

**OCCURRENCE AND EFFECTS Prevalence OF fish PARASITES IN *B. BAYAD* AND *P. ANNECTENS* FROM UPPER RIVER BENUE, in MUTUM BIU, TARABA STATE, NIGERIA**

**Abstract**

The occurrence and effects of parasites in *Bagrus bayad* and *Protopterus annectens* from Upper River Benue, Mutum Biu, Taraba State Nigeria was carried out using standard parasitological method. Twelve (12) parasite species belonging to 3 species of protozoa (*Trichodina* spp., *Henneguya* spp. and *C. iubilans*), 3 species of cestode (*Diphilobothrium latum*, *H. nanna* and *Bothriocephalus aegypticus*), 5 species of nematode (*C. philipinensis*, *C. briggsae*, *Camallanus* spp., *Eustrongylides* spp. and *Contracaecum* spp.) and a species of trematode (*Clinostomum* spp.) were recovered from samples of *B. bayad* while seven (7) parasites species belonging to 2 species of protozoa (*Trichodina* spp. and *C. iubilans*), a species of cestodes (*B. aegypticus*) and 4 species of nematodes (*C. philipinensis*, *Camallanus* spp., *Eustrongylides* spp. and *Contracaecum* spp.) were recovered from the samples of *P. annectens*. Among the body parts of *B. bayad*, while intestine had the highest percentage parasite load (56.37%), highest percentage parasite load (46.22%) in *P. annectens* was recorded for stomach (46.22%). Out of the 400 fish samples comprising of 200 each of *B. bayad* and *P. annectens*, 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. However, there was no significant difference in the prevalence of infection and parasite load between the fish species, respectively ( $P > 0.05$ ). Larger sized fishes were observed to have 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 although, the prevalence of infection in relation to sizes of both fish species was not statistically significant ( $P > 0.05$ ). Female *B. bayad* and *P. 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 ( $P > 0.05$ ). Pathological conditions such as epidermal necrosis of the caudal fin and skin, epidermal necrosis of the skin, hyperplasia of the gill epithelial covering of secondary lamellae with gill thickening, stomach ulceration, abdominal distention, thickened intestinal epithelium surface, hyperplasia of the intestinal villi and lamina propria, eroded and flattened tips of folds of the intestine, lymphocytic infiltration of intestinal mucosa and edema of the lamina propria of infected intestine were observed.

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

**Comment [L1]:** Abstract needs to be rewritten to clearly explain the rationale, background, objectives, methods, scope and outlook of this study

**Comment [L2]:** Spelling correction

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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 (Tossaviet *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 (Otoret *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.

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 source of 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

**Comment [L8]:** It is suggested to incorporate background and rationale of this work in this paragraph

**Comment [L9]:** Current status of parasitic diseases of fish in Nigeria and worldwide needs to be highlighted and discussed

**Comment [L10]:** It is suggested to incorporate more recent data

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, make the study of fish parasites a necessity as it 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.

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Comment [L12]: Please rephrase this by avoiding long sentence and need to be rewritten to be meaningful; also need to mention the objectives and hypothesis of this work at the end of section

## 2. Materials and Methods

### The Study Area 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.

Comment [L13]: It is suggested to exclude any superfluous details and only provide the primary geographic data for the study area and its execution period

### Sample Collection

Comment [L14]: Please merge this paragraph with above and modify it highlighting the standard method for collecting and processing samples

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, MutumBiu, 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 done based 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 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

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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 Adegroyeet *al.*, (2019), the histopathological techniques of the 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 the Department of Veterinary Pathology, histological unit, University of Agriculture, Makurdi for histopathological processing and dehydrated twice 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 4-5 microns, 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).

### Statistical analysis 2.3 Analysis for the degree of parasitic infestation

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 Poulin and Rohde (1997) as thus;

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

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

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

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

### 2.4 Statistical analysis

Chi-square was used to calculate the significant difference of the levels of infection and to compare the parasitic load in fish hosts and also to statistically determine if there was any significant difference between prevalence of infection and sex, and prevalence of infection and total length of the fish samples.

