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

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Abstract

Background

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. Fish samples were collected within a period of 12 months, 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 and comparison among categories was done using chi-square and student t-test.

Results

A total of seven parasites species were harboured in branchial chamber and gastrointestinal tracts of fish species from Rivers Niger and Benue at Lokoja; *Clinostomum* sp. (trematode), *Camallanus* sp. (nematode), *Capillaria* sp., *Rhabdochona congolensis* (nematode), *Contracaecum* sp. (nematode), *Proteocephalus* sp. (cestode) and *Spinitectus guntheri*. *T. zilli* 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 with prevalence of 191(80.3%) and 148(73.3%) in females and males respectively. The gastrointestinal tracts 287(65.2%) was significantly harboured more parasites than branchial chamber 52(11.8%).

Conclusion

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 maybe of zoonotic importance.

1. Background

Freshwater environments are exceedingly biodiverse. Freshwater constitute only 0.8% of the earth surface area with approximately 0.02% of the habitable volume of the Earth and contain about 30% of vertebrate species [1, 2, 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 are threatened. Series of factors are responsible for this loss in the freshwater biodiversity and quality; habitat loss, pollution, invasive species, over exploitation and climate change [7, 8]. These factors affects 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 contains 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 affects the health, growth and survival of the fish while causing nutrient devaluation, alteration in biology and behaviour, lowering of 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 to 8°10´N and Longitude 6°40´E to 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 between 1016 and 1700 mm and mean daily temperature range 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 between the confluence of the two rivers (Fig. 1).

2.2. Ethics 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, 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, 24].

2.4. Sex Determination

The sex of each fish were determined by physical observation of the urogenital papillae. It is long or distended in male while in the 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 [25].

2.5. Examination of Fish for Parasites

The two opercula of each fish were removed and their inner sides examined under the dissecting microscope. Recovered parasites were placed in 0.7% physiological saline, thereafter the gills were dissected out and place in petri dish containing physiological saline and examined with the aid of 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 stereo-microscope. Standard keys for identification of fish parasites were used [26, 27].

2.7. Statistical Analysis

Prevalence of parasites were estimated through the following formula;

$$\text{Prevalence (\%)} = \frac{\text{Number of Fish Host Infected}}{\text{Total Number of Fish Host Examined}} \text{ x } 100$$

Significance difference was analyzed using chi-square while student t-test was used to compare sexes, body parts examined and season of sample collection. Analyses was performed using the Statistical Package for Social Science version 21.0 (SPSS Inc., Chicago, IL) at $p < 0.05$.

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 zilli*, *Oreochromis niloticus*, *Synodontis schall* and *Megalops atlanticus*) examined from River Niger and Benue at Lokoja. These parasites were *Clinostomum* sp. (trematode) (Fig. 2a), *Camallanus* sp. (nematode) (Fig. 2b), *Capillaria* sp. (nematode) (Fig. 2c), *Rhabdochona congolensis* (nematode) (Fig. 2d), *Spinitectus guntheri* (Fig. 2e), *Contracaecum* sp. (nematode) (Fig. 2f) and *Proteocephalus* sp. (cestode) (Fig. 2g).

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 zilli* 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%), *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 significant difference ($p < 0.05$).

Table 1
Prevalence of Parasites of Fish Species in River Niger at Lokoja

Fish Species	Number Examined	Number Positive (%)	Number Negative (%)	Chi-square	Df	p Value
Clarias sp.	120	96 (80.0)	24 (20.0)	85.560	4	0.000*
Tilapia zilli	85	81 (95.3)	4 (4.7)			
Oreochromis niloticus	97	87 (89.7)	10 (10.3)			
Synodontis schall	68	48 (70.6)	20 (29.4)			
Megalops atlanticus	70	27 (38.6)	43 (61.4)			
Total	**440**	**339 (77.0)**	**101 (23.0)**			

* - Significant at $p \leq 0.05$.

Comparison of parasites harboured by the fishes revealed significant difference ($p < 0.05$) in their occurrence. *Contracaecum* sp. (18.0%) was the most prevalent parasites 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).

