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Growth Status and Parasitic Fauna of *Clarias gariepinus* Collected from Ogbese River and Owena River, South-West Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine condition status and identify parasitic fauna in intestine, gills and skins of *Clarias gariepinus* collected from two natural waters: Ogbese River (River A) (Longitude 5°26'E' and Latitude 6°43'N), and Owena River (River B) (Longitude 5.03E and Latitude 7.03N) in Ondo state, Nigeria respectively.
Study Design: Laboratory-experimental design was used in this study.
Place and Duration of Study: 120 live *C. gariepinus* African Mud Catfish were collected by the assistance of fishermen using cast net during the wet season during April to July 2016 from the two natural water bodies (Ogbese River and Owena River).
Methidology: Fish were transported live to the laboratory for examinations. Length (cm) and weight (g) measurement of fish were determined. Condition factor (K), isometric value (b) and regression coefficient were determined. Fish samples were examined using electronic Microscope (x 400 Mag.) by dissecting fish to remove organs (Intestines, gills and skins) for parasites occurrence (s). Descriptive and analytical statistics were used to analyse the data obtained.
Results: The condition factor for all *C. gariepinus* samples collected from both Rivers were less than one (<1), which indicated that the health status of the fish is biased, and the environment is not conducive. The parasitic examination carried out revealed that seventy-eight (65%) *C.*

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gariepinus fish samples were infested; while 42 (35%) of fish samples showed no parasite infestation. A total of Ninety-six (96) individual parasites were recovered from River A while a total of two hundred and twelve (212) individual parasites were recovered from River B. A total of eight (8) different parasites species were recovered while their percentage of occurrence was recorded. These include *Ambiphrya* spp. (4.17%), *Camallanus* spp. (6.25%; 2.83%), C*apillaria* spp. (16.98%), *Chilodonella* spp. (14.58%), *Dactylogyrus* spp. (64.58%; 5.66%), *Diphyllobothrium latum* (10.42%; 4.72%), *Gyrodactylus* spp. (61.32%) and *Protoopalina symphysodonis* (8.49%).
Conclusion: The water bodies need to be protected against further pollutants to prevent disease condition for the benefit of aquatic organisms and public health.

Keywords: Condition factor; pathogens; natural waters; health status.

1. INTRODUCTION

Fish is an important sources of protein with high nutritional value for humans and other animals in the tropics [1,2], with high quality and easily digestible protein containing essential amino acids and other beneficial nutrients providing a good source of vitamins and minerals [2]. Fish also serve as a good source of animal protein for livestock [3], besides, people rely on fishing for economic gains and jobs [1]. A well-processed fish product from the tropics has a ready market in developed countries and is a good foreign earner [4]. The most common fish available in Nigeria are catfish species (e.g. *Clarias* spp.). The sharp mouth catfish, *Clarias gariepinus* [5] occurs mainly in quiet waters, lakes and pools but may also occur in fast flowing rivers [6]. It is highly priced in Nigeria either as smoked, dried or fresh [4].

Studies on parasites of freshwater fishes in Africa vary considerably from area to area, being the parasites mostly mentioned as part of the fulfilment of the biology of the host fish species [7]. Parasites are a major concern to freshwater and marine fishes all over the world, and of particular importance in the tropics [8,9]. The effects of parasites on fish include nutrient devaluation [10], lowering of immune capability, induction of blindness and mechanical injuries depending on the parasite species and load [11,12]. Parasites may induce a shift in fish species densities, size, composition and affect commercially relevant stocks. Parasites are also good indicators of environmental contaminants and stress [13].

Parasitic diseases of fish are most frequently caused by small microscopic organisms called protozoa, which live in the aquatic environment. There is a variety of protozoans infesting the gills and skin of fish that cause irritation, weight loss, and eventually death. Most protozoan infections are relatively easy to control using standard fishery chemicals such as copper sulphate, formalin, or potassium permanganate, [14]. Protozoans are single-celled organisms, with many as free-living in the aquatic environment. They typically have a direct life cycle, that is, no intermediate host is required for the parasites to reproduce, and are the most commonly encountered fish parasites [15].