**Comment [L16]:** The presented reference for this sentence is not appropriate. The authors must cite the original document in which these formulas are defined. Please check: L. Margolis, G. W. Esch, J. C. Holmes, A. M. Kuris and G. A. Schad (1982). The Use of Ecological Terms in Parasitology (Report of an Ad Hoc Committee of the American Society of Parasitologists). The Journal of Parasitology, 68(1), 131–133. doi:10.2307/3281335

**Comment [L17]:** Please rewrite this section mentioning the statistical software used for data analysis with specific tests and percentage of confidence interval and p value considered for statistically significant different.

### 3. Results of the study

#### 3.1 Parasite species spectrum and over all prevalence of *B. bayad* and *P. annectens* from Upper River Benue

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The prevalence of parasite species spectrum of *B. bayad* and *P. annectens* from Upper River Benue is shown in Table 1. Twelve (12) parasite species belonging to 3 species of protozoa (*Trichodina* spp., *Henneguya* spp. and *Cryptobia. iubilans*), 3 species of cestode (*D. latum*, *Hymenolepis nanna* and *Bothriocephalus aegypticus*), 5 species of nematode (*C. philipinensis*, *Caenorhabditis briggsae*, *Camallanus* spp., *Eustrongylides* spp. and *Contracaecum* spp.) and a species of trematode (*Clinostomum* spp.) were recovered from samples of *B. bayad* while seven (7) parasite species belonging to 2 species of protozoa (*Trichodina* spp. and *C. iubilans*), a species of cestodes (*B. aegypticus*) and 4 species of nematodes (*C. philipinensis*, *Camallanus* spp., *Eustrongylides* spp. and *Contracaecum* spp.) were recovered from the samples of *P. annectens*.

Comment [L18]: It is suggested to rephrase using proper text to make it shorter rather than lengthier.

Among the parasites species from *B. bayad*, while *D. latum* was the most prevalent (32.52%), *B. aegypticus* was the least prevalent (2.44%). On the other hand, while *Contracaecum* spp. was the most prevalent in samples of *P. annectens*, the least prevalent was *C. iubilans* (1.68%). Among the body parts of *B. bayad*, while intestine had the highest percentage parasite load (56.37%), the least percentage parasite load (2.44%) was recorded for skin. 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.

Comment [L19]: Please insert the percentage.

Comment [L20]: There should be no inadequacy between the text and the tables. For example, is Table 1 useful? Please modify the table showing this data accordingly.

**Table 1. Prevalence of parasites species in *B. bayad* and *P. annectens* from Upper River Benue, MutumBiu, Taraba state**

Parasitic species	Site of attachment of each parasite	% of each parasite on/in each infected part from		% total of each parasite species on host fish	
		<i>B. bayad</i>	<i>P. annectens</i>	<i>B. bayad</i>	<i>P. annectens</i>
<i>Trichodina</i> spp.	Fin	2.44	-	4.88	10.08
	Skin	2.44	10.08		
<i>Clinostomum</i> spp.	Gill	6.50	-	6.50	-
<i>Henneguya</i> spp.	Gill	1.63	-	4.61	-
	Intestine	2.98	-		
<i>C. briggsae</i>	Intestine	4.61	-	8.68	-
	Stomach	4.07	-		
<i>Camalanus</i> spp.	Intestine	4.07	7.56	9.49	15.12
	Stomach	5.42	7.56		
<i>H. nanna</i>	Intestine	3.79	-	4.87	-
	Stomach	1.08	-		
<i>Eustrongylides</i> spp.	Intestine	3.25	13.45	4.88	25.21
	Stomach	1.63	11.76		
<i>C. iubilans</i>	Stomach	3.25	1.68	3.25	1.68
<i>D. latum</i>	Intestine	31.71	-	32.52	-
	Stomach	0.81	-		
<i>Contracaecum</i> spp.	Intestine	2.44	12.61	10.84	26.06
	Stomach	8.40	13.45		
<i>C. philippinensis</i>	Intestine	3.52	6.72	7.04	13.45
	Stomach	3.52	6.73		
<i>B.aegypticus</i>	Intestine	0	3.36	2.44	8.40
	Stomach	2.44	5.04		
<b>TOTAL</b>		<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