Table 2
Parasites in Fish Species in River Niger at Lokoja

Parasites	Number of Fish Examined	Number Positive (%)	Number Negative (%)	Chi-square	df	p Value
Clinostomum sp.	440	36 (8.2)	404 (91.8)	58.418	6	0.000*
Camallanus sp.	440	55 (12.5)	385 (87.5)			
Capillaria sp.	440	46 (10.5)	394 (89.5)			
Rhabdochona congolensis	440	38 (8.6)	402 (91.4)			
Contracaecum sp.	440	79 (18.0)	361 (82.0)			
Proteocephalus sp.	440	18 (4.1)	422 (95.9)			
Spinitectus guntheri	440	67 (15.2)	373 (84.8)			
Total	**440**	**339 (11.0)**	**2741 (89.0)**			

* - Significant at $p \leq 0.05$.

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. zilli* and *S. schall* (17.6%) while *Camallanus* sp. and *S. guntheri* had equal prevalence of 10% in *M. atlanticus* while *Proteocephalus* sp. was the least occurring fish parasite in all the fish species examined; *Clarias* sp. (5.8%), *T. zilli* (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 significant difference ($p \leq 0.05$) in *Clarias* sp., *T. zilli*, *O. niloticus* and *S. schall* while no significant difference ($p > 0.05$) in *M. atlanticus* (Table 3).

Table 3
Comparison of Prevalence of Parasites in Individual Fish Species

Fish Species	n	NP, %							Chi-square	df	p Val
		Clinostomum sp.	Camallanus sp.	Capillaria sp.	Rhabdochona congolensis	Contracaecum sp.	Proteocephalus sp.	Spinitectus guntheri			
Clarias 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	0.000
T. zilli	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	0.000
O. niloticus	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	0.000
S. schall	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
M. atlanticus	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
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**	**0.000**

* - Significant at $p \leq 0.05$, ns – Not significant at $p > 0.05$, n = Number Examined, NP – Number Positive.

3.2. Sex Specific Prevalence of Parasites in Fish Species

The occurrence of parasites in sexes of fish species examined is presented in table 4.4. 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, comparison between sexes revealed significant difference ($p < 0.05$) in this species. 42(95.5%) males and 39(95.1%) females in *T. zilli*, 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*, no significant difference between sexes of *T. zilli*, *O. niloticus*, *S. schall* and *M. atlanticus*.

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	p Value
Clarias sp.	M	48	32 (66.7)	8.889	1	0.003*
	F	72	64 (88.9)			
		120	**96 (80.0)**			
Tilapia zilli	M	44	42 (95.5)	0.005	1	0.942 ns
	F	41	39 (95.1)			
		85	**81 (95.3)**			
Oreochromis niloticus	M	50	44 (88.0)	0.319	1	0.572 ns
	F	47	43 (91.5)			
		97	**87 (89.7)**			
Synodontis schall	M	32	20 (62.5)	1.905	1	0.168 ns
	F	36	28 (77.8)			
		68	**48 (70.6)**			
Megalops atlanticus	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 $p > 0.05$.

3.3. Prevalence According to Body Parts Examined

Comparison of the prevalence of the prevalence of the parasites examined from the gills to that of the intestines revealed highly significant difference ($p < 0.05$) in all the fish species. It was observed that the intestines harboured more parasites than the gills. A total of 287(65.2%) intestines had parasites while 52(11.8%) gills had parasites with 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. zilli*, *O. niloticus*, *S. schall* and *M. atlanticus* harboured parasites respectively (Table 5). Comparison of each parasites between the gills and intestines in fish species was observed to differ significantly with the intestines of all the fish harbouring more parasites than the gills (Table 6).

Table 5
Prevalence of Parasites According to Body Parts of the Fish Species

Fish Species	Body Parts	Number Examined	Number Positive	Chi-square	df	p Value
Clarias sp.	Gills	120	14 (11.7)	80.278	1	< 0.001*
	Intestines	120	82 (68.3)			
		120	**96 (80.0)**			
Tilapia zilli	Gills	85	14 (16.5)	66.241	1	< 0.001*
	Intestines	85	67 (78.8)			
		85	**81 (95.3)**			
Oreochromis niloticus	Gills	97	12 (12.4)	82.714	1	< 0.001*
	Intestines	97	75 (77.3)			
		97	**87 (89.7)**			
Synodontis schall	Gills	68	8 (11.8)	32.970	1	< 0.001*
	Intestines	68	40 (58.8)			
		68	**48 (70.6)**			
Megalops atlanticus	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 ≤ 0.05, ns – Not significant at p > 0.05.

