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Seasonal Variation in Parasitic Prevalence of *Oreochromis niloticus* from Upper River Benue, Mutum Biu, Taraba State, Nigeria

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ABSTRACT

Seasonal variation in parasitic prevalence of *Oreochromis niloticus* from Upper River Benue, Mutum Biu, Taraba State, Nigeria was conducted using standard parasitological methods. 400 samples of varied sizes of *Oreochromis niloticus* consisting of 200 samples each in dry and rainy seasons were bought from fishermen at the Upper River Benue, Mutum Biu, Taraba State for a period of ten months and transported fresh to the Parasitology Laboratory, College of Veterinary Medicine, Joseph Sarwuan Tarka University, Makurdi (formerly called University of Agriculture, Makurdi) where they were sorted out into different sizes and sexes. Out of the 400 samples comprising of 200 samples each of *Oreochromis niloticus* collected in dry and rainy seasons, 211 (52.75%) samples were infested with 605 parasites. Out of the 200 samples collected in dry season, while 105 (52.50%) were infested with 327 parasites, in rainy season, 106 (53.00%) samples were infested with 278 parasites out of the 200 samples. Prevalence of infection (53.00%) was higher in rainy season than dry season with prevalence of infection of 52.50% whereas, percentage parasite load (54.05%) was higher in dry season than rainy season with the percentage parasite load of 45.95%. Among the parasite species in dry season, while *Camallanus spp.* was the most prevalent (22.02%) *Ichthyopthirius multifilis* was the least (3.67%). In rainy season, while *Diphillobothrium latum* was the most prevalent (19.07%), *Ichthyopthirius multifilis* was the least (1.44%). Among the external parts, while the gill had the highest percentage parasite load in both seasons, the least was recorded for fin and skin, respectively. Percentage parasite load was higher in the intestine than the stomach in both seasons though, there was no significant difference ($p>0.05$) recorded for percentage parasite load of both external and internal parts of the fish samples in both seasons. Male *Oreochromis niloticus* had higher prevalence of infection and percentage parasite load than the female though, there was no significant difference ($p>0.05$) in the prevalence of infection and percentage parasite load and the sexes in both seasons. Samples of *Oreochromis niloticus* with longer lengths and greater weight had higher percentage parasite load than the samples with shorter lengths and smaller weight.

Keywords: *Seasonal variation, Parasitic prevalence, Oreochromis niloticus, Upper River Benue, Diphillobothrium latum.*

1. Introduction

The contribution of fish to animal proteins cannot be overvalued (Abolagba and Melle, 2008); it is low in cholesterol and contains the essential amino acids. According to Emikpe *et al.,* (2011), the contribution of fish to the global demand for protein is about 60% and that 60% of the developing world derives more than 30% of their animal protein from fish. Sadly, the habitats of fish (aquatic ecosystem) have been seriously threatened of recent by all forms of anthropogenic activities (Meijide *et al.,* 2018; Zhu *et al.*, 2018) leading to the emergence of parasites and diseases that consequently affect the aquatic biota (Schmeller *et al.*, 2018).

The parasites of aquatic organisms are ubiquitous and major components of ecosystem, which are closely related to several characteristics of the biotic and abiotic environment in which they exist (Lacerda *et al.*, 2017). Among the vertebrates, fish have the highest rates of parasitic infestation because of the unique characteristics of their aquatic environment, which facilitate the spread, reproduction and life cycle completion of each parasitic group (Emily *et al.*, 2018).Parasites and parasitic diseases form a major limiting factor to the growth of fish in Nigeria (Bichi and Yelwa, 2010). They slow the growth rates of the fish, lowering the food conversion rates, decreased marketability and lead to rejection of the fish by the consumers (Shinn *et al.,* 2015, Hamouda *et al.*, 2018) as well as posing zoonotic cases to animal and humans who are fish consumers (Elsheikha and Elshazly, 2008). Parasites and parasitic diseases also affect fish by devaluating their nutrient (Hassan *et al*., 2010), altering their behavior and biology (Lafferty, 2008), they act as a stress factor, lowering or reducing the immune capacity of the infected fish

thereby making them prone to the attack of pathogens and thus the fish become more vulnerable to diseases with a resultant effect of morbidity and mortality (Nmor *et al.,* 2004). Often times, they also cause mechanical injuries depending on the parasitic species and abundance (Echi *et al.,* 2009).

According to Hoffman (2019), the impact exerted by parasites on host could be mechanical, chemical or physical. According to the author, effects of parasitic infection on fish are of notable importance, for instance respiratory function of the skin and gills of fish are disturbed by genera G*yrodactylus, Dactylogrus* and *argulosis* infections, causing the fish to become dull, feeble, frequently swimming to water surface with erratic movement and may die of exhaustion.