% = Percentage, - = Not present

**Comment [L21]:** The data present in the table required more clarification. Author should modify the table by incorporating total no. of sample (n), percentage no. corresponding to the sample examined and statistical analysis in separate column. Further positive percentages of parasites from different bodily parts need to be analyzed to check whether the difference is statistically significant or not.

### 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.

Comment [L22]: Please show this data in the table 2.

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

Fish samples	Infestation status of fish samples			Prevalence (%)	Total no. of parasites recovered
	No. of fish examined	No. of fish Infested	No. of fish not infested		
<i>B. bayad</i>	200	99	101	49.50	369
<i>P. annectens</i>	200	135	65	67.50	119
<b>Total</b>	<b>400</b>	<b>234</b>	<b>166</b>	<b>58.50</b>	<b>488</b>

Comment [L23]: This table is likewise perplexing because the data stated in the text is missing. Please update the table and include the statistical data analysis results in a separate column.

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 infection in relation to the size of *B. bayad* and *P. annectens* from Upper River Benue is shown in figure 1 while figure 2 shows the prevalence of parasite infection in relation to the sexes of the host fishes.

From figure 1, it was generally observed that the larger sized fishes were observed to have 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) of *P. annectens* 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 ( $P>0.05$ ).

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From figure 2, 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 ( $P>0.05$ ).

Comment [L24]: It is suggested to re-write this paragraph to make the content clear and simple to understand.

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Figure 1. Prevalence of parasite infection in relation to the size of *B. bayad* and *P. annectens* from Upper River river Benue

Comment [L25]: Please provide X-axis and Y-axis title like in Figure 2 and separate color bar diagram for two kinds of fish showing the value of each column bar.

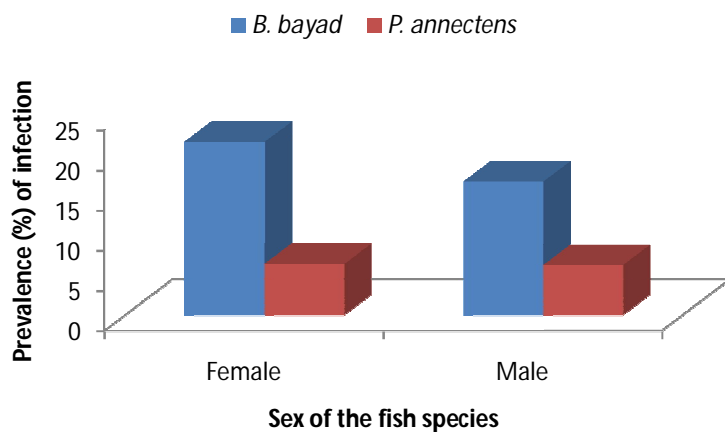


Figure 2. Prevalence of parasite infection in relation to the sexes of *B. bayad* and *P. annectens* from Upper River-river Benue

### 3.4 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. Plate 1 shows the epidermal necrosis of the caudal fin and skin of *B. bayad* while plate 2 shows the epidermal necrosis of the skin of *P. annectens*. Hyperplasia of the gill epithelial covering of secondary lamellae with gill thickening was observed with infected fish samples of *B. bayad* (plate 3). Stomach ulceration (plate 4) and abdominal distension (Plate 5) were observed with the infected of *B. bayad*. At the site of parasite attachment in the intestine, the surface of the intestinal epithelium of infected *B. bayad* appeared thickened (Plate 6). Hyperplasia of the intestinal villi and lamina propria near the site of parasite attachment (Plate 7) was observed with infected intestine of *P. annectens* where only *Eustrongylides spp.* was observed. Tips of folds of the intestine at the sites of parasite attachment in *B. bayad* were eroded and appeared flattened (Plate 8). Plate 9 shows the Lymphocytic infiltration of intestinal mucosa and edema of the lamina propria of infected intestine of *B. bayad*.