Fish like any other valuable natural resources, require careful management. Despite the interest in the freshwater ichthyofauna of Nigeria, little or no attempt is made to identify and manage or control parasites. At present, the paucity of research in fish diseases in Africa is not seen as a factor that will have a negative impact on fisheries development and as such is not a target research area. Occurrences of helminth parasites in fishes have been studied extensively in various water bodies in Nigeria, with most of the work done primarily from the morphologic and morphometric descriptions. However, factors that may limit the ability of parasites to co-exist in multiple infections in a host fish species had in most studies been neglected [16].

In Nigeria, the emanating need to culture fishes for protein consumption for the rapidly growing populations have made it necessary to intensify studies on the parasitic fauna of the African freshwater fishes (*Clarias gariepinus*). The study of parasites in fishery resource management is of paramount importance because they may lead to mass mortality of fish, or in some cases, the emergence of zoonotic species [17]. Hence, there is a need to provide a deeper appreciation for the role of parasites in fish health assessments using *Clarias gariepinus* collected from two different natural water bodies. Therefore, this study was designed to investigate and identify the parasitic fauna in the intestine, on the gills and skin of adult *Clarias gariepinus* from two natural waters in Ondo State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

This study was conducted in Ogbese River (A) located between Longitude 5°26'E' and Latitude 6°43'N; and Owena River (B) located between Latitude 7.03N Longitude 5.03E. Ogbese River is one of the major perennial rivers in South-Western Nigeria being its source from Awo-Ekiti in Ekiti State. Owena River is also perennial in nature and is used as a major source of domestic water supply to the people of Ondo and Akure towns. It has a surface area of about 15 Km^2.

2.2 Sample Collection

A total of one hundred and twenty (120) live *Clarias gariepinus* fishes were collected with the assistance of fishermen from Ogbese and Owena Rivers in Ondo state from April to July 2016. Fish samples were transported during the early hours (9:00-10:00) of the day in a sanitized plastic container (25 litres) with water from River Source to Fisheries laboratory, Federal University of Technology, Akure, where growth assessments and parasitological examination were carried out.

2.2.1 Growth parameters assessment

- Measurement of standard length (cm) was taken using graduated meter rule, while weight (g) of fish was taken using electronic scale (Mettler Toledo electronic weighing balance – PB8001).
- Condition factor (K) of the fish were determined to evaluate the health status of the fish in relation to its environment using:

$$K = 100W/ L^3 \quad [18].$$

In which:

K = The Condition factor
W = Weight of fish in grams (g)
L = Standard length of fish in centimetres (cm)

- Regression analysis was carried out to assess the relationship between the increase in length with a weight gain of the fish using:

$$W=aL^b \qquad (1)\ [19]$$

In which:

W=Weight of fish in grams (g)
L= Total Length (TL) of fish in centimetres
a= Scaling Constant
b= Allometric growth coefficient

The “a” and “b” values were obtained from a linear regression of the length and weight of fish.

Transformed equation into linear regression:

$$\text{Log } W = \text{Log } a + b \text{ Log } L \qquad (2)\ [20]$$

The regression coefficient (R^2) correlation coefficient of the fish was determined.

2.3 Sex Grouping

Clarias gariepinus samples collected from Ogbese River and Owena River were separated into male and female respectively.

2.4 Parasitological Study

Clarias gariepinus fish samples were dissected, and the body cavities were opened with the aid of a dissecting set. The fish were examined for endoparasites and ectoparasites using the microscopic technique (direct wet mounts using Giesma staining method).

Skin samples were collected by removal of 1 gram specimens below the dorsal fins of respective fish. The specimens were squashed in NaCl solvent (1 gram NaCl and 10 ml of distilled water), and a drop was placed in cavity slide and viewed under Olympus trinocular microscope at CX 40 magnification.