Previous studies have been conducted to explore the different parasites infecting various fish species in Nigeria (Simon-Oke 2017, Awosolu *et al*., 2018, Khadijah *et al*., 2019; Uruku and Adikwu, 2017; Ani *et al.,* 2017; Abba *et al.,* 2018; Oghenochuko, *et al.,* 2020; Omeji *et al.,* 2022).

The present study was conducted to Isolate and identify the parasites of *Oreochromis niloticus* from upper River Benue, evaluate the seasonal prevalence of infection, determine the effect of host sex, size and weight on the parasitic prevalence of *Oreochromis niloticus* from upper River Benue, Mutum Biu, Taraba State.

2. Materials and Methods

2.1. The Study Area

This study took place at the Upper River Benue Mutum Biu, Taraba State. According to Collins Discovery encyclopedia (2005), River Benue is the major tributary of the Niger River and it is approximately 1,400 km long and almost entirely navigable during the rainy months. As a result, it is an important transportation route in the regions through which it flows. It rises in the Adamawa Plateau of northern Cameroon, from where it flows west, and through the town of Garoua and Lagdo Reservoir, into Nigeria south of the Mandara mountains, and through Jimeta, Ibi and Makurdi before meeting the Niger at Lokoja. The river's largest tributary is the Mayo Kébbi, which connects it with the Logone River (part of the Lake Chad basin system) during floods. Other tributaries are Taraba River and River Katsina Ala.

2.2. Sample Collection

400 samples of varied sizes of *O. niloticus* consisting of 200 samples each in dry and rainy seasons were bought from fishermen at the Upper River Benue, Mutum Biu, Taraba State for a period of ten months and transported fresh to the Parasitology Laboratory, College of Veterinary Medicine, Joseph Sarwuan Tarka University, Makurdi (formerly called University of Agriculture, Makurdi) where they were sorted out into different sizes and sexes. Identification of the fishes was done based external body features (Idodo-Umeh, 2003). Sex determination as well as length and weight measurements were done in line with methods described by Idodo-Umeh (2003). The fishes were immediately subjected to ecto and endo parasitological examinations.

2.3. Parasitological examinations of fish samples for ectoparasites

Examination of the fish samples for ectoparasites was carried out using the methods described by Bichi and Ibrahim (2009). Fish samples were gently rendered inactive by cervical dislocation for easy handling prior to

dissection for parasitological examination. The external surface of the fish was grossly examined using a hand lens for ectoparasitic species. Thereafter, skin smear was made using scalpel where a spatula was used to scrap the skin (smears) from the head to the tail mucus mixed with epidermal cells. The scraped samples of mucus together with the tissues were later placed on a petri-dish containing 3mls of 0.9% saline solution and stirred using a mounted pin. Some drops of the mixed solution were collected using dropper, placed on a clean slide and examined using dissecting microscope.

For detection of parasites from the gills of the fish samples, the gills were cut by scissors, placed in a petri-dish and gill filaments were dissected using anatomical needle and examined under the microscope. Gill scrapings were placed on few drops of water previously placed on the glass slides then covered with cover-slide and examined using dissecting microscope.

For detection of parasites from the fins, fins were first examined by the naked eyes for detection of any macroscopically visible lesions using hand lens. Samples of mucus were later scraped gently from the fins using a scalpel. The tissues were placed on a petri-dish containing 3mls of 0.9% saline solution and stirred using a mounted pin. Some drops of the mixed solution were collected using dropper, placed on a clean slide and freshly examined using dissecting microscope.

2.4. Parasitological examinations of fish samples for endoparasites

Examination of fish parasites in the stomachs and intestines was carried out using the techniques of Emere and Egbe (2006), Bichi and Dawaki (2010). The stomach and intestine of each of the fish were dissected and the alimentary canals were removed and cut into parts in physiological saline for parasite recovery. The stomachs and intestines were further carefully split open longitudinally to aid the emergence of the parasites. The worms were recognized by their wriggling movements on emergence. Contents of the stomachs and intestines were further washed into petri-dishes containing the saline solution. One or two drops of the preparation were placed on slide covered with slips and observed using dissecting microscope. The infected guts were removed and fixed in Bouins fluid for 7 hours. They were later fixed in 4% formalin and preserved in formal acetic acid, stained using Haematoxylin and Eosin and identified using taxonomic guides of Paperna (1996). Photomicrographs of the recovered parasites from the various body parts of the fish samples were taken, counted and recorded.

