Prevalence OF fish PARASITES IN *Bagrus bayad* AND *Protopterus annectens* FROM UPPER RIVER BENUE in MUTUM BIU, TARABA STATE, NIGERIA

Abstract

The prevalence of fish parasites in *Bagrus bayad* and *Protopterus annectens* from Upper River Benue in Mutum Biu, Taraba State, Nigeria was carried out using standard parasitological method. The objectives of this study were to investigate the parasite species spectrum, prevalence of each parasites species, overall prevalence, prevalence of parasite infection in relation to the size and sexes of *Bagrus bayad* and *Protopterus annectens* and the infection induced by parasites on/in their body parts, with the view of providing relevant information that can be used in combating the rate of economic losses that could be experienced as a result of parasitic infestations. 4 parasite taxa comprising of Twelve (12) parasite species (*Trichodina spp., Henneguya spp. Cryptobia iubilans, Diphillobothrium latum, Hymenolepis nanna* and *Bothriocephalus aengypticus, Capillaria philipinensis, Caenorhabditis briggsae, Camallanus spp., Eustrongylides spp., Contracaecum spp.* and *Clinostomum spp.* were recovered from the samples of fish species used during the study period. Twelve (12) of the parasite species were recovered from *Bagrus bayad* while seven (7) were recovered from *Protopterus annectens*. Among the body parts of *Bagrus bayad*, while intestine had the highest percentage parasite load (56.37%), highest percentage parasite load (46.22%) in *Protopterus annectens* was recorded for stomach (46.22%). Out of the 400 fish samples comprising of 200 each of *Bagrus bayad* and *Protopterus annectens*, 234 (58.50%) comprising of 99 (49.50%) and 135 (67.50%) samples each of *Bagrus bayad* and *Protopterus annectens* were infested with 369 and 119 parasites, respectively. However, there was no significant difference in the prevalence of infection and parasite load between the fish species, respectively ($P>0.05$). Generally, larger sized samples of *Bagrus bayad* and *Protopterus annectens* had higher percentage of infection compared to the smaller sized of both samples although, the prevalence of infection in relation to sizes of both fish species was not statistically significant ($P>0.05$). Female *Bagrus bayad* and *Protopterus annectens* had higher prevalence of infection (21.61%) and (16.63%) than the males (6.37%) and (6.24%), respectively. There was no significant difference in the prevalence of infection in relation to the sexes of both fish species ($P>0.05$). Epidermal necrosis of the caudal fin and skin, thickened intestinal epithelium at the site of parasite attachment, hyperplasia of the intestinal villi and lamina propria, hyperplasia of infected gills at the secondary lamellae, ulceration of the stomach, abdominal distention, eroded and flattened intestinal folds and lymphocytic infiltration of intestinal mucosa and edema of the lamina propria of the intestine were observed with the infected samples of *B. bayad.* The infected samples of *P. annectens* exhibited epidermal necrosis of the skin.

Keywords: Fish parasites, prevalence, pathological effects, Upper River Benue, Taraba State

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1. Introduction

Fish is an important affordable source of animal protein with different dietary and health benefits compared to muscle meat (Tossavi*et al*., 2014). Fish and fishing serve as means of livelihood for many countries especially where foreign exchange is earned to avert food shortages faced by their ever increasing population via fish farming (Otor *et al*., 2016).

Parasitic diseases are not only restricted to fish production but also a serious menace to fish consumers worldwide most especially, in areas where freshwater fish are not adequately processed or eaten raw, as the case may be. The deleterious effects of parasites cannot be overemphasized. According to (Owolabi, 2008), fish parasites often have deleterious effects on fish tissues; they also reduce fish growth yield, aesthetic value, marketability, palatability and reproductive potential, hence posing serious threats and concern to fish culturists. Several zoonotic diseases caused by fish parasites have been reported (Khalil *et al*., 2014). According to Fagbenro *et al*., (1993), fish parasites are commonly infectious – capable of infecting other fish living in the same ecological niche and zoonotic– capable of transmitting diseases from fish to other animals including man.

Previous studies have been conducted to explore the different parasites infecting various fish species in Nigeria (Omeji *et al.* 2022, Afolabi *et al.* 2020, Olajide *et al.* 2020 and Absalom *et al.* 2018). The prevalence of ecto and endo parasites in some fresh water fishes from Jabi Lake, Abuja, F.C.T. has also been reported by Solomon *et al.*, (2021). In other countries, studies on parasites of different fish species have also been conducted (Bibi *et al.* 2018 and Gomes *et al.* 2017). Parasitic infections of the gills of wild African sharptooth catfish (*Clarias gariepinus*) has been addressed by Mahmoud *et al.*, (2018).

Unlike the major world aquaculture producers such as China and America, Nigeria as at 2012 was the largest African aquaculture producer with a yearly production output of about 620,000 metric tons (Ayinla, 2012). Furthermore, according to Adewunmi, (2015), Nigeria had a capture fisheries production exceeding 37%, coming behind imported fish that was at over 54% of Nigeria's fish production. Adedeji and Okocha (2011) earlier reported that the sector accounted for about 2% of Nigeria's national GDP, 40% of the animal protein intake and was a principal sourceof livelihood for well over three million people in the country. According to Idowu *et al*., (2017), fish diseases are generally an important source of challenges to the development and sustainability of the fisheries industry in Nigeria from both the social and economic perspectives. This is usually a function of increased production cost, cost of treatment and decreased quality and quantity of yield. All these factors coupled with the high percentage contribution of the capture fisheries sub-sector, which is about 15 times more than that of culture fish production (Idowu *et al.*2017), make the study of fish parasites a necessity. The authors further reported that, these will not only enhance the sustenance of fish in their natural environment but also serve as the basis for information on the potential risk of diseases and pathogens involved in fishing and fish farming in Nigeria, reduce fish marketability, employment opportunities and economic viability.

