high parasitic infection in fish species from rivers Niger and Benue at Lokoja. This prevalence was higher than the prevalence of 59.2% observed in a study at Niger River at Illushi, Edo State [27], 17.1% in Osse River, Benin, Nigeria [28], 6.9% in Okhuo River, Benin, Nigeria [29], and 3.3% in Great Kwa River, Calabar [16]. The high prevalence of infection in this study could be due the high level of pollutants accumulation as a result of long distance travelled by both rivers as well as the influx of pollutants from their several tributaries [30, 31]. Heavy parasitic infection in fish has been linked to environmental contamination by different pollutants including heavy metals and hydrocarbons [32] and organic enrichment of sediments by

domestic sewage [33]. Other studies reported that urban effluents promote aquatic pollution, therefore making aquatic organisms vulnerable to increased incidence to parasites [34, 35]. The high parasitic infection in this study might be due to the large influx of pollutants from the environment into the water bodies. Rohlenova et al. [36] reported that unfavourable temperature may alter fish physiology including immune function favouring parasite invasion. Other factors such as the behaviour and life history of the parasites and host fish might contribute to high parasitic infection [37].

A total of seven parasites species were found in fish samples from rivers Niger and Benue at Lokoja. Similar fish species were reported in a study carried out in Lake Gerio, Yola, Adamawa [15]; two of the parasites (*Capillaria* sp. and *Contracaecum* sp.) observed in this study were found in the Lake Gerio. *Capillaria* sp. was the second most prevalent parasite observed in their study with a prevalence of 16.7% higher than the prevalence of 10.5% observed in this study. Another study [38] on *Clarias gariepinus* in Owerri, Nigeria, reported the presence of *Camallanus* sp. (48.33%) and *Contracaecum* sp. (11.67%). In a study carried out on *Clarotes laticeps*, a fish species found in rivers Niger and Benue at Lokoja [18], they reported the presence of the *Proteocephalus largoproglotis*, *Rhabdochona congolensis*, and *Contracaecum microcephalum* alongside other parasites. The presence of the metacercariae of *Clinostomum* in the fish samples observed is an indicator of the presence of snails in the study sites which are the first intermediate hosts of parasites (*Clinostomum*). The metacercariae of *Clinostomum* is known to damage the muscles of fish, making it degusting and unsalable [39]. The high nematode parasites in fish host is an indication that the fish hosts feed on mud, debris, or detritus as found in most *Clarias* sp. and *Synodontis* sp. [40]. Hussen et al. [41] reported that helminths are mostly found in fresh water fishes where factors such as parasite species and its biology, host, and its feeding habitats, physical factors, hygiene of the water body, and presence of intermediate hosts contribute to their prevalence and intensity.

This study observed that female fish were more parasitized than male fish. Similar observation was reported in the studies by Mhaisen et al. [42], Ibiwoye et al. [43], and Amos et al. [15] that female fish are more infested than their male counterpart, while Biu et al. [44] disagree when they reported that variations in parasitic infection among the sexes of fish were by chance. Emere [45] reported differences

TABLE 3: Comparison of prevalence of parasites in individual fish species.

Fish species	n	NP (%)								Chi-square	df	p value
		<i>Clinostomum</i> sp.	<i>Camallanus</i> sp.	<i>Capillaria</i> sp.	<i>Rhabdochona congolensis</i>	<i>Contracaecum</i> sp.	<i>Proteocephalus</i> sp.	<i>Spinitectus guntheri</i>				
<i>Clarias</i> sp.	120	10 (8.3)	10 (8.3)	16 (13.3)	15 (12.5)	28 (23.3)	7 (5.8)	10 (8.3)	24.486	6	<0.001*	
<i>T. zillii</i>	85	7 (8.2)	16 (18.8)	8 (9.4)	12 (14.1)	12 (14.1)	3 (3.5)	23 (27.1)	25.781	6	<0.001*	
<i>O. niloticus</i>	97	8 (8.2)	13 (13.4)	13 (13.4)	6 (6.2)	26 (26.8)	6 (6.2)	15 (15.5)	27.105	6	<0.001*	
<i>S. schall</i>	68	7 (10.3)	9 (13.2)	5 (7.4)	3 (4.4)	10 (14.7)	2 (2.9)	12 (17.6)	13.438	6	0.037*	
<i>M. atlanticus</i>	70	4 (5.7)	7 (10.0)	4 (5.7)	2 (2.9)	3 (4.3)	0 (0.0)	7 (10.0)	10.662	6	0.099 ns	
Total	440	36 (8.2)	55 (12.5)	46 (10.5)	38 (8.6)	79 (18.0)	18 (4.1)	67 (15.2)	62.405	6	<0.001*	