2.5. Statistical Analysis

The prevalence of parasitic infection, percentage host part infected, percentage parasite load on each location and Percentage total of each parasite species on/in fish were calculated according to Poulin and Rohde (1997) as follows:

$$\text{Prevalence} = \frac{\text{Total number of infected fish}}{\text{Total number of fish examined}} \times 100$$

$$\%\ \text{host part infected} = \frac{\text{Number each host part infected}}{\text{Total number of all parts of the host infected}} \times 100$$

$$\%\ \text{of each parasite on each location} = \text{Sum of the percentage of each parasite on each location}$$

Where: % = percentage

Effect of host sex and size on infestation and intensity of each parasite species were calculated in Microsoft Excel Spreadsheet Program version 2016 and presented as simple proportions.

3. Results

The infestation status and percentage parasite load of *O. niloticus* in dry and rainy seasons from Upper River Benue are presented in Fig.1 while the prevalence and distribution of parasite species of *O. niloticus* in relation to sites of attachment in dry and rainy seasons from Upper River Benue are presented in Table 1.

From Fig. 1, Out of the 400 samples comprising of 200 samples each *O. niloticus* collected in dry and rainy seasons, 211 samples accounting for 52.75% were infested with 605 parasites.

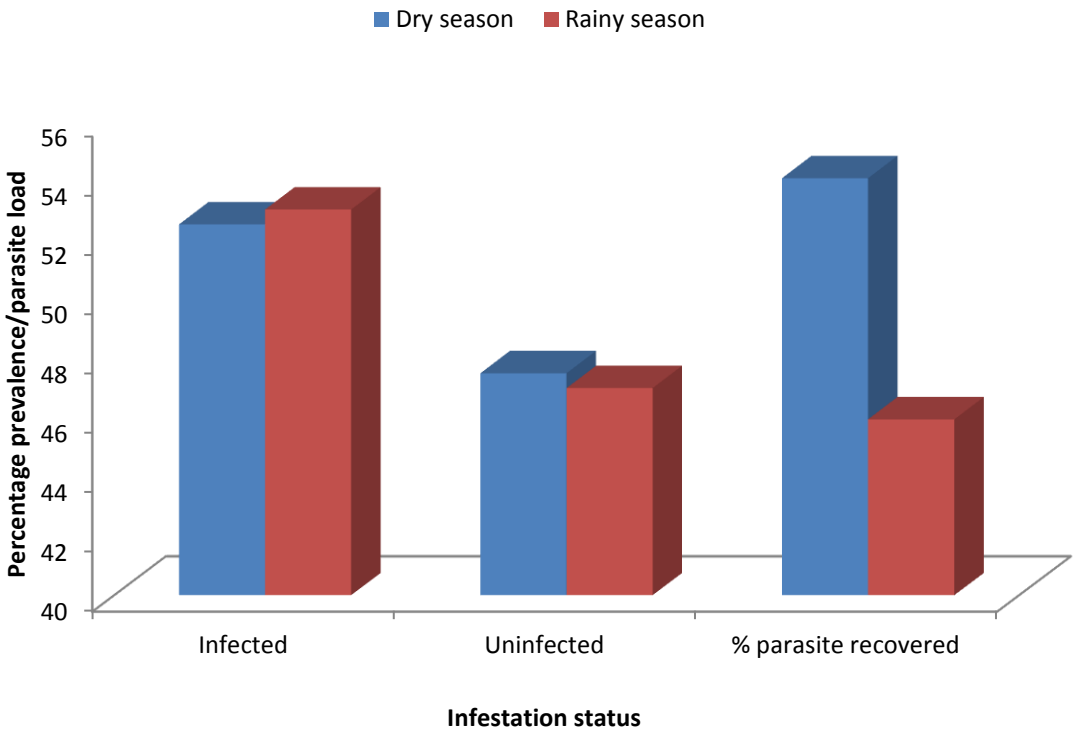

Fig.1. Infestation status and percentage parasite load of *O. niloticus* in dry and rainy seasons

Out of the 200 samples of *O. niloticus* collected in dry season, while 105 (52.50%) were infested with 327 parasites, 95 (47.50%) samples were not infested with any parasite. whereas, out of the 200 samples of *O. niloticus* collected in rainy season, while 106 (53.00%) were infested with 278 parasites, 94 (47.00%) samples were not infested with any parasite. Prevalence of infection (53.00%) was higher in rainy season than dry season with prevalence of infection of 52.50 whereas, percentage parasite load (54.05%) was higher in dry season than rainy season with the percentage parasite load of 45.95%.