Parasites have been a great concern since they often produce disease conditions in fish thereby increasing their susceptibility to other diseases (Edeh, and Solomon 2016). In addition, due to the importance of fish as one of the major sources of obtaining cheap animal protein, studies on parasites and diseases of fishes is very important (Bichi and Ibrahim, 2009). This study was therefore designed to investigate the prevalence of fish parasites in *Bagrus bayad* and *Protopterus annectens* from Upper River Benue in Mutum Biu, Taraba State, Nigeria, with a

view to providing relevant information that could be useful in the attempt to combat the rate of economic losses experienced as a result of parasitic infestations.

2. Materials and Methods

2.1 Sampling sites, and collection and processing of sample

This study took place at the Upper River Benue MutumBiu, 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.

A total of 400 randomly selected samples comprising of 200 each of *Bagrus bayad* and *Protopterus annectens* of different sizes were bought from fishermen at the Upper River Benue, MutumMbiu, Taraba State for a period of ten months and transported fresh to the Veterinary laboratory Teaching Hospital, Joseph SarwuanTarka University, Makurdi formerly called University of Agriculture, Makurdi in plastic jars with good aeration where they were sorted out into different sizes and species. Identification of the fishes was donebased external body features (Idodo-Umeh, 2003). Sex determination as well as length and weight measurements were done in line with methods described earlier by Idodo-Umeh (2003). The fishes were immediately subjected to ecto and endo parasitological examinations.

2.2 Parasites identification

2.2.1 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 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.

2.2.2 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.

2.2.3 Histopathological Techniques

Following the method described by Adegoroye*et al.*, (2019), the histopathological techniquesofthe infected as well as uninfected parts were placed in bottles containing Bouin fluid (fixing reagent) for about six hours. The tissues were then transferred into bottles containing 10% phosphate buffer formalin to prevent shrinking of the cells as well as decomposition by enzymes, bacteria and subsequent treatment. Random selection of the preserved tissues was done based on the presence of infection and was taken to theDepartment of Veterinary Pathology, histological unit, University of Agriculture, Makurdi for histopathological processing and dehydratedtwice at 70% in absolute alcohol for 30 minutes. The tissues were impregnated in molten paraffin wax three times and later embedded in molten paraffin wax and allowed to

solidify. The blocked tissues were sectioned at 4-5microns, floated into pre-coated slides and dried. The sections were stained properly to differentiate the nucleus from the cytoplasm. The stains were washed off in tap water and the tissues dried. They were examined and their photomicrographs taken at X40 and X100 magnifications (Binocular Microscope, Germany).

2.3 Degree of parasitic infestation/Statistical analysis

Parasitic indices (prevalence (%), and mean intensity, percentage parasite load on each location and percentage frequency of occurrence of each parasite species per location in fish were calculated according to (Margolis *et al.* 1982) as thus;

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

$$\text{Mean intensity} = \frac{\text{Total number of parasites}}{\text{Total number of infected ish}}$$

$$\%\ \text{parasite load on each location} = \frac{\text{Total number of each parasite}}{\text{Total number of parasites observed}} \times 100$$

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

Effect of host length and sex on parasitic infestation were calculated in Microsoft Excel Spreadsheet Program version 2016 and presented as simple proportions. Infection of host by parasites was not normally distributed therefore, significance of parasitic infection was tested using a non parametric statistical method (two independent sample Kolmogorov-Smirnov K-S test at p=0.05 via Statistical Package for the Social Science (SPSS) version 21.0.

3. Results

3.1 Parasite species spectrum

The prevalence of parasite species spectrum of *B. bayad* and *P. annectens* from Upper River Benue is shown in Table 1 while Table 2 shows the percentage parasite load per body parts of *B. bayadand P. annectens* from Upper River Benue.

From Table 1, Twelve (12) parasite species (*Trichodina spp., Henneguya spp. Cryptobia iubilans, Diphillobothrium latum, Hymenolepis nanna* and *Bothriocephalus aengypticus, Capillaria philipinensis, Caenorhabditis briggsae, Camallanus spp., Eustrongylides spp., Contracaecum spp.* and *Clinostomum spp.* were recovered from the samples of fish species used during the study period. Twelve (12) of the parasite species were recovered from *Bagrus bayad* while seven (7) were recovered from *Protopterus annectens*.

Among the parasites species from *B. bayad*, while *D. latum* was the most prevalent (32.52%), *B. aengypticus*was the least prevalent (2.44%). On the other hand, while *Contracaecum spp.* was the most prevalent (26.06%) in samples of *P. annectens*, the least prevalent was *C. iubilans*(1.68%).

From Table 2, among the body parts of *B. bayad*,while intestine had the highest percentage parasite load (56.37%), the least percentage parasite load (2.44%) each was recorded for skin and fin, respectively. Also, among the body parts of *P. annectens*,while stomach had the highest percentage parasite load (46.22%), the least percentage parasite load (10.08%) was recorded for skin. No parasite was recorded for fin and lung.