Gill samples were carefully removed from one of gill arch. And the filaments were slightly teased apart to enable a clear view of gill filaments and lamellar profiles. It was put in NaCl solvent (1 gram NaCl and 10 ml of distilled water) and placed in cavity slide and mounted on glass slide without coverslip and viewed under Olympus trinocular microscope at CX 40 magnification.

Intestinal samples were dissected and contents were emptied inside Petri-dishes. NaCl solvent (1 gram NaCl and 10 ml of distilled water) were added and drops of the mixture were mounted in glass slides and viewed under Olympus trinocular microscope at CX 40 magnification.

The parasites observed from the respective organs were counted, identified and recorded. Degree of parasitic infection in intestine, gills and skin of *Clarias gariepinus* collected from the rivers were observed and recorded.

2.5 Data Analysis

Data were subjected to statistical analysis using Software Package Social Sciences (SPSS Version 6.0). Analytical and descriptive statistics were performed to analyse the data collected. Further analysis was carried out using Duncan Multiple Range Test. Mean and standard deviation (Mean ± Standard Deviation) of data was determined. Regression analyses were carried out and correlation (r) for respective data on growth were determined.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters Determinations

3.1.1 Length and Weight Measurements

A total of 120 *Clarias gariepinus* collected from Ogbese River and Owena River indicated a length range of 22.90–34.40 cm and weight range of 133.5–332.4 g. Table 1 shows the mean and standard deviation of standard length (cm) and weight (g) of fish samples collected over four months.

3.1.2 Regression analysis

The regression analysis of the length (cm) and weight (g) of fish from the two Rivers are shown in Figs. 1 and 2. Frequency of occurrence of fish, mean and standard deviation on standard length (cm) and weight (g) of all fish samples collected; Condition Factor (K), regression coefficient (R^2), coefficient of determination (r), and isometric values (b) of fish were also determined (Table 2).

3.2 Parasite Occurrence in *Clarias gariepinus* Samples Collected

The highest parasitic occurrence (64.58%) in Ogbese River was for *Dactylogyrus* sp. with 232.49 prevalence; *Gyrodactylus* species ranked highest (61.32) in occurrence and 220.75 prevalence in Owena River. Tables 3 and 4 showed the frequency and prevalence of parasites occurrence on *C. gariepinus* from the two environments. Fig. 3 showed the prevalence of parasites in male and female samples of *C. gariepinus* in both environments over the experimental period.

Table 1. Mean and standard deviation of length (cm) and weight (g) of *Clarias gariepinus* collected from Ogbese River and Owena River

	Weight (g)	Standard length (cm)
Ogbese River		
April	201.00 ± 16.72^{c}	27.89 ± 2.58^{a}
May	232.99 ± 31.92^{a}	28.08 ±1.73^{a}
June	219.53 ± 48.25^{b}	27.29 ± 3.64^{a}
July	228.35 ± 26.17^{a}	27.73 ± 2.56 ^{a}
Owens River		
April	208.00 ± 57.17^{c}	28.01 ± 2.10 ^{a}
May	234.68 ± 58.19^{a}	27.96 ± 2.65 ^{a}
June	155.36 ± 20.20^{d}	27.06 ± 1.90 ^{a}
July	212.47 ± 31.22^{b}	26.84 ± 2.14 ^{a}

Means with different alphabet superscript represent the significant level at P ≥5% within the column n = 120.

Table 2. Growth parameters determined for *Clarias gariepinus* collected from Ogbese River and Owena River

Freshwater Environments→ Growth Parameters↓	Ogbese River	Owena River
Frequency of Occurrence	60	60
Mean Standard length (cm)± standard deviation	27.58± 0.32	27.86± 0.68
Mean Weight (g) ± standard deviation	205.34± 2.24	217.26± 2.74
Condition Factor (K)	0.98	1.00
Regression Coefficient (R^2)	0.60	0.69
Coefficient of Determination (r)	0.78	0.83
Isometric Value (b)	2.17	2.28

Table 3. Frequency, percentage occurrence and prevalence of parasitic fauna in *Clarias gariepinus* from Ogbese River and Owena River