*Significant at $p \leq 0.05$. ns, not significant at $p > 0.05$. n, number examined; NP, number positive.

TABLE 4: Sex-specific prevalence of parasites in fish species in rivers Niger and Benue at Lokoja.

Fish species	Sex	Number examined	Number positive	Chi-square	df	<i>p</i> value
<i>Clarias</i> sp.	M	48	32 (66.7)	8.889	1	0.003*
	F	72	64 (88.9)			
		120	96 (80.0)			
<i>Tilapia zillii</i>	M	44	42 (95.5)	0.005	1	0.942 ns
	F	41	39 (95.1)			
		85	81 (95.3)			
<i>Oreochromis niloticus</i>	M	50	44 (88.0)	0.319	1	0.572 ns
	F	47	43 (91.5)			
		97	87 (89.7)			
<i>Synodontis schall</i>	M	32	20 (62.5)	1.905	1	0.168 ns
	F	36	28 (77.8)			
		68	48 (70.6)			
<i>Megalops atlanticus</i>	M	28	10 (35.7)	0.161	1	0.688 ns
	F	42	17 (40.5)			
		70	27 (38.6)			
Overall	M	202	148 (73.3)	3.014	1	0.083 ns
	F	238	191 (80.3)			
		440	339 (77.0)			

*Significant at $p \leq 0.05$. ns, not significant at $p > 0.05$.

TABLE 5: Prevalence of parasites according to body parts of the fish species.

Fish species	Body parts	Number examined	Number positive	Chi-square	df	<i>p</i> value
<i>Clarias</i> sp.	Gills	120	14 (11.7)	80.278	1	<0.001*
	Intestines	120	82 (68.3)			
		120	96 (80.0)			
<i>Tilapia zillii</i>	Gills	85	14 (16.5)	66.241	1	<0.001*
	Intestines	85	67 (78.8)			
		85	81 (95.3)			
<i>Oreochromis niloticus</i>	Gills	97	12 (12.4)	82.714	1	<0.001*
	Intestines	97	75 (77.3)			
		97	87 (89.7)			
<i>Synodontis schall</i>	Gills	68	8 (11.8)	32.970	1	<0.001*
	Intestines	68	40 (58.8)			
		68	48 (70.6)			
<i>Megalops atlanticus</i>	Gills	70	4 (5.7)	16.565	1	<0.001*
	Intestines	70	23 (32.9)			
		70	27 (38.6)			
Overall	Gills	440	52 (11.8)	264.985	1	<0.001*
	Intestines	440	287 (65.2)			
		440	339 (77.0)			

*Significant at $p \leq 0.05$. ns, not significant at $p > 0.05$.

TABLE 6: Prevalence of fish parasites according to locations at rivers Niger and Benue, Lokoja.

Sampling locations	Number of fish examined	Number positive (%)	Number negative (%)	Chi-square	df	<i>p</i> value (ns)
Chintaco (downstream of confluence)	153	113 (73.9)	40 (26.1)	1.402	2	0.496
Irenedu (River Niger)	142	111 (78.2)	31 (21.8)			
Mozum (River Benue)	145	115 (79.3)	30 (20.7)			
Total	440	339 (77.0)	101 (23.0)			

ns, not significant at $p > 0.05$.

TABLE 7: Comparison of prevalence of parasites from different locations at rivers Niger and Benue, Lokoja.