From Table 1, the recovered parasites comprised of 2 species of protozoa (*Trichodina spp.* and *Ichthyophthirius multifilis*), a species of trematode (*Clinostomum spp.*), 5 species of nematode (*Caenorhabditis briggsae, Camallanus spp., Eustrongylides spp., Contracaecum spp.,* and *Capillaria spp.*) and a species of cestode (*Diphillobothrium latum*). In dry season, among the parasite species, while *Camallanus spp.* was the most prevalent (22.02%) *I. multifilis* was the least prevalent (3.67%); among the external parts of the fish samples gill had the

highest percentage parasite load (11.62%) while the least (8.56%) was recorded for fin. In addition, between the internal parts (stomach and intestine), while intestine recorded higher percentage parasite load (40.98%), stomach recorded (27.83%) though there was no significant difference ($p>0.05$) recorded for percentage parasite load of both external and internal parts of the fish samples. In rainy season on the other hand, among the parasite species, while *D. latum* was the most prevalent (19.07%), *I. multifilis* was the least prevalent (1.44%); among the external parts, while gill had the highest percentage parasite load (8.42%) the least (7.37%) was recorded for skin. In addition, between the internal parts, while intestine recorded the higher percentage parasite load (49.12%), stomach recorded (27.12%). No significant difference ($p>0.05$) was recorded for percentage parasite load of both external and internal parts of the fish samples

Table 1. Prevalence and distribution of parasite species of *O. niloticus* in relation to sites of attachment in Dry and Rainy Seasons from Upper River Benue

Parasites site of Attachment on/in the host fish	Parasitic species	% host part infected By parasite in		% of each parasite on each location in		Percentage total of each parasite species on fish	
		Dry season	Rainy season	Dry season	Rainy season	Dry season	Rainy season
Fin	*Trichodina sp*	9.15	10	8.26	7.55	9.48	12.23
Skin		0	3.08	0	2.16		
Gill		1.41	2.31	1.22	2.52		
Fin	*Clinostomum sp*	7.04	3.08	3.36	1.80	18.04	17.63
Skin		6.34	3.07	4.89	1.80		
Gill		11.27	13.85	9.79	14.03		
Gill	*I. mutifilis*	0	0	0	0	3.67	1.44
Skin		2.1	0.77	3.67	1.44		
Intestine	*C. briggsae*	4.23	5.38	3.98	3.96	7.65	9.72
Stomach		4.93	6.15	3.67	5.76		
Intestine	*Camalanus sp*	12.67	6.15	13.76	7.19	22.02	10.07
Stomach		7.04	1.54	8.26	2.88		
Intestine	*Eustrongyloids*	3.52	6.15	4.28	5.04	11.62	15.47
Stomach		7.75	7.69	7.34	10.43		
Intestine	*D. latum*	9.86	13.08	12.84	14.39	14.67	19.07
Stomach		2.11	3.85	1.83	4.68		
Intestine	*Contracaecum sp*	0.70	1.54	0.92	1.44	4.59	5.04
Stomach		2.11	3.08	3.67	3.60		
Intestine	*Capilaria sp*	4.93	7.69	5.20	8.27	8.26	9.35
		2.82	1.54	3.06	1.08		
TOTAL		**100**	**100**	**100**	**100**	**100**	**100**

Relationship between sex and degree of infection of *O. niloticus* from Upper River Benue are presented in Fi.2. Out of the 200 samples of *O. niloticus* collected in dry season, while 105 (52.50%) comprising of 58(29%) male and 47(23.50%) female were infested with 57.80% and 42.20% parasite load, in rainy season, 106 samples out of 200 samples of *O. niloticus* comprising of 62(31.00%) male and 44(22.00%) female were infested with 51.80% and 48.20% parasite loads, respectively. Prevalence of infection (29.00%) and percentage parasite loads (57.80%) of male samples of *O. niloticus* in dry were higher than the prevalence of infection (23.50.00%) and percentage parasite loads (42.20%) recorded for female samples of *O. niloticus*. Also in rainy season, the prevalence of infection (31.00%) and percentage parasite loads (51.80%) of male samples of *O. niloticus* were higher than the prevalence of infection (22.00%) and percentage parasite loads (48.20%) recorded for female samples of *O. niloticus*.

Generally, the prevalence of infection and percentage parasite load (30.00% and 55.04%) recorded for male samples of *O. niloticus* were higher than the prevalence of infection and percentage parasite load of 22.75% and 44.96% recorded for female samples of *O. niloticus*, respectively. There was no significant difference ($p>0.05$) in the prevalence of infection and percentage parasite load between the sexes of *O. niloticus* in both seasons.