Parasites	Ogbese River			Owena River		
	Frequency	% Occurrence	Prevalence	Frequency	% occurence	Prevalence
Ambiphrya spp.	4	4.17	15.01	0	0.00	0.00
Camallanus spp.	6	6.25	22.50	6	2.83	10.19
Capillaria spp.	0	0.00	0.00	36	16.98	61.13
Chilodonella spp.	14	14.58	52.49	0	0.00	0.00
Dactylogyrus spp.	62	64.58	232.49	12	5.66	20.38
D. latum	10	10.42	37.69	10	4.72	16.99
Gyrodactylus spp.	0	0.00	0.00	130	61.32	220.75
P. symphysodonis	0	0.00	0.00	18	8.49	30.56
Total	96	100.00	360.00	212	100.00	360.00

Table 4. Monthly Frequency of Occurrence and Percentage Occurrence of Parasites Infestation in *Clarias gariepinus* from Ogbese River and Owena River

Month	Frequency of occurrence of parasites in Ogbese River	Percentage occurrence in Ogbese (%)	Frequency of occurrence of parasites in Owena River	Percentage occurrence in Owena (%)
April	30	31.25	74	34.91
May	24	25	65	30.66
June	24	25	40	18.87
July	18	18.75	33	15.56
Total	96	100	212	100

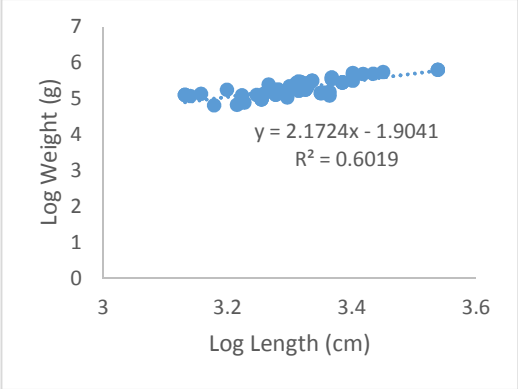

Fig. 1. Regression of *Clarias gariepinus* collected from Ogbese River

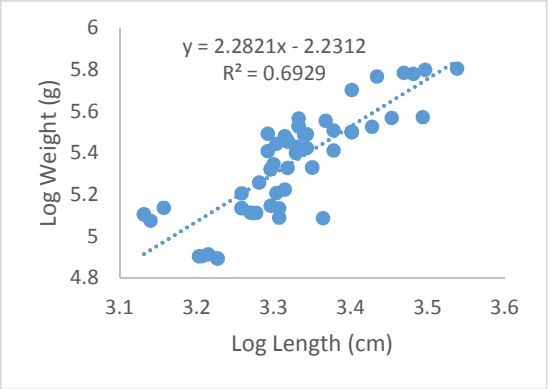

Fig. 2. Regression of *Clarias gariepinus* collected from Owena River

Prevalence (%) and comparative parasitic fauna recovered of the parasite in fish organs revealed parasites occurred most in the gills and intestines, and least in skins of *C. gariepinus* fish samples from Ogbese River and Owena River (Tables 5 and 6).

