Morphometric indices and Parasitic incidence of *Synodontis nigrita* from Lower River Benue, Makurdi, Nigeria

Abstract

The study was carried out to determine the morphometric indices and parasitic incidence of 160 fresh samples of *Synodontis nigrita* comprising of 80 samples each of female and male sexes. Fish samples were obtained from the catches of local fishermen along Lower River Benue at Wadata fish landing site of Benue State. Length–weight relationship was analyzed using the equation $W=aL^b$. The condition factor of the fish samples was determined using the equation, $K=100W/L^3$. Samples of *Synodontis nigrita* were later subjected to parasitological examination using standard parasitological method. The mean total length, body weight, condition factor, regression and correlation coefficients were higher for un-infested female samples of *Synodontis nigrita* than the infested female. Similarly, the mean total length body weight, condition factor, regression and correlation coefficients of un-infested male samples of *Synodontis nigrita* were higher than the infested males. A total of three hundred and fifty seven (357) parasites were recovered from 76(47.50%) infested samples. Out of the 357 parasites, 251 were recovered from 49(61.3%) infested female samples, 106 parasites were recovered from 27(33.8%) infested male samples. Among the infested parts of the female samples, the intestine accounted for the highest number/percentage (116/46.4%) parasite load, the least 2(0.8%) was recorded for the skin. Between the external parts (gill and skin) of the female fish samples~~, while~~ the gill recorded the higher number of parasite load 28(12.8%), skin recorded 2(0.8%). Similarly, among the infested parts of the male samples, the intestine accounted for the highest number/percentage (65/61.3%) parasite load, the least 9(8.5%) was recorded for the gill. Between the external parts (gill and skin), the gill recorded 9(8.5%) number/percentage parasite load, no parasite was recovered from the skin. Prevalence (61.25), number of parasites (251) and intensity (5.10) of parasite infection were higher for female samples compared to the male with the prevalence, and intensity of parasite infection of 33.80, 106 and 3.90, respectively. However, the chi square value showed that there was no significant difference ($p>0.05$) in the prevalence, number of parasites and intensity of parasite infection between the sexes of *Synodontis nigrita*. Variation in the prevalence and intensity of parasite infection of female and male *Synodontis nigrita* based on size groups existed. However, it was generally observed that longer and heavier sized fish of both sexes were more infested with higher number of parasites than the smaller sized samples of both sexes.

Keywords: Morphometric indices, parasitic incidence, *Synodontis nigrita,* Lower River Benue, Sex diversity

1. Introduction

The scientific basis for morphometric in fishes and the mathematical way that weight relates to length was set by Fulton, in 1906; who for the first time introduced fisheries science into "allometry" (Froese 2006). "The most commonly used relationships are those relating weight to body length (in the majority of cases, total body length-TL) and different types of lengths (i.e., standard-SL and fork-FL-lengths) to TL" (Froese 2011). "In Fisheries science, the condition factor is used in order to compare the "condition", "fatness", or well-being of fish. It is based on the hypothesis that heavier fishes of a particular length are in a better physiological condition" (Bagnenal 1978). "It provides information on the well-being of a fish and is usually influenced by the fish, sex, season, maturity stage, etc." (Anyawu *et al*. 2007). "A high condition factor reflects good environmental quality; while a low condition factor reflects poor environmental quality" (Fawole and Adewole 2004).

"The fish from Family Mochokidae is represented mainly by Genus *Synodontis*, commonly known as catfish which accounts for an important part of the commercial catches in Northern Nigeria" (Shinkafi *et al.* 2010). The state of knowledge on the various *Synodontis* species in Nigeria is largely on their gross anatomy and some behavioral characteristics. The available scientific investigations on their biology are still inadequate for their propagation and management.

"In developing and developed countries of the world, both the poor and rich feed on fish protein on daily basis" (Olagbemide and Akharaiyi, 2019). "In many regions where carbohydrate based foods is the food of choice for many due to poverty, fish is the common source of protein as they are readily available, affordable in markets and trapped in many surrounding streams and rivers" (Olagbemide, and Akharaiyi 2019).

Due to increase aquaculture practices recently, attention has been shifted to fish parasites in order to carter for increasing demand of fish as source of animal protein. Fish consumption is however not devoid of risks in any way owing to the tendency of them harboring infectious or pathogenic parasites especially if such organisms are of zoonotic concern (Bichi and Yelwa 2010). Apart from poor handling of fish and other stress which are some of the major factors contributing to the emergence of bacteria and parasitic infections in fish, rearing of fish under potentially stressful conditions of compromised water quality coupled with increased nutrient levels in the culture media also promote the proliferation of parasites in fish which may compromise the fitness of such fish for human consumption (Danba *et al.* 2015).

"In aquaculture, some parasites may be highly pathogenic and contribute to high fish mortalities and economic loss, while in natural systems they may threaten the abundance and diversity of indigenous fish species" (Mashego 2001). "Parasites of fish are of concern since they often deteriorates the host immune system thereby resulting to secondary infections, energy loss, nutritional reduction as well as reproduction, inhibiting growth leading to morbidity as well as mortality with consequent economic losses" (Onyedineke *et al.* 2010; According to Khalil 1997). In natural environments, parasites of fish may be of minimal significance but in a situation where fish are crowded and stressed due to poor compromising physicochemical parameters of the water, they can cause substantial problems (Sogbesan *et al.,* (2018).

Several studies have been carried out on the diet compositions of different fish species (Omoike 2021, Haque *et al.* 2020, Khaing and Khaing 2018, Imaobong *et al.* 2014). Also, previous studies have been conducted to explore the different parasites infecting various fish species (Omeji *et al.* 2022, Afolabi *et al.* 2020, Olajide *et al.* 2020, Bibi *et al.* 2018, Absalom *et al.* 2018). The prevalence of ecto and endo parasites in some fresh water fishes from Jabi Lake, Abuja, Federal Capital Territory has also been reported by Solomon *et al.*, (2021). Parasitic infections of the gills of wild African sharptooth catfish (*Clarias gariepinus*) has also been addressed by Mahmoud *et al