Table 1. Prevalence of parasite species spectrum of *B. bayad* and *P. annectens* from Upper River Benue

Parasitic species	% total of each parasite species on host fish	
	B. bayad	***P. annectens***
Trichodina spp.	4.88	10.08
Clinostomum spp.	6.50	-
Henneguya spp.	4.61	-
C. briggsae	8.68	-
Camalanus spp.	9.49	15.12
H. nanna	4.87	-
Eustrongylides spp.	4.88	25.21
C. iubilans	3.25	1.68
D. latum	32.52	-
Contracaecum spp.	10.84	26.06
C. philippinensis	7.04	13.45
B.aengypticus	2.44	8.40
TOTAL	**100**	**100**

% = percentage, - = not present

Table 2. Prevalence of parasites species in *B. bayad* and *P. annectens* from Upper River Benue, MutumBiu, Taraba state. n = 200 samples each of the fish species.

Fish part	Parasite species	Fish species/parasite load			
		B. bayad		*P. annectens*	
		% of each parasite per fish part	Total % parasite load per fish Part	% of each parasite per fish part	Total % parasite load per fish Part
Fin	*Trichodina spp.*	2.44	**2.44**	0.00	**0.00**
Lung	-	-	**-**	0.00	**0.00**
Skin	*Trichodina spp.*	2.44	**2.44**	10.08	**10.08**
Gill	*Clinostomum spp.*	6.5	**8.13**	0	**-**
	Henneguya spp.	1.63		0	
Intestine	*Henneguya spp.*	2.98		0	
	C. briggsae	4.61		0	
	Camalanus spp.	4.07		7.56	
	H. nanna	3.79		0	
	Eustrongylides spp.	3.25	**56.37**	13.45	**43.70**
	D. latum	31.71		0	
	Contracaecum spp.	2.44		12.61	
	C. philippinensis	3.52		6.72	
	B.aengypticus	0		3.36	
Stomach	*C. briggsae*	4.07		0	
	Camalanus spp.	5.42		7.56	
	H. nanna	1.08		0	
	Eustrongylides spp.	1.63		11.76	
	C. iubulans	3.25	**30.62**	1.68	**46.22**
	D. latum	0.81		0	
	Contracaecum spp.	8.4		13.45	
	C. philippinensis	3.52		6.73	
	B.aengypticus	2.44		5.04	

% = Percentage, n = number of each fish species used, - = not present

3.2 The overall prevalence of *B. bayad* and *P. annectens* from Upper River Benue

The overall prevalence of infection of *B. bayad* and *P. annectens* from Upper River Benue are shown in Table 2. A total of 400 fish samples comprising of 200 each of *B. bayad* and *P. annectens* were used for the study. Out of the 400 samples, 234 (58.50%) comprising of 99 (49.50%) and 135 (67.50%) samples each of *B. bayad* and *P. annectens* were infested with 369 and 119 parasites, respectively. *P. annectens* had higher prevalence of infection (67.50%) than *B. bayad* with prevalence infection of 49.50%. However, higher number 369(75.61%) parasite was recorded for *B. bayad* than *P. annectens* with 119(24.39%) parasite.

Table 2. Over all prevalence of *B. bayad* and *P. annectens* from Upper river Benue

Infestation status	Fish species		Total
	B. bayad	*P. annectens*	
Number of fish examined	200	200	400
No. (%) of infested fish	99(49.50)	135(67.50)	234(58.50)
No. (%) of fish not infested	101(50.50)	65(32.50)	166(41.50)
Total number (%) Parasite	369(75.61)	119(24.39)	488(100.00)

No. = Number, % = Percentage

3.3 The prevalence of parasite in relation to the size of *B. bayad* and *P. annectens* from Upper River Benue

The prevalence of parasite in relation to the size of *B. bayad* and *P. annectens* from Upper River Benue are shown in figures 1a and 1b, respectively. In samples of *B. bayad* (Figure 1a), highest prevalence (34.15%) was recorded in length group of 54.1 – 63.0cm while the lowest (5.70%) was recorded in length group of (18.0 – 27.0cm). For samples of *P. annectens* (Figure 1b), while highest prevalence of 39.50% was recorded in the length group of 22.0 – 31.0cm, the lowest 3.36% each was recorded for length groups of 22.0 – 31.0cm and 58.1 – 67.0cm, respectively. Generally, it was observed in the present study that the larger sized fishes had the highest percentage of infection compared to the smaller sized ones although, the prevalence of infection in relation to the size groups of both fish species was not statistically significant ($P>0.05$).

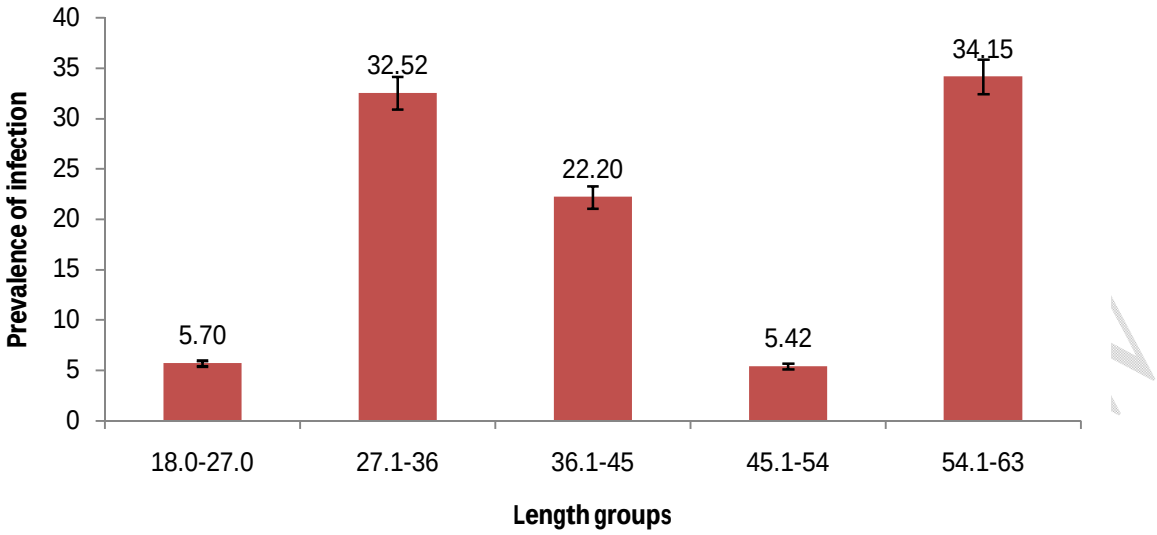

Figure 1a. Prevalence of parasite infection in relation to the size of *B. bayad* from Upper river Benue