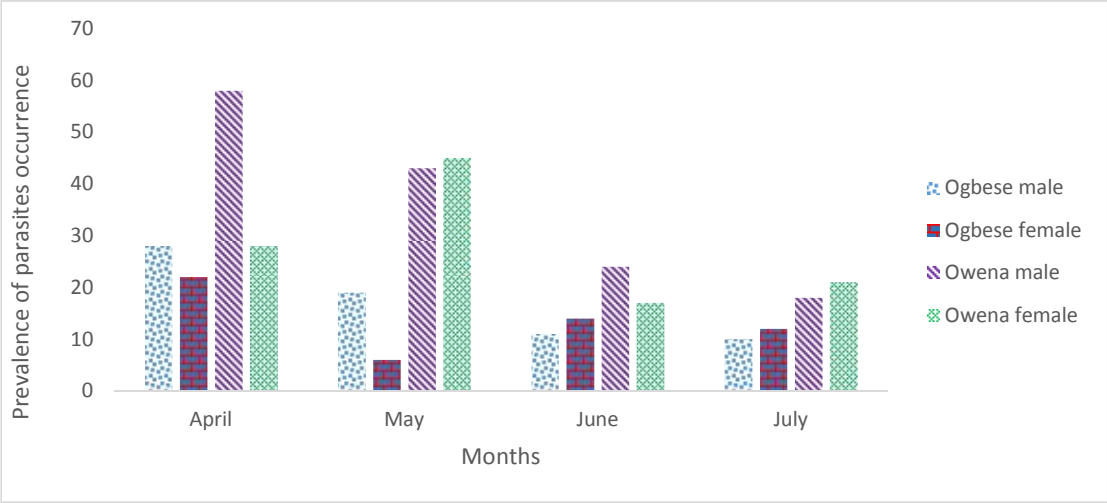

Fig. 3. Prevalence of parasites in male and female *Clarias gariepinus* from Ogbese River and Owena River in relation to sex and months

Table 5. Prevalence (%) of Parasites in Intestines, Gills and Skins of *Clarias gariepinus*

Parasite	Ogbese River			Owena River			Total
	Intestine	Gills	Skin	Intestine	Gills	Skin	
Ambiphrya spp.	0.00	4.17	0.00	0.00	0.00	0.00	4.17
Camallanus spp.	6.25	0.00	0.00	2.83	0.00	0.00	9.08
Capillaria spp.	0.00	0.00	0.00	16.98	0.00	0.00	16.98
Chilodonella spp.	0.00	0.00	14.58	0.00	0.00	0.00	14.58
Dactylogyrus spp.	0.00	64.58	0.00	0.00	5.66	0.00	70.24
D. latum	10.42	0.00	0.00	4.72	0.00	0.00	15.14
Gyrodactylus spp.	0.00	0.00	0.00	61.32	0.00	0.00	61.32
P. symphysodonis	0.00	0.00	0.00	8.49	0.00	0.00	8.49
Total	16.67	68.75	14.58	94.34	5.66	0.00	200

Table 6. Comparative parasitic fauna recovered in organs (intestine, gills and skin) of *Clarias gariepinus* in Ogbese River and Owena River

Parasitic species	River		Part/Location		
	Ogbese	Owena	Intestine	Gills	Skin
Ambiphrya spp.	+	-	-	+	-
Camallanus spp.	+	+	+	-	-
Capillaria spp.	-	+	+	-	-
Chilodonella spp.	+	-	-	-	+
Dactylogyrus spp.	+	+	-	+	-
Diphyllobothrium spp.	+	+	+	-	-
Gyrodactylus spp.	-	+	-	+	-
Protoopalina spp.	-	+	+	-	-

spp: Species;+Present; -Absent

Figs. 4 and 5 showed percentage infestation of parasites on *C. gariepinus* from Ogbese and Owena Rivers. *Dactylogyrus* spp. ranked highest in Ogbese River, while *Gyrodactylus* spp. ranked highest in Owena River.

Taxonomy and classification with the site of recovery of parasitic fauna in *C. gariepinus* are indicated in Table 7; and Plates 1–8 show the parasitic fauna pictorially.

Plates showing recovered parasites in *Clarias gariepinus* from Ogbese river and Owena river: A total of eight (8) parasites were recovered from the intestine, gills and skin of *Clarias gariepinus* comprised of two types of ectoparasitic protozoans (*Ambiphrya* sp. and *Chilodonella* sp.), one endoparasitic protozoan (*Protoopalina symphysodonis*), two monogenean trematodes (*Dactylogyrus* sp. and *Gyrodactylus* sp.), two nematodes (*Camallanus* sp. and *Capillaria* sp.) and a cestode (*Diphyllobothrium latum*).

The parasites recovered in *Clarias gariepinus* catfish samples from Ogbese River and Owena River are shown below (Plates 1–8).