Table 6
Prevalence of Parasites from Gills and Intestines of Fish Species in Rivers Niger and Benue at Lokoja

Fish Parasites	*Clarias sp.* (NP, %)		*Tilapia zilli* (NP, %)		*Oreochromis niloticus* (NP, %)		*Synodontis schall* (NP, %)		*Megalops atlanticus* (NP, %)		Total (NP, %)	
	Gil (n = 120)	Int (n = 120)	Gil (n = 85)	Int (n = 85)	Gil (n = 97)	Int (n = 97)	Gil (n = 68)	Int (n = 68)	Gil (n = 70)	Int (n = 70)	Gil (n = 440)	Int (n = 440)
Clinostomum sp.	2 (1.7)	8 (6.7)	1 (1.2)	6 (7.1)	1 (1.0)	7 (7.2)	1 (1.5)	6 (8.8)	0 (0.0)	4 (5.7)	5 (1.1)	31 (7.1)
Camallanus sp.	1 (0.8)	9 (7.5)	2 (2.4)	14 (16.5)	2 (2.1)	11 (11.3)	1 (1.5)	8 (11.8)	1 (1.4)	6 (8.6)	7 (1.6)	48 (10.9)
Capillaria sp.	3 (2.5)	13 (10.8)	1 (1.2)	7 (8.2)	0 (0.0)	13 (13.4)	0 (0.0)	5 (7.4)	0 (0.0)	4 (5.7)	4 (0.9)	42 (9.6)
Rhabdochona congolensis	2 (1.7)	13 (10.8)	2 (2.4)	10 (11.8)	0 (0.0)	6 (6.2)	0 (0.0)	3 (4.4)	0 (0.0)	2 (2.9)	4 (0.9)	34 (7.7)
Contracaecum sp.	5 (4.2)	23 (19.2)	1 (1.2)	11 (12.9)	4 (4.1)	22 (22.7)	3 (4.4)	7 (10.3)	1 (1.4)	2 (2.9)	14 (3.2)	65 (14.8)
Proteocephalus sp.	0 (0.0)	7 (5.8)	0 (0.0)	3 (3.5)	1 (1.0)	5 (5.2)	0 (0.0)	2 (2.9)	0 (0.0)	0 (0.0)	1 (0.2)	17 (3.9)
Spinitectus guntheri	1 (0.8)	9 (7.5)	7 (8.2)	16 (18.8)	4 (4.1)	11 (11.3)	3 (4.4)	9 (13.2)	2 (2.9)	5 (7.1)	17 (3.9)	50 (11.4)
Total	**14 (11.7)**	**82 (68.3)**	**14 (16.5)**	**67 (78.8)**	**12 (12.4)**	**75 (77.3)**	**8 (11.8)**	**40 (58.8)**	**4 (5.7)**	**23 (32.9)**	**52 (11.8)**	**287 (65.2)**
T – test	-6.378		-6.459		-4.861		-7.039		-3.991		-7.904	
Df	6		6		6		6		6		6	
p Value	0.001*		0.001*		0.003*		< 0.001*		0.007*		< 0.001*	

* - Significant at p ≤ 0.05, Gil – Gills, Int – Intestine, NP – Number Positive.

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 [28], 17.1% in Osse River, Benin Nigeria [29], 6.9% in Okhuo River, Benin, Nigeria [30] 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 [31, 32]. Heavy parasitic infection in fish has been linked to environmental contamination by different pollutants including heavy metals and hydrocarbons [33] and organic enrichment of sediments by domestic sewage [34]. Other studies reported that urban effluents promote aquatic pollution, therefore making aquatic organisms vulnerable to increased incidence to parasites [35, 36]. We can therefore deduce that the high parasitic infection in this study is as a result of large influx of pollutants from the environment into the water bodies. Rohlenova et al. [37] reported that unfavourable temperature may alter fish physiology including immune function favouring parasite invasion. Apart from climate, other factors such as the environment of the host, behaviour and life history of the parasites and host fish may also contribute to high parasitic infection [38].

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 [39] on *Clarias gariepinus* in Owerri, Nigeria reported the presence of *Camallanus* sp. (48.33%) and *Contracaecum* sp. (11.67%). 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 [40]. 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. [41]. Hussen *et al*. [42] 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.* [43], Ibiwoye *et al.* [44] and Amos *et al*. [15] that female fish are more infested than their male counterpart while Biu *et al*. [45] disagrees when he reported that variations in parasitic infection among the sexes of fish were by chance. Emere [46] reported differences 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 [47, 48].