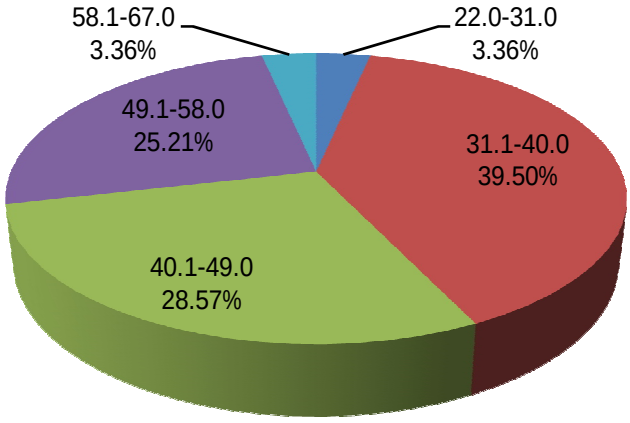

Figure 1b. Prevalence of parasite infection in relation to the size of *P. annectens* from Upper river Benue

3.4 The prevalence of parasite infection in relation to the sexes of *B. bayad* and *P. annectens* from Upper River Benue

Female samples of *B. bayad* and *P. annectens* had higher prevalence of infection (21.61%) and (16.63%) than the males (6.37%) and (6.24%), respectively although, the prevalence of infection in relation to the sexes of both fish species was not statistically significant ($P>0.05$).

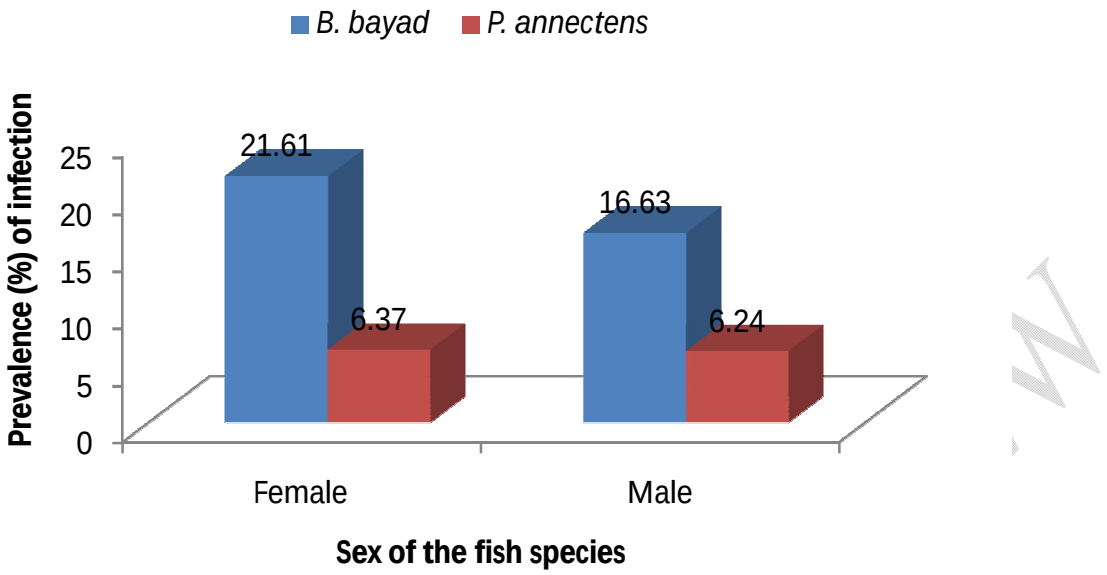

Figure 2. Prevalence of parasite infection in relation to the sexes of *B. bayad* and *P. annectens* from Upper River Benue.

3.5 Infection induced by parasites on/in the host body parts

The infection by recovered parasites induced a number of pathological lesions that changed with the intensity of the parasites. The photomicrograph of the caudal fin and skin exhibiting epidermal necrosis of the *B. bayad* is shown in figure 3A. Figure 3B shows the photomicrograph of skin exhibiting epidermal necrosis of the skin of *P. annectens*. Figure 3 C shows photomicrograph of thickened intestinal epithelium at the site of parasite attachment from *B. bayad*, Figure 3 D shows the photomicrograph of hyperplasia of the intestinal villi and lamina propria. Figure 4 A shows the photomicrograph of hyperplasia of infected gills at the secondary lamellae of *B. bayad*, Figure 4 B shows the photomicrograph of ulceration of the stomach of *B. bayad*, Figure 4 C shows the photomicrograph of abdominal distention of *B. bayad*, Figure 4 D shows the photomicrograph of eroded and flattened intestinal folds of *B. bayad* and Figure 4 E shows the photomicrograph of lymphocytic infiltration of intestinal mucosa and edema of the lamina propria of infected intestine of *B. bayad.*