The condition factor for fish samples (*Clarias gariepinus*) collected from both Rivers were less than one, which indicated that the living aquatic environment for the fishes was not conducive. Also, parasitic fauna in and on wild *Clarias gariepinus is* made up of myriads of parasitic and pathogenic organisms.

Eight (8) parasites were recovered in the intestine, on the gills and skin of *Clarias gariepinus* belong to different *phyla*; Protozoa, Nematoda, Ciliophora, Trematoda and Heterokontophyta. The parasites comprised of two ectoparasitic protozoans (*Ambiphrya* sp. and *Chilodonella* sp.), one endoparasitic protozoan (*Protoopalina symphysodonis*), two monogenean trematodes (*Dactylogyrus* sp. and *Gyrodactylus* sp.), two nematodes (*Camallanus* sp. and *Capillaria* sp.) and one cestode (*Diphyllobothrium latum*).

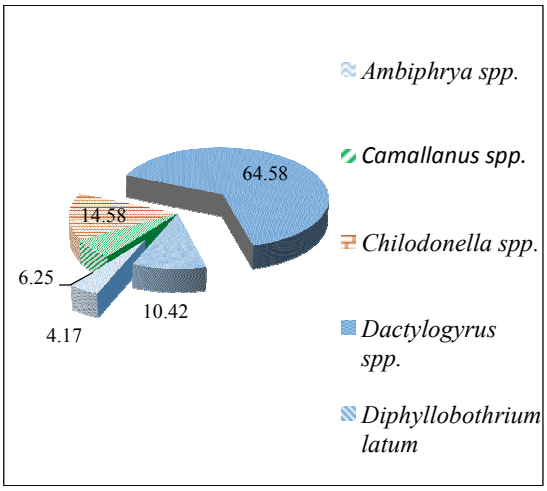

Fig. 4. Percentage Infestation in *Clarias gariepinus* from Ogbese River

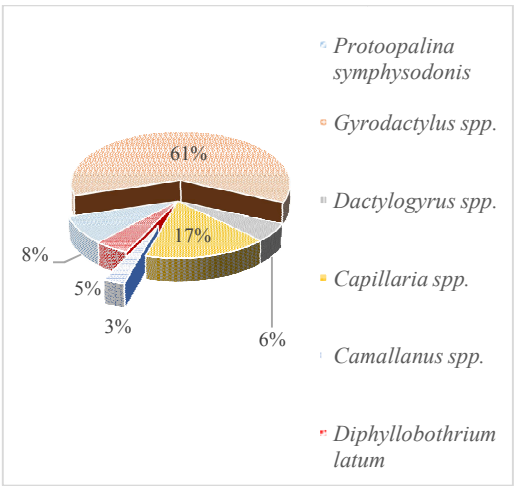

Fig. 5. Percentage Infestation in *Clarias gariepinus* from Owena River

Table 7. Taxonomical classifications and sites of recovery of parasitic fauna recovered in *Clarias gariepinus* fish samples

Parasites	Taxonomical group or classification							
	Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Genus**	**Site of Recovery**	**Type of parasite**
Ambiphrya	Animalia	Protozoa	-	Sessilida	Ambiphridae	*Ambiphrya*	Gills	Ectoparasite
Camallanus	Animalia	Nematoda (roundworms)	Secernentea	Camallanida	Camallanidae	*Camallanus*	Intestine	Endoparasite
Capillaria	Animalia	Nematoda	Adenophrea	Trichurida	Capillaridae	*Capillaria*	Intestine	Endoparasite
Chilodonella	Protista	Ciliophora	Phyllopharyngea	Cyrtophorida	Chilodonellidae	*Chilodonella*	Skin	Ectoparasite
Dactylogyrus	Animalia	Trematoda (Platyhelminthes)	Monogenea	Monopisthocotylea	Dactylogyridae	*Dactylogyrus*	Gills	Ectoparasite
Diphyllobothrium	Animalia	Platyhelminthes	Cestoidea	Pseudophyllidea	Diphyllobothriidae	*Diphyllobothrium*	Intestine	Endoparasite
Gyrodactylus	Animalia	Trematoda (Platyhelminthes)	Monogenea	Monopisthocotylea	Gyrodactylidae	*Gyrodactylus*	Gills	Ectoparasite
Protoopalina	Chromista	Heterokontophyta	Opalinea	Opalinida	Opalinidae	*Protoopalina*	Intestine	Endoparasite