Comment [L26]: Please show the value of each bar diagram.

Comment [L27]: Please rephrase this paragraph accordingly

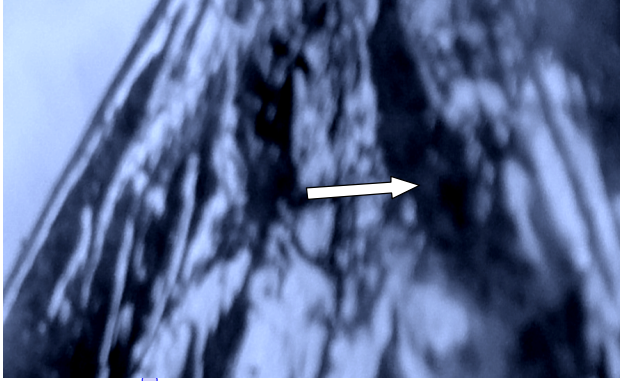


Plate 1: Figure 3(A): Photomicrograph of Epidermal necrosis of the Caudal fin and skin exhibiting epidermal necrosis of the *B. bayad*. Magnification:  $\times$  (400X)

Comment [L28]: Please mark A at the upper left side on the image

Comment [L29]: Please mention the stain name along with magnification

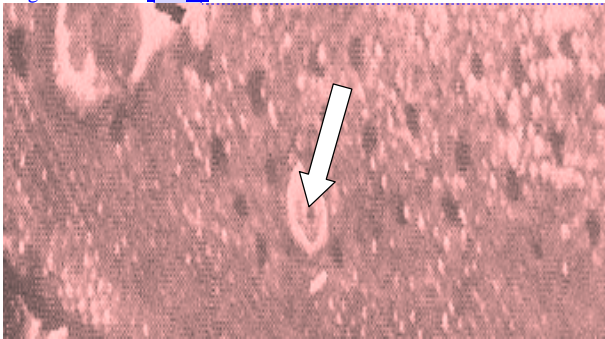


Plate 2: Figure 3(B): Photomicrograph of skin exhibiting Epidermal Necrosis of the skin of *P. annectens*. Magnification:  $\times$  (400X)

Comment [L30]: Please mark B at the upper left side on the image

Comment [L31]: Please mention the stain name along with magnification

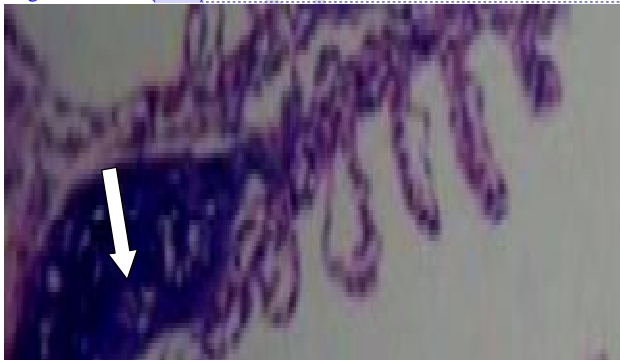


Plate 3: Figure 4 (A): Photomicrograph of Hyperplasia of infected Gills at the secondary lamellae of *B. bayad*. Magnification:  $\times$  (400X)

Comment [L32]: Please mention the stain name along with magnification



Plate 4: ~~Figure 4. B)~~ Photomicrograph of ~~Ulceration-ulceration~~ of the ~~Stomach-stomach~~ of *B. bayad*.  
Magnification: ~~x-(400X)~~