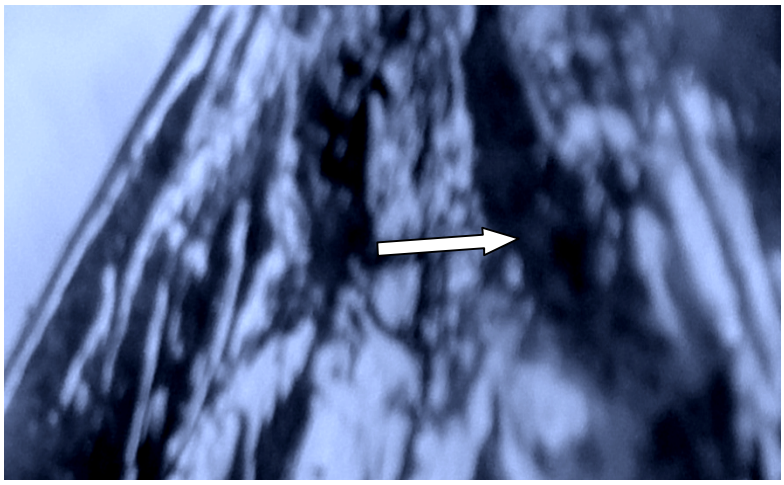

Figure 3A) Photomicrograph of caudal fin and skin exhibiting epidermal necrosis of the *B. bayad.* (400X)

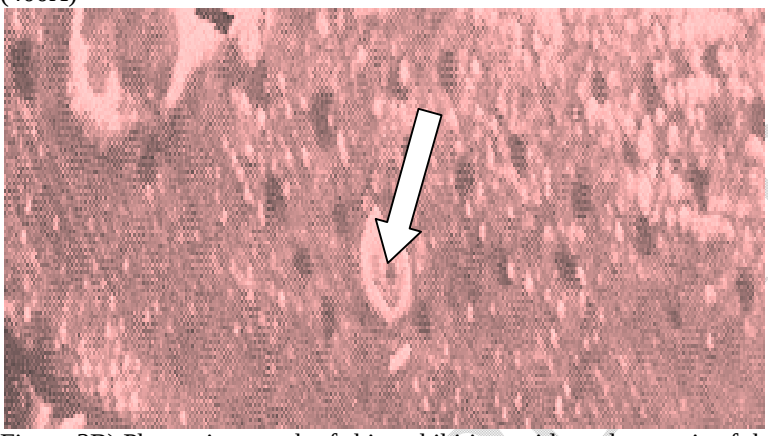

Figure 3B) Photomicrograph of skin exhibiting epidermal necrosis of the skin of *P. annectens* (400X)

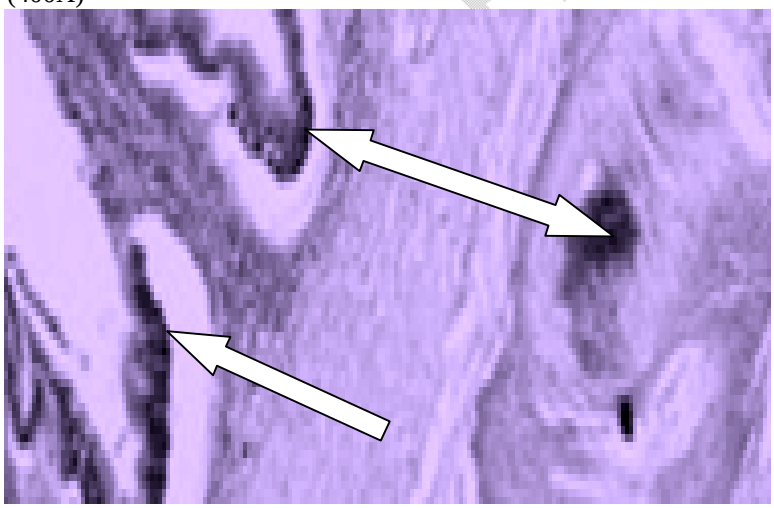

Figure 3 C) Photomicrograph of thickened intestinal epithelium at the site of parasite attachment from *B. bayad.* (400X)

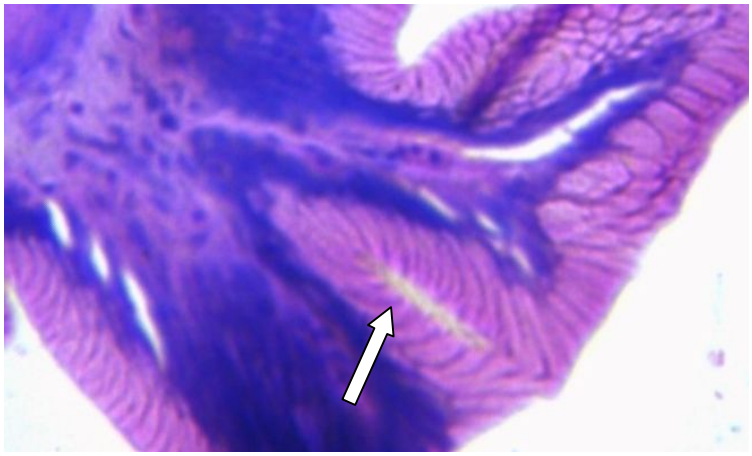

Figure 3 D) Photomicrograph of hyperplasia of the intestinal villi and lamina propria of *P. annectens.*(400X)

Figure 4 A) Photomicrograph of hyperplasia of infected gills at the secondary lamellae of *B. bayad.* (400X)