Studies by Paperna [49], Onwuliri and Mgbamena [50] and Oniye [60] 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 [52]. No study in Nigeria have 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 parasite was higher than what was observed in the studies of Anosike *et al*. [53], Oniye *et al*. [54] and Dankishiya and Zakari [55] 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. zilli* 81(95.3%) had the highest prevalence while other 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 gastro-intestinal tract 287(65.2%) was significant difference in prevalence in comparison to branchial chamber 52(11.8%). Fish consumers should subject the fish to proper processing before consumption, as some of these parasites maybe of zoonotic importance.

Abbreviations

GIT: Gastrointestinal tracts

Declarations

Authors' contributions

Conceptualization, A.E.O.-A.; methodology, A.E.O.-A. and C.A.Y.; formal analysis, A.E.O.-A. and C.A.Y.; investigation, A.E.O.-A., M.A.O. and C.A.Y.; writing original draft, A.E.O.-A., M.A.O. and C.A.Y.; resources, A.E.O.-A., M.A.O., C.A.Y., O.N., S.A.A. and G.E.-S.B.; review and editing, A.E.O.-A., M.A.O., C.A.Y., O.N., S.A.A. and G.E.-S.B.

Ethics 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.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and material

The data sets in this study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Conflicts of Interest

The authors declare no conflict of interest.