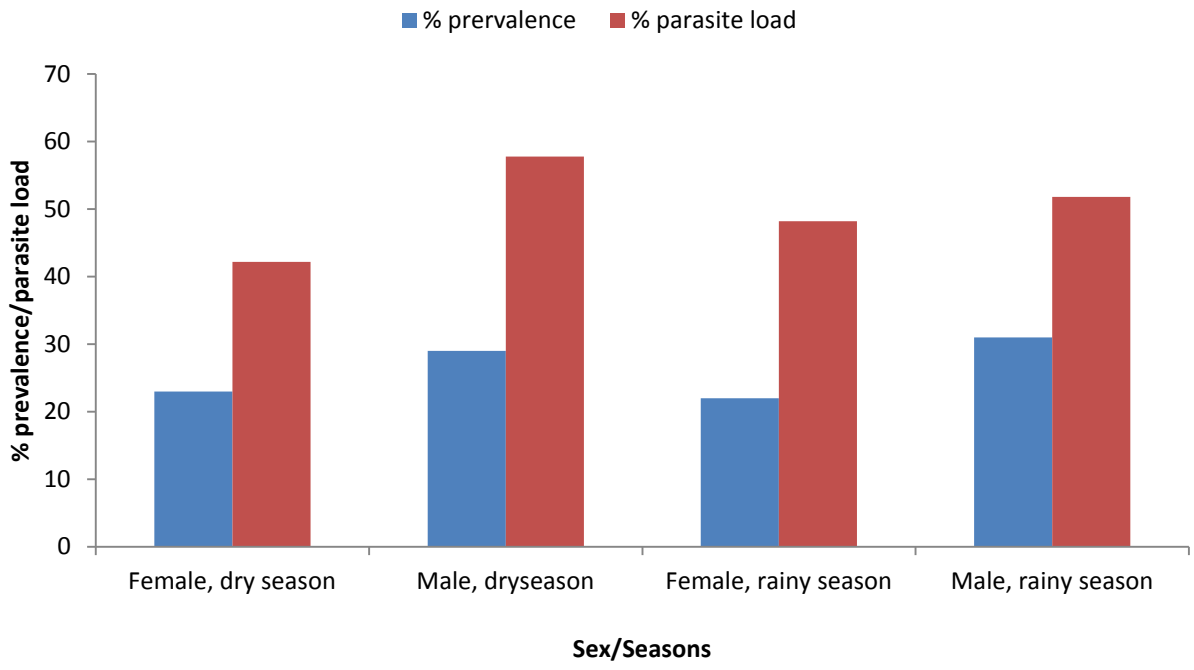

Fig.2. Relationship between size and degree of infection of *O. niloticus* from Upper River Benue

The size distribution and percentage parasite load of *O. niloticus* in dry and rainy seasons from Upper River Benue are presented in fig.1 while fig. 2 presents the weight distribution and percentage parasite load of *O. niloticus* in dry and rainy seasons from Upper River Benue.

From fig.1, variation in the percentage parasite load in both seasons among the size groups existed. In dry season, percentage parasite load was highest (41.28%) in the size group of 21.10 – 24.00cm but lowest (3.36%) in the size group of 10.00 – 13.00cm. In rainy season, percentage parasite load was highest (36.69%) in the size group of 21.10 – 23.00cm but lowest (4.68%) in the size group of 17.10 – 19.00cm. Size group of 11.00 – 13.00cm had no

parasite infestation. Generally, samples of *O. niloticus* with longer lengths had higher percentage parasite load than the samples with shorter lengths.

From fig.2, the majority of samples of *O. niloticus* infected with parasites in dry season were within the weight group of 198.1 – 250.00g (40.06%) but the least were found in the weight group of 146.10 – 198.00g (9.17%). In rainy season on the other hand, the majority of samples of *O. niloticus* infected with parasites in dry season were within the weight group of 174.10 – 219.00g (32.01%) but the least were found in the weight group of 39.00 – 84.00g (10.07%). Generally, samples of *O. niloticus* with greater weight had more percentage parasite load than those with small weight.