**Comment [L33]:** Please mention the stain name along with magnification.

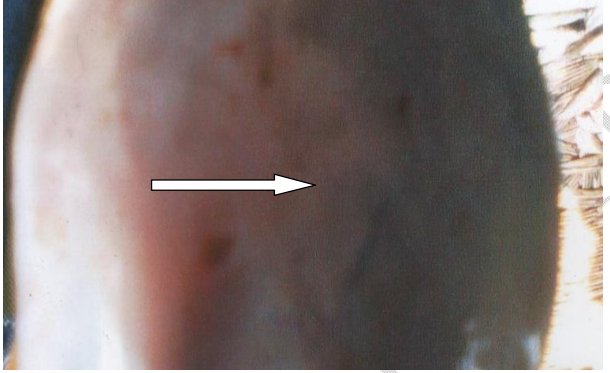


Plate 5: ~~Figure 4. C)~~ Photomicrograph of ~~Abdominal-abdominal~~ ~~Distention-distention~~ of *B. bayad*.  
Magnification: ~~x-(400X)~~

**Comment [L34]:** Please mention the stain name along with magnification.

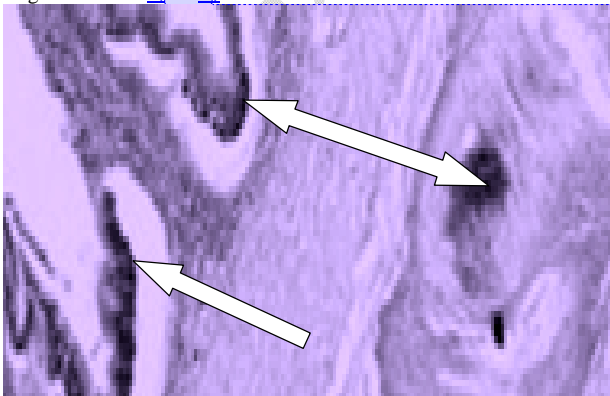


Plate 6: ~~Figure 3C)~~ Photomicrograph of ~~Thickened-thickened~~ ~~Intestinal-intestinal~~ ~~Epithelium-epithelium~~ at the site of parasite attachment from *B. bayad*. Magnification: ~~x-(400X)~~

**Comment [L35]:** Please mark C at the upper left side on the image

**Comment [L36]:** Please mention the stain name along with magnification

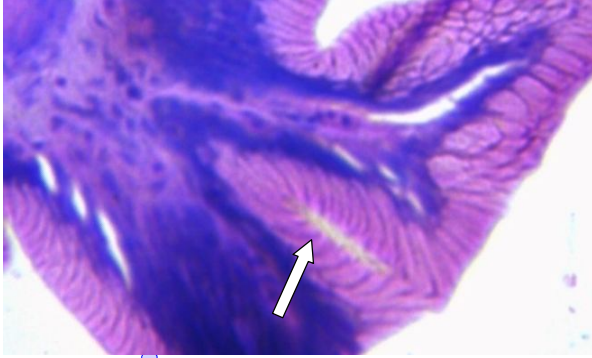


Plate 7: Figure 3D) Photomicrograph of Hyperplasia-hyperplasia of the Intestinal-intestinal Villi-villi and Lamina lamina Propria-propria of *P. annectens*. Magnification: x (400X)

Comment [L37]: Please mark D at the upper left side on the image

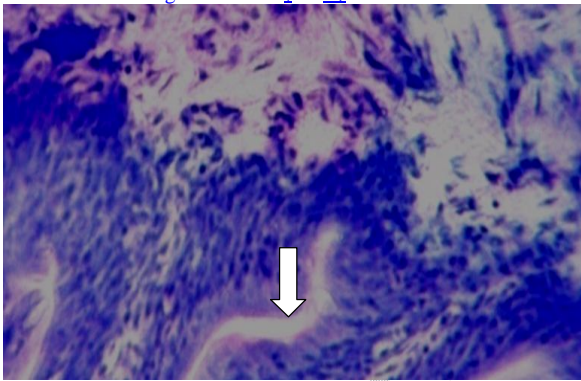


Plate 8: Figure 4. D) Photomicrograph of Eroded-eroded and Flattened-flattened Intestinal-intestinal Folds-folds of *B. bayad*. Magnification: x (400X)

Comment [L38]: Please mention the stain name along with magnification.