Fish species	Chintaco (downstream of the confluence)		Irenedu (River Niger)		Mozum (River Benue)		Total	
	Number examined	Number positive (%)	Number examined	Number positive (%)	Number examined	Number positive (%)	Number examined	Number positive (%)
<i>Clarias</i> sp.	43	35 (81.4)	37	33 (89.2)	40	28 (70.0)	120	96 (80.0)
<i>Tilapia zillii</i>	28	27 (96.4)	26	24 (92.3)	31	30 (96.8)	85	81 (95.3)
<i>Oreochromis niloticus</i>	33	29 (87.9)	30	27 (90.0)	34	31 (91.2)	97	87 (89.7)
<i>Synodontis schall</i>	22	12 (54.5)	26	19 (73.1)	20	17 (85.0)	68	48 (70.6)
<i>Megalops atlanticus</i>	27	10 (37.0)	23	8 (34.8)	20	9 (45.0)	70	27 (38.6)
Total	153	113 (73.9)	142	111 (78.2)	145	115 (79.3)	440	339 (77.0)
Chi-square	35.220		33.905		25.535		85.560	
df	4		4		4		4	
<i>p</i> value	0.000*		0.000*		0.000*		0.000*	

*Significant at $p \leq 0.05$.

in the incidence of infestation between male and female fish, which may be due to differential feeding either by quantity or quality of feed or as a result of different degrees of resistance to infection. Also, the increased rate of food intake by the female fish to meet their food requirements for the development of their eggs might have exposed them to more contact with the parasites [17, 46].

Studies by Paperna [47], Onwuliri and Mgbamena [48], and Oniye [49] have reported parasites of gills from different fish species. The prevalence observed in this study is lower than what was observed in River Kaduna [17] and 17.7% in Kano [50]. No study in Nigeria has reported parasites from the gills of freshwater fish examined in this study. Majority of the parasites observed in this study were from the gastrointestinal tracts (GIT). The prevalence of these GIT parasites was higher than what was observed in the studies of Anosike et al. [51], Oniye et al. [52], and Dankishiya and Zakari [53] who reported prevalence of 34.70%, 19.17%, and 40.85%, respectively.

5. Conclusions

Seven parasite species, namely, *Clinostomum* sp. (trematode), *Camallanus* sp. (nematode), *Capillaria* sp., *Rhabdochona congolensis* (nematode), *Contracaecum* sp. (nematode), *Proteocephalus* sp. (cestode), and *Spinitectus guntheri*, were found in the branchial chamber and gastrointestinal tracts of fish species from Niger and Benue rivers at Lokoja. Among the fish species examined, *T. zillii* (81 (95.3%)) had the highest prevalence, while others had prevalence of 87 (89.7%), 96 (80.0%), 48 (70.6%), and 27 (38.6%) in *O. niloticus*, *Clarias* sp., *S. schall*, and *M. atlanticus*, respectively, with prevalence of 191 (80.3%) and 148 (73.3%) in females and males, respectively. The gastrointestinal tract (287, 65.2%) had a significant difference in prevalence in comparison to the branchial chamber (52 (11.8%)). This study did not observe the influence of physicochemical parameters on parasites assemblage in fish species in Benue and Niger rivers. Future

studies to establish the relationship between the physicochemical parameters and parasites assemblage are highly encouraged.

Abbreviations

GIT: Gastrointestinal tracts.

Data Availability

The datasets used to support the findings of this study are available from the corresponding author upon request.

Ethical Approval

This study follows guidelines for the care and use of experimental animals established by the Animal Care and Use Committee of the Kogi State University, Anyigba, Nigeria, for the purpose of control and supervision of experiments on animals.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

A.E.O.-A. conceptualized the study. A.E.O.-A. and C.A.Y. developed methodology and performed formal analysis. A.E.O.-A., M.A.O., and C.A.Y. investigated the study and wrote the original draft. A.E.O.-A., M.A.O., L.A., C.A.Y., and G.E.-S.B. collected resources and reviewed and edited the article.

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