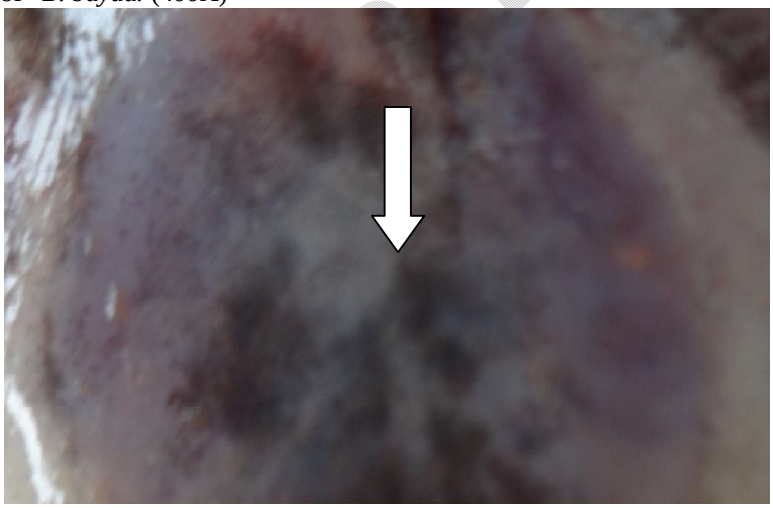

Figure 4 B) Photomicrograph of ulceration of the stomach of *B. bayad.* Magnification:(400X)

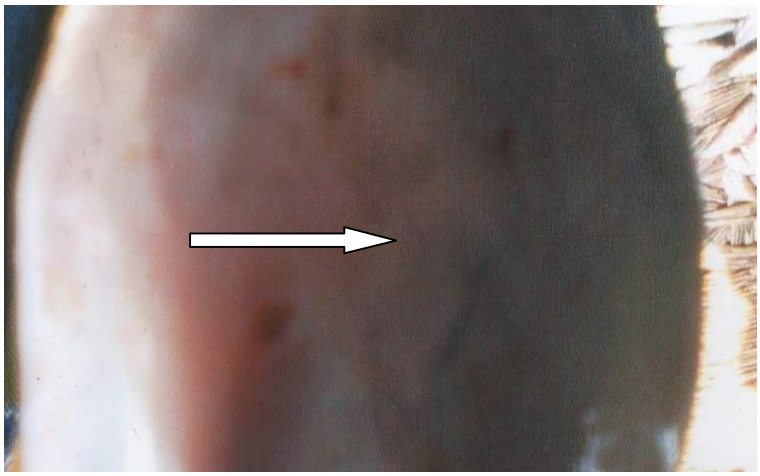

Figure 4 C) Photomicrograph of abdominal distention of *B. bayad.* Magnification: –(400X)

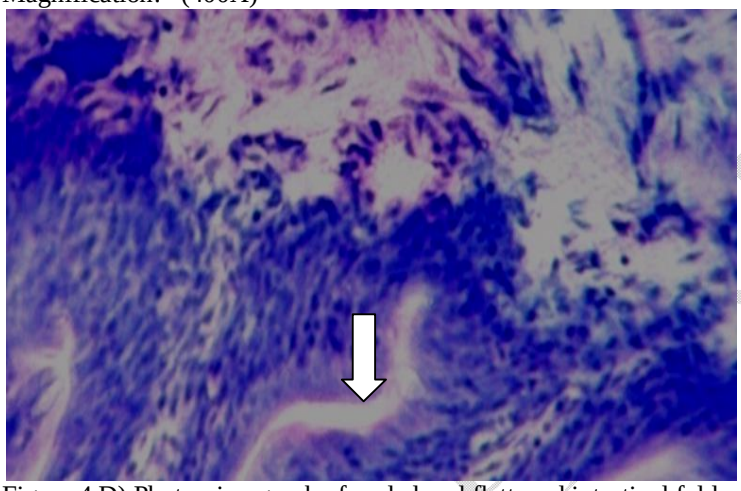

Figure 4 D) Photomicrograph oferoded and flattened intestinal folds of *B. bayad.* (400X)

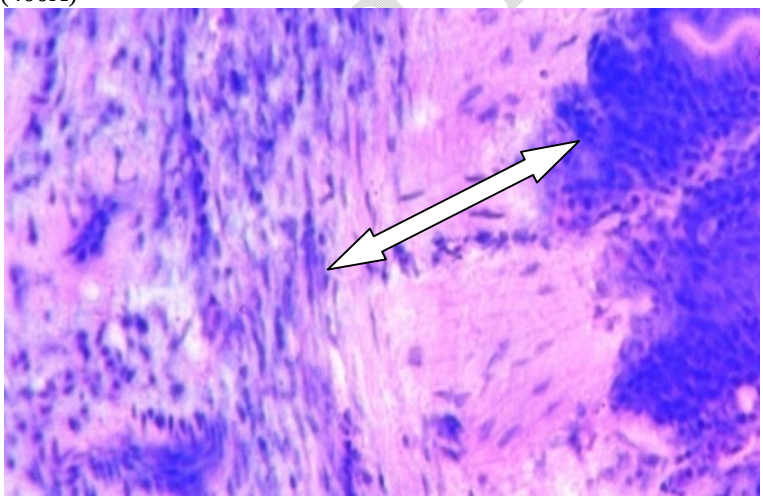

Figure 4 E) Photomicrograph of lymphocytic infiltration of intestinal mucosa and edema of the lamina propria of infected intestine of *B. bayad. (400X)*