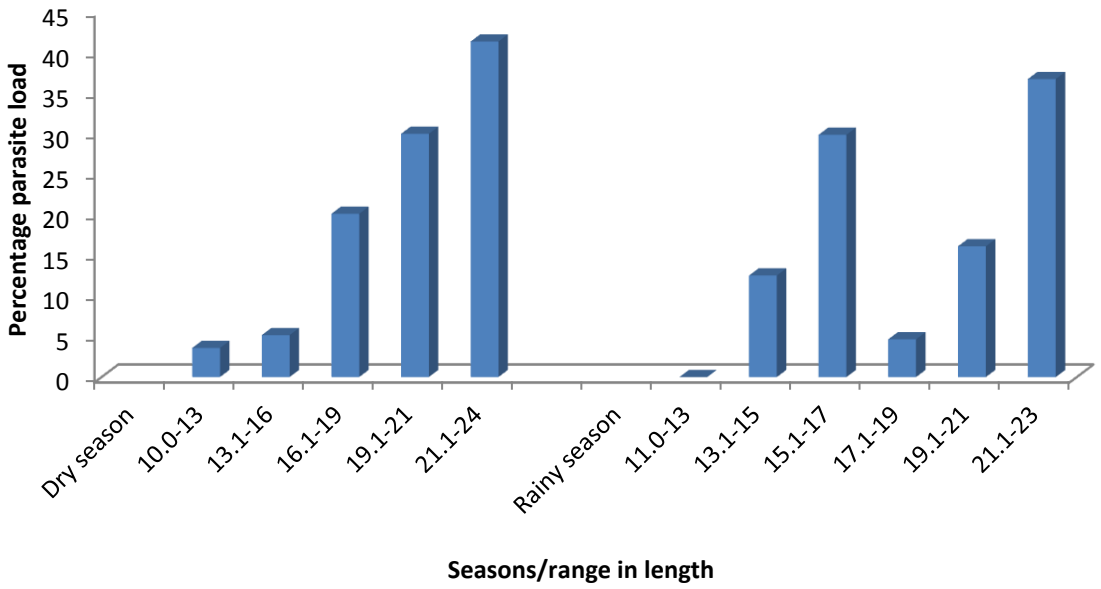

Fig.3. Size distribution and percentage parasite load of *O. niloticus* in dry/rainy seasons from Upper River Benue

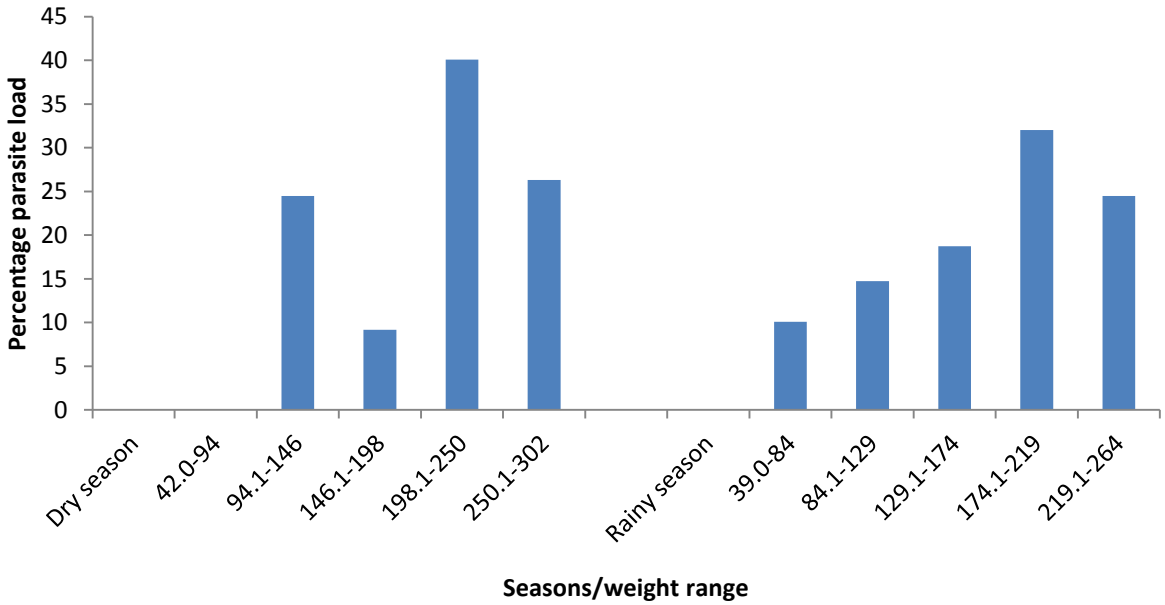

Fig.4. Weight distribution and percentage parasite load of *O. niloticus* in dry/rainy seasons from Upper River Benue

The Correlation matrix for total number of parasites found on *O. niloticus* by size in dry and raining seasons are presented in Table 2. In dry season, there was a strong positive correlation between the total length and weight (0.89) but a negative correlation between total length and total number of parasite (-0.02) and a weak correlation between the weight and total number of parasite (0.03). In rainy season, there was a strong correlation between the total length and weight (0.89) but a weak correlation between the total length and total number of parasites (0.08); weight and total number of parasites (0.07). There was a significant difference ($P<0.05$) between total length and weight of *O. niloticus* in both seasons. However, there was no significant difference ($P>0.05$) between total length and number of parasites, total number of parasite and weight of *O. niloticus* in both seasons.