The presence of cestode as being report in earlier work of Akinsanya and Olubanjo, [21] corroborated the result of this study with the occurrence of cestode and nematode parasites in *C. gariepinus.*

The effects of parasites on fish hosts in the wild may be difficult to quantify because the aquatic environment is constantly polluted from different sources [22]. *Ambiphrya* spp. and *Protoopalina symphysodonis* occurred in very small percentages when compared to total parasitic percentage; this may indicate the possibility of the parasites naturally existing at a negligible level in wild *Clarias gariepinus*. *Camallanus* sp. nematode has a negative health effect on fish with the high infestation. *Dactylogyrus* sp. and *Gyrodactylus* sp. had high prevalence while *Diphyllobothrium latum* (broad fish tapeworm) had negative health implications on fish and humans (the end-users of fish and fish products). This parasite is the causative agent of human Diphyllobothriosis [23].

Plate 1. *Protoopalina symphysodonis* in the intestine of *Clarias gariepinus* (Mg. 40X)

Plate 2. *Diphyllobothrium latum* in the intestine of Clarias *gariepinus* (Mg. 40X)

Plate 3. *Gyrodactylus* sp. on the gills of *Clarias gariepinus* (Mg. 40X)

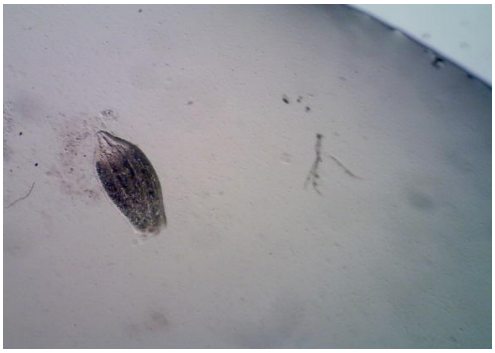

Plate 4. *Dactylogyrus* sp. on the gills of *Clarias gariepinus* (Mg. 40X)

Plate 5. *Capillaria* sp. in the intestine of *Clarias gariepinus* (Mg. 40X)

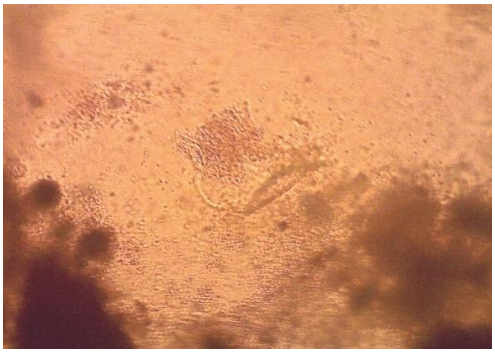

Plate 6. *Ambiphrya* sp. on the gills of *Clarias gariepinus* (Mg. 40X)

Plate 7. *Chilodonella* sp. on the skin of *Clarias gariepinus* (Mg. 40X)

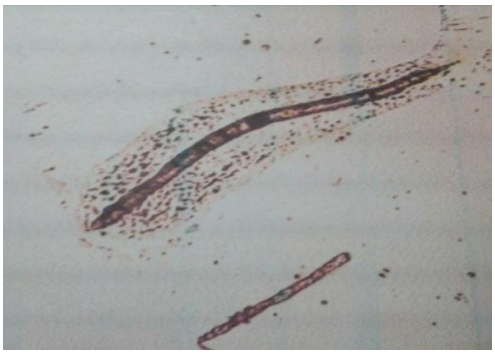

Plate 8. *Camallanus* sp in the intestine of *Clarias gariepinus* (Mg. 40 X)