4. Discussion

The prevalence of fish parasites in *Bagrus bayad* and *Protopterus annectens* from Upper river Benue in Mutum Biu, Taraba State, Nigeria was carried out using standard parasitological method. 4 parasite taxa comprising of 12 different parasite species (*Trichodina spp., Henneguya spp.*and *C. iubilans,,Diphilobothrium latum*, *H. nanna* and *Bothriocephalus aengypticus*, *C. philipinensis, Camallanus spp., C. briggsae, Eustrongylides spp.* and *Contracaecum spp. Clinostomum spp.*) were recovered from different body parts of the fish species used for this work. The recovery of these parasites from the different body parts of the fish species in this study is not surprising as they have been previously recorded from the same species or related species elsewhere. For instance, high prevalence of *Henneguya spp* was obtained as whitish cyst of variable sizes which usually attach to arborescent organ, few were observed on the gill filament of infected fish in different fish species from various fish farms and rivers, respectively in Zaria, Kaduna State (Oniye 2000). Haladu (2003) reported thesame incidence in Tiga dam, Kano. Makeri*et al.,* (2020) recovered *Eustrongylides spp.* (Nematode) and *D. latum* (Cestode) from the gastrointestinal tract of *Citharinus citharus, Heterobranchus bidorsalis, Synodontis clarias* and *Heterotis niloticus*in their reported work on seasonal variation in endoparasite loads in four fish species from Lower River Benue, Makurdi Nigeria, Okoye *et al*. (2016) recovered *Camallanus spp*. from *C. gariepinus* in Imo State, Afolabi *et al.* (2020) also recovered *Camallanus spp*. from *C. gariepinus*. Solomon *et al.* (2018) in their reported work recovered *Capillaria spp. Camallanus spp.* and *Eustrongylides spp.* from *Bagrusbayad*in Lower River Benue Makurdi, Nigeria. Also, Omeji*et al.* (2018) recovered *D. latum* from *Synodontis eupterа*and *Auchenoglanis occidentalis* in Lower River Benue, Nigeria. Recovery of *Henneguyaspp.*, *C. iubilans, B. aengypticus*, *Clinostomum spp.*, and *H nanna* from *Clarotes*

macrocephalus in Lower and Upper River Benue, Nigeria had also been reported by Omeji *et al*., (2014).

The highest number of parasites recorded in the intestine of the infected *B. bayad* compared to the fin, gill and stomach in this work conforms to the works of Adegoroye *et al.,* (2019) and Onyedineke *et al*., (2010) who in their works reported higher number of parasites in the intestine of the infected samples. The highest number of parasites recorded for the intestine of the infected fish samples in this study could be attributed to the favourable nutritional advantage presented by the host's intestine to the parasites; this assertion is supported by the findings of Omeji *et al.,* (2022), Absalom *et al.,* (2018) and Akinsanya *et al.,* (2008). Also, the major factor that may have contributed to the high parasitic prevalence in the intestine than the stomach could be that most parasites found in the reservoir were cestodes that lacked digestive systems. Obligatory, they had to depend on the digested food in the intestine of their host for survival, which they absorbed through thin body tegument. These parasites might have found an acid medium as presented by the stomach not conducive, hence their preference for inhabiting the intestine. The high prevalence is further supported by the findings from other studies that reported high prevalence in the wild population of *Clarias gariepinus* (Olufemi 2008; Ajala and Fawole, 2012). From a similar observation to this study, Ekanem *et al*. (2011) reported that the higher number of parasites in the intestines could be as a result of the many digestive activities that took place in the intestines resulting in the release of parasite ova/cysts in food particles. However, the major factor that may have contributed to the high parasitic prevalence in the stomach of *P. annectens* compared to the intestine could be that most parasites found in the stomach might have found favourable acid medium presented by the stomach. This finding disagrees with the reported works of Afolabi *et al.,* (2020) and Olumuyiwa *et al.,* (2014) who reported higher number of

parasites in the intestine of infected *Clarias gariepinus* compared to the stomach due to the favourable acid medium presented by the intestine to the parasites.

Also, different species of parasites were recovered from the different parts of the fish species. The recovery of these different species of parasites from the different infected parts of the fish species could be attributed to the fact that parasites most especially, the helminthes depend on the presence of absorbable food materials in the lumen of the gut. The availability of certain classes of nutrient, their different sites of digestion and absorption will play a definite role in determining the kind of parasite and their distribution in the intestine, this also agrees with the works of Adegoroye *et al.,* (2019); Morenikeji and Adepeju (2009).

The parasitological examination of *B. bayad* and *P. annectens* from Upper River Benue showed a high parasite prevalence of 58.50%, consisting of 4 parasitic group/taxa with 12 different parasite species. The high overall parasite prevalence in this work is in agreement with the observation of Yakubu *et al.,* (2002) who reported high infection prevalence of 59% in their comparative study of gut helminths of *Tilapia Zilli* and*Clarias gariepinus* from River Uke, Plateau State, Nigeria but higher than the (40.85%) recorded by Dankshaya and Zakari, (2007), 25.34% recorded in Edo State, Nigeria (Osimen and Anagha, 2020), 32.90% recorded in Warri River, Delta State (Ejere *et al.,* 2014), 6.90% in Okhuo River (Edema *et al*., 2008) and 3.30% recorded in Great Kwa River (Ekanem *et al.,* 2011). However, The high overall parasite prevalence in this work is lower than the 100% recorded for Nile Tilapia (*Oreochromis niloticus*) from Lake Koftu in central Ethiopia (Mitiku *et al.,* 2018), 67.5% recorded in Abuja, Nigeria (Kawe*et al.,* 2016), 65.0% recorded in Ebonyi River, Enugu State, Nigeria (Onyishi and Aguzie, 2018), 61.00 and 62% recorded for *O. niloticus*from River Nile and drainage branch, respectively in Egypt (Sami *et al.,* 2020) and 59.20% recorded for fishes in Niger River at

Illushi, Edo State, Nigeria (Onyedineke *et al.*, 2010). Variations in the prevalence of infection may be due to the differences in environmental fluctuation, availability of parasitic intermediate hosts and the life history patterns of parasites (Marcogliese, 2005). Also, the rate of parasitic prevalence could be determined by the sanitary condition of the River prior to its increase in the nutrient status by the anthropogenic activities (Onyedineke*et al.*, 2010). Furthermore, the shift in the host's feeding behaviour as well as the availability of food items from one ecological location to another might have been responsible for the variation in the prevalence of infection. Similar observation had been made by Osimen and Anagha (2020).