Table 2. Correlation matrix for total number of parasites found on *O. niloticus* by size dry and raining seasons

	Dry season			**Raining season**		
	TL	**TNP**	**WT**	**TL**	**TNP**	**WT**
TL	1.00			1.00		
TNP	-0.02	1.00		0.08	1.00	
WT	0.89	0.03	1.00	0.89	0.07	1.00

TL = Total length, TNP = Total number of parasites, WT = Weight

4. Discussions

4.1. Effect of seasonal variation on parasitic infection/load of O. niloticus from Upper River Benue

Prevalence of infection (53.00%) was higher in rainy season than dry season with prevalence of infection of 52.50. However, percentage parasite load (54.05%) was higher in dry season than the rainy season with the percentage parasite load of 45.95%. The differences in the prevalence of infection and percentage parasite load between the dry and rainy seasons could be attributed to eutrophication, which often raises parasitism because the associated increase in productivity will increase the abundance of the invertebrate intermediate hosts, mostly crustaceans (Lafferty and Kuris, 1999). Eutrophication leads to algal bloom at the peak of the rainy season, which results in increase in species variety and population of parasites, towards the end of the rainy season. This may result in the infection of fishes that fed on them, and thus probably bring about the maturity of the parasites in the fish towards the dry season, depending on the life cycle of the individual parasite. Another factor that may be advanced is that during the dry season, (which roughly corresponds to the dry phase of the hydrological cycle) there is virtually no precipitation and the flow and volume of water is very much reduced, resulting in much higher contact between the parasites and fish leading to a relatively higher parasite load. This may account for the variation in the number of parasites that was higher the dry season than the rainy season in this study. This observation also agrees with Ajala and Fawole (2014) and Omeji *et al.* (2014).

4.2. Infestation status and percentage parasite load of O. niloticus in dry and rainy seasons

The prevalence of 52.75% was higher than the prevalence of 36.60% previously recorded for four economically important fish species (*Synodontis Budgetti, Chrysichthys Nigrodigitatus, Bagrus Docmac* and *Heterobranchus*

Bidorsalis) from River Okpokwu,Apa, Nigeria, 22.33% for fishes from the Lower Benue River, Nigeria (Uruku and Adikwu 2017), 18.5% in the Niger Delta tidal creek ((Okaka and Akhigbe, 1999;), 17.1% in Osse River (Edema *et al.* 2008;), 6.9% in the Okhuo River (Ekanem *et al.*, 2011;) and 3.3% in Great kwa River (Anthony *et al.*, 2014) all in Nigeria. It is however, lower than the prevalence of (63%) for *Clarias gariepinus* at River Gudi, Akwanga Local Government Area of Nasarawa State, Nigeria (Absalom *et al.*, 2018), 59.37% (Iyaji *et al.*, 2015) recorded for *Synodontis sorex* which is a common fish in the confluence of river Niger and Benue and 53.92% (Ajala and Fawole, 2015) in Oba reservoir Ogbomoso, all in Nigeria. Differences in parasitic prevalence could be attributed to numerous factors which affect the parasitic fauna of the fish species; these factors include changes in the physical and chemical properties of the aquatic environment and changes in the physiological and biological conditions of the host (FerrariHoeinghaus *et al.*, 2006 and Eyo *et al.*, 2013). Fish parasitic prevalence can also be influenced by host related factors (biotic factors) such as diet, body size, reproductive behaviour, vagility migratory habits (Violante-Gonzalez *et al.*, 2009; Tavares *et al.*, 2015, 2008), host age, host size and parasite size, host specificity and host sex (Iyaji *et al.*, 2009).

4.3. Prevalence and distribution of parasite species of O. niloticus in relation to sites of attachment in Dry and Rainy Seasons from Upper River Benue

Different parasites comprising of different parasitic groups, viz, 2 species of protozoa (*Trichodina spp.* and *Ichthyophthirius multifilis*), a species of trematode (*Clinostomum spp.*), 5 species of nematode (*Caenorhabditis briggsae, Camallanus spp., Eustrongylides spp., Contracaecum spp.*, and *Capillaria spp.*) and a species of cestode (*Diphillobothrium latum*) were observed and identified to be present on/in different locations of of *O. niloticus* from the Upper and Lower River Benue.

The recovery of these parasites from the different body parts of the fish species in this study is not amazing as they have been previously recorded from the species or related species elsewhere by other researchers for example, Omeji *et al.* (2022) recovered *Capillaria spp., Estrongylides spp.* and *Diphillobothrium latum* from *Clarias gariepinus* in Makurdi, Benue State, Okoye *et al.* (2016) and Afolabi *et al.* (2020) recovered *Camallanus spp*. from *C. gariepinus* in Imo and Akure States, repectively. Solomon *et al.* (2018) in their reported work recovered *Capillaria spp. Camallanus spp.* and *Eustrongylides spp.* from *Bagrus bayad* in Lower River Benue Makurdi, Nigeria. Also, recovery of *Diphyllobothrium latum* from the studied fish in the present work is not surprising as it has been recovered by Omeji *et al.* (2018) from *Synodontis euptera* and *Auchenoglanis occidentalis* in Lower River Benue, Nigeria. More ectoparasites were recovered from the gill than the skin and fin of the infested of *O. niloticus*. the higher number of parasites in the gills than the skin and fin of the infested *O. niloticus* could be due to the fact the gills are the center of filter-feeding and also an important site used for gaseous exchange in fish.