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Figures

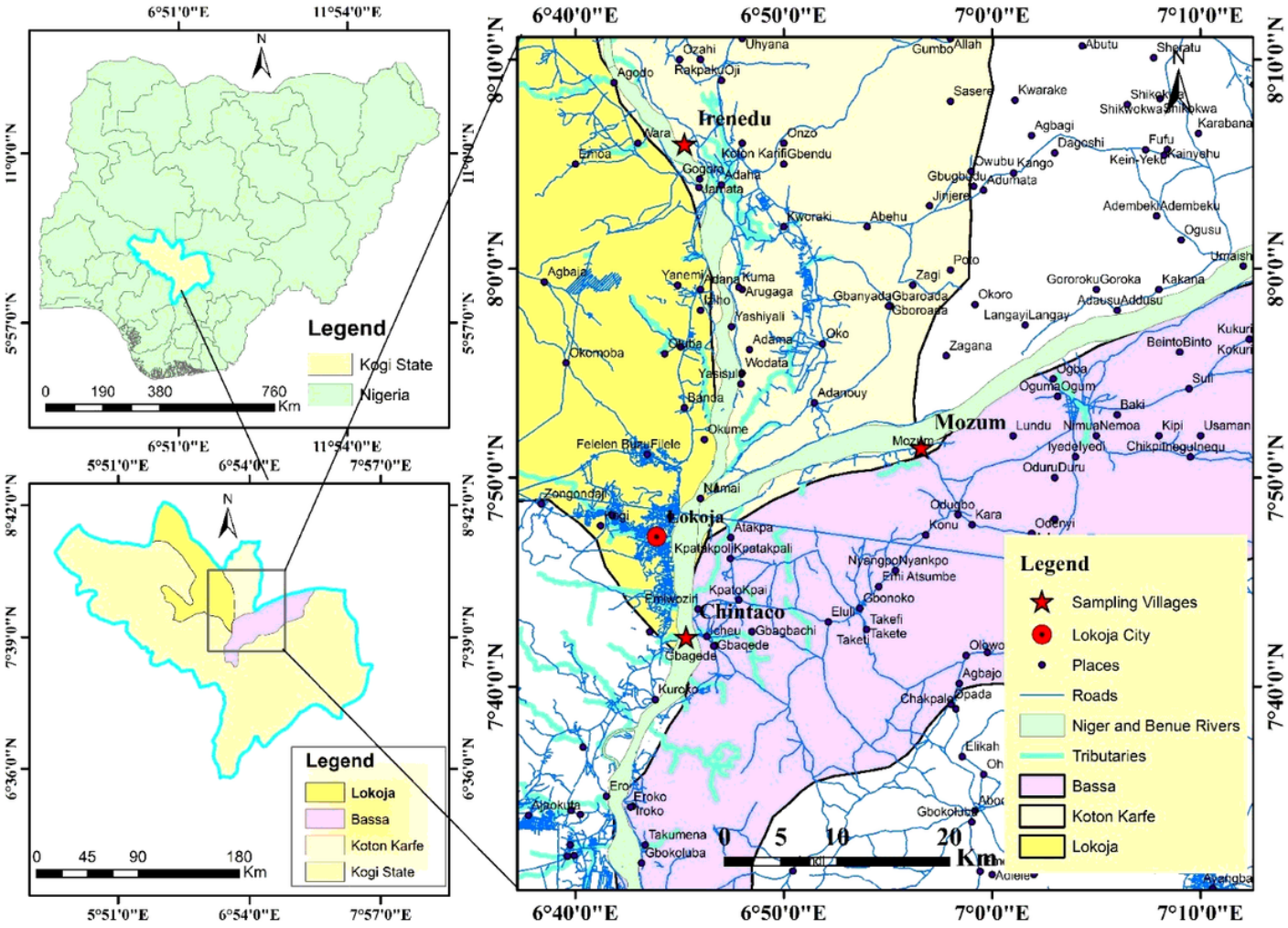

Figure 1

Map of Sampling Villages in the Study Area Source: GIS Unit, Geography Department, Kogi State University, Anyigba.

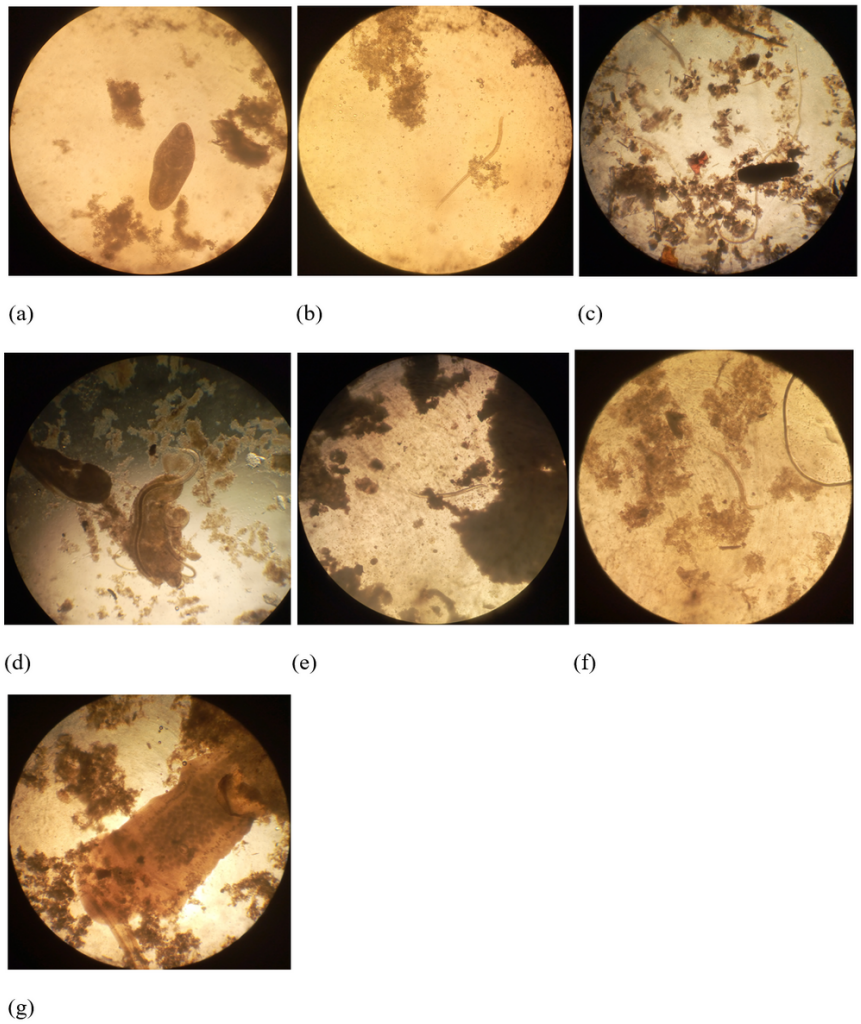

Figure 2

Parasites Observed in Fish Species from Rivers Niger and Benue (a) Clinostomum sp. (Trematode: Digenea), (b) Camallanus species (Nematode), (c) Capillaria sp. (Nematode), (d) Rhabdochona congolensis (Nematode), (e) Spinitectus guntheri, (f) Contracaecum sp. (Nematode), and (g) Proteocephalus sp.