Variation in theprevalence of parasite infection in relation to the size of *B. bayad*and *P. annectens* from Upper River Benue existed. Generally, it was observed that the larger sized fishes had the highest percentage of infection compared to the smaller sized fishes being highest (34.15%) and (39.50%) in length ranges of 54.1 – 63.0cm and 22.0 – 31.0cm for samples of *B. bayad*and *P. annectens*, respectively. However, while the length range (18.0 – 27.0cm) of *B. bayad* recorded the lowest percentage of infection (5.70%), length ranges (22.0 – 31.0cm and 58.1 – 67.0cm) recorded the lowest percentage of infection of 3.36% each although, the prevalence of infection in relation to sizes of both fish species was not statistically significant (P>0.05).

The variation in the prevalence of parasite infection in relation to the size of *B. bayad*and *P. annectens* from Upper River Benue could be as a result of the varying distribution of parasites in the different ecological niches of the water and quest for survival of the fishes which might have probably exposed them to infection by parasites. A similar result for *Clariasgariepinus*and *Tilapia zilli* obtained from Lamingo Dam, Jos, Nigeria had been reported by Goselle *et al.* (2008). However, Bichi and Ibrahim (2009) reported higher prevalence of smaller sized *Tilapia*

zilli compared to the bigger ones in their survey of Tiga Lake, Kano, Nigeria and attributed the reason in the prevalence variation to the varying distribution of parasites in the different habitat which could be due to host-parasite interaction and the water quality parameters of dissolved oxygen, temperature and pH of the fish environment. A similar observation had been made by Oghenochuko *et al. (*2020) in their reported work of endo and ect parasite prevalence and abundance in some fish species from Akomoje, Ogun River South-West, Nigeria.

More so, the non-significant relationship between prevalence and size (P>0.05) of *B. bayad* and *P. annectens* recorded in this is in agreement with the finding of Eyo *et al*. (2013) who reported similar result for *Synodontis batensoda*, suggesting an increase in parasitism with size

Female samples of *B. bayad* and *P. annectens* had higher prevalence of infection (21.61%) and (16.63%) than the males (6.37%) and (6.24%), respectively although, the prevalence of infection in relation to the sexes of both fish species was not statistically significant (P>0.05).

The sexual differences in the prevalence of infection between the female and male may be attributed to the immune response of the host as a result of the variation in endocrine glands activities between the host sexes which have been suggested by many authors (Ibrahim and Soliman, 2010). Also, the higher prevalence in female fishes of both fish species may be related to investment in the reproductive activities of the female fishes which could be more costly than in the male counterpart; therefore females are more susceptible to parasite infection in periods of investment in gonad development (Šimková *et al.*, 2005). This observation is in line with the reported work of Ibrahim and Soliman *(*2010) who reported that females *Tilapia niloticus*were generally more parasitized than the males.

The degrees of tissue changes in infected fins, skin, gills, intestine and stomach of *B. bayad* and *P. annectens* from Upper River Benue as revealed by histopathological study is similar to the

observations by Adegoroye *et al*. (2019);Akinsanya and Kuton, (2016). The histopathological screening revealed pathological conditions such as epidermal necrosis of the caudal fin and skin of *B. bayad*, epidermal necrosis of the skin of *P. annectens*, hyperplasia of the gill epithelial covering of secondary lamellae with gill thickening, stomach ulceration, distended stomach or abdominal distention. Also, **a**t the site of parasite attachment in the intestine, the surface of the intestinal epithelium of infected fish appeared thickened, hyperplasia of the intestinal villi and lamina propria near the site of parasite attachment, tips of folds of the intestine at the sites of parasite attachment were eroded and appeared flattened and lymphocytic infiltration of intestinal mucosa and edema of the lamina propria of infected intestine, all which could lead to fish mortality with a resultant effect of economic loss.

5. Conclusion

The relatively high prevalence of parasites of *B. bayad* and *P. annectens* from the Upper River Benue, Nigeria could be a serious problem to their productivity and could lead to their extinction if attention is not given. Parasite invasion, attachment and establishment in a fish compromise the efficiency of the fish in preventing further infection, lowering the fish reproductive efficiency, feed utilization and economic devaluation of the fish.

The degree of damages caused by parasite depends not only on the intensity of the infection but also on how deep the developmental stages of the parasites reach within the infected parts.

In order to maximize productivity of these fish species in the Upper River Benue even down the Lower River Benue, Nigeria and to further ensure their continuous existence, further studies need to be carried out so as to ascertain the major causes of the high rate of infection, and the appropriate measures to be taken to ensure better productivity.

Fish farmers and sellers should be enlightened on the potential risk of parasitic infestation in fishes in order to avoid economic loss and consumers of fish are by this work advised to cook their fish food very well so as to destroy any parasite harbored in the fish in order to avoid zoonotic cases.

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