Of the total of one hundred and twenty (120) live fish samples (*Clarias gariepinus*) examined, seventy-eight (78) fish samples were infested with parasites, giving a prevalence of 65%. The frequency of parasite infestation included the percentage intensity in *Clarias gariepinus* from the two natural water bodies. Table 4 revealed higher parasite prevalence in Owena River than Ogbese River. And more parasites were recovered in fish samples from Owena River than Ogbese River. Infestation of *C. gariepinus* with protozoan and cestode in dam and pond samples and from gill, skin and intestine respectively was reported by Udechukwu and others [24]. And this is in line with the findings of this study on recovery of protozoan and cestode parasites. Also, the occurrence of intestinal parasites *Diphyllobothrium latum* corroborated previous work and reported helminth infections as quite common in wild fish [1], and in the dam and pond-raised *C. gariepinus,* [24].

Infestation rates vary greatly from one area to another. Previously work is in line with the findings as the reported such infestation in Northern Nigeria, [3]. Overall infestation rate (65%) obtained depicted high infestation when compared to 16.6% reported from Asa River at Ilorin. This may be due to the fact that definitive host amongst others determines to a large extent the rate of infection, [25].

The study revealed the rate of parasites infestation differed with the sex of fish in the study, male fish had higher parasites occurrence than female. This may be as a result of differential feeding either by quantity or quality of food or as a result of different degrees of resistance to infestation. However, this contradicts [1] who reported that variations in parasitic infestation among the sexes of fish studied were not significant implying that higher infestation rates in either male or female were simply by chance. Also, no significant difference in parasites occurrence between male and female samples; and their findings corroborated with this study in that cestodes and nematodes species are among the parasites recovered from *C. gariepinus* samples studied, [21].

A reduction in the prevalence of parasite with an increase in weight of *C. gariepinus* [26]; an increase in fish length and weight with a corresponding increase in parasite load was reported [21]; while it was indicated that intestine having the highest parasitic load, [24]. This is in line with the result which indicated larger fish recorded higher parasite prevalence. In addition, the occurrence of parasites in *Clarias gariepinus* may be indicative of similar diets, feeding habits and patterns among the freshwater fishes. The pathological effects of helminths recovered are as a result of the mechanical damage caused by the attachment organs, [27].

Owena River revealed the higher frequency and percentage prevalence parasite infestation on *C. gariepinus* fish samples than Ogbese river samples over experimental months (Figs. 1 and 2). A high economic loss in stock with parasitic infection occurred in diseased fish [28]. As most of the parasites recovered were found in the intestine and on gills but to a lesser extent on the skin; interfering with the optimum response to fish wellness. Ectoparasites recovered include *Ambiphrya* spp., *Chilodonella* sp., *Dactylogyrus* sp. and *Gyrodactylus* sp. Endoparasites recovered include *Protoopalina symphysodonis*, *Diphyllobothrium latum*, *Capillaria* sp. and *Camallanus* sp. The parasites *Capillaria* sp. and *Diphyllobothrium latum* were very common in the course of this research work. *Ambiphrya* spp.

and *Protoopalina symphysodonis* only occurred in very small percentages (Table 7) when compared to the whole. *Camallanus* sp. nematode a serious negative health effect on fish but only in the case of high infestation, [29].

4. CONCLUSION

Fish parasites cause commercial losses in both the fisheries and aquaculture industries. Different parasite species affect fisheries by decreasing the yield, reducing the quality of fish or rendering them aesthetically unacceptable. Hence, affecting human health and socio-economic implication.

Inferences from this study revealed endoparasites and ectoparasite fauna identified in wild *Clarias gariepinus* consisted of pathogenic and non-pathogenic organisms. These organisms are in their own individual of more or less economic and health importance for the fish, other organisms and humans. However, parasite occurrence should not be neglected because its increasing population in the fish environment will be problematic and create public health menace.

Therefore, control of parasites should be looked upon as a major aspect of management in fish production. Proper processing and culinary methods should also be put in place to reduce transmission of parasites within the aquatic environment and for public health purposes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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