The sieving ability of the gill rakers may help to trap some parasites, hence the higher number of parasites. This finding agrees with the findings of Omeji *et al.* (2022) Omeji *et al.* (2011) who reported a higher number of parasites in the gills compared to the skin. Contrary to this finding Afolabi *et al.* (2020) reported more parasites from the skin of *C. gariepinus* than the gills and suggested that the skin is easily accessible by these parasites due to direct contact of the skin with the surrounding water or continuous movement of water over the skin.

However, it was observed in this study that the intestine had more parasites than the stomach. The higher number of parasites recovered from the intestine compared to all other parts (fin, skin and stomach could probably be attributed to the presence of digested food present in the infested intestine or due to greater surface area present in the intestines. This finding is in line with the reported works of Omeji *et al.* (2022), Kawe *et al.* (2016) and Owolabi 008). According to the authors, the higher number of parasites recovered from the intestine compared to the skin and stomach could imply that it is the most preferred predilection site; this could be due to the favourable conditions that enhanced their survival.

4.4. Relationship between sexes and degree of infection of O. niloticus from Upper River Benue

The prevalence of *O. niloticus* parasites in relation to sexes as reported by this study was not significant. This finding is a deviation from the study of other authors. For instance, a higher prevalence of parasites in female *C. gariepinus* compared to male has been reported by Afolabi *et al.* (2020), Ajala and Fawole (2019) and Ogonna *et al.* (2017). Both authors recorded higher parasitic infections in female compared to male. Similar reports of Ayanda (2009) at different locations reported higher parasitic infections in female species than the males. According to the authors, the higher prevalence of parasites in female compared to the male could be due to the physiological state of the females as most gravid females could have reduced resistance to infection by parasites; this is because the immune system of the females is highly compromised during pregnancy. Omeji *et al.* (2013) noted that female fish need increased food intake to meet their food requirements for the development of eggs and that this may have exposed them to more contact with the parasites, which subsequently increased their chance of being infected. In contrast, the report of Oniye *et al.* (2004) recorded a higher prevalence of infection in male (15.0%) than the female catfishes (4.17%) and Tachia *et al.* (2010) also recorded higher infection in males (65.12%) than the females (34.89%). The higher prevalence of parasites recorded for male compared to the female *O. niloticus* in this study could be attributed to the food of the fish species as quest for survival and differential feeding either by quantity or quality of food and not by sexes (Ogonna *et al.* 2017).

4.5. Size distribution and percentage parasite load of O. niloticus in dry/rainy seasons from Upper River Benue

Disparity in parasite prevalence existed among the length and weight groups of *O. niloticus* across the two seasons. In general, higher rate of parasitic infection was observed in the bigger sized samples of *O. niloticus* than the smaller sized ones across the two seasons. An increase in size as postulated by Oniye *et al.* (2004) is an evidence of an increase in length and weight of fish and this can also be considered as a measure of age.

Therefore, this observation may be attributed to the fact that bigger size samples of *O. niloticus* provided a larger surface area for parasitic infection than the smaller size counterparts and the ability of bigger size fish to cover wide areas in search of food, and as a result of these, they take in more food than smaller ones which may expose them to parasitic infections. Bichi and Dawaki (2010) reported that parasitic prevalence increases as fish grows and could be attributed to the longer time of exposure to the environment by body size. In relation to this observation, a plausible explanation could be due to the change in diet of *O. niloticus* from weeds, seeds, phytoplankton, and zooplankton as juvenile to insect larvae, crustaceans, worms, and smaller fish as sub-adult and adulthood are reached (Ajala and Fawole 2014).

5. Conclusions

This study showed the presence of parasites in *Oreochromis niloticus* that were randomly bought from fishermen from Upper River Benue at Mutum Biu, Taraba, Nigeria. Samples of *O. niloticus* collected in the dry and rainy seasons were observed to be infected. However, prevalence of infection was higher in rainy season than dry season whereas, percentage parasite load was higher in dry season than rainy season.

Among the external parts, while the gill had the highest percentage parasite load in both seasons, the least was recorded for fin and skin, respectively. Percentage parasite load was higher in the intestine than the stomach in both seasons Male *Oreochromis niloticus* had higher prevalence of infection and percentage parasite load than the female. Samples of *Oreochromis niloticus* with longer lengths and greater weight had higher percentage parasite load than the samples with shorter lengths and smaller weight.

In view of zoonotic cases, fish should be properly cooked before consumption as undercooked fish could cause health issues to the consumers.

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Competing Interests Statement

The authors declare no competing financial, professional, and personal interests.

Consent for publication

Authors declare that they consented for the publication of this research work.

Availability of data and material

Authors are willing to share the data and material according to relevant needs.

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