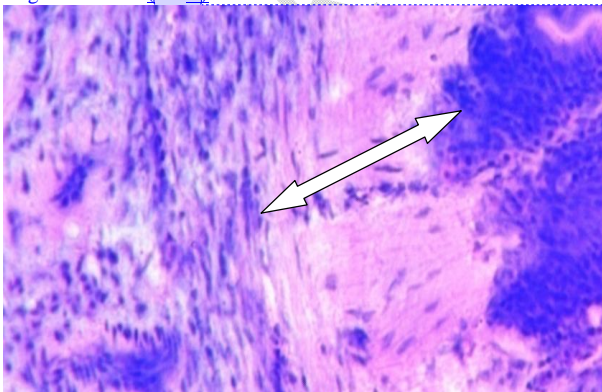


Plate 9: Figure 4. E) Photomicrograph of lymphocytic-lymphocytic infiltration of intestinal mucosa of infected intestine and edema of the lamina propria of infected intestine of *B. bayad*. Magnification: x (400X)

Comment [L39]: Please mention the stain name along with magnification.

#### 4. Discussion

The occurrence and effects of parasites in *B. bayad* and *P. annectens* from Upper River Benue was carried out using standard parasitological method. 4 parasite taxa with 12 different parasite species namely; 3 species of protozoa (*Trichodina* spp., *Henneguya* spp. and *C. iubilans*), 3 species of cestodes (*Diphilobothrium latum*, *H. nanna* and *Bothriocephalus aegypticus*), 5 species of nematodes (*C. philipinensis*, *Camallanus* spp., *C. briggsae*, *Eustrongylides* spp. and *Contracaecum* spp.) and a species of trematode (*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 ~~aborescent~~ 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 similar incidence in Tiga dam, Kano. Makeriet *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. gariiepinus* in Imo State, Afolabi *et al.* (2020) also recovered *Camallanus* spp. from *C. gariiepinus*. 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, Omeji *et al.* (2018) recovered *D. latum* from *Synodontis euptera* and *Auchenoglanis occidentalis* in Lower River Benue, Nigeria. Recovery of *Henneguya* spp., *C. iubilans*, *B. aegypticus*,

**Comment [L40]:** This section needs to be revised and compare the findings with more relevant study data without redundancy.

**Comment [L41]:** Repetition, already mentioned in the result section.

**Comment [L42]:** What does it mean? The authors should first mention the incidence rate of the current study and then compare with earlier findings sequentially.

*Clinostomum* spp., and *H. nanna* from *Claroetes macrocephalus* in Lower and Upper River Benue, Nigeria had also been reported by Omejiet *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 Adegoro *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 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* *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 work of Olumuyiwa *et al.*, (2014) who

**Comment [L43]:** This reference is missing in the reference section.

**Comment [L44]:** This reference is missing in the reference section.

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

Also, different species of parasites were recovered from the different parts of the fish species.

**Comment [L45]:** Does this sentence add anything to the discussion?

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).

**Comment [L46]:** It is suggested to rephrase this section.

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 (Ekanemet *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 (Kaweet *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

**Comment [L47]:** This reference is missing in the reference section.

(Onyedinekeet *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 (Onyedinekeet *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 the prevalence 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 *Clarias gariepinus* and *Tilapia zilli* obtained from Lamingo Dam, Jos, Nigeria had been reported by Goselleet *al.* (2008). However, Bichi and Ibrahim (2009) reported higher prevalence of smaller sized *Tilapia*

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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 or age.

Comment [L48]: This is repetition

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 ( $P > 0.05$ ).

Comment [L49]: It is suggested to merge this statement with above paragraph.

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 Adegoro *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, at 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.

**Comment [L50]:** Repetition and somehow not suitable suggestion, please rephrase highlighting the main findings of this study with an appropriate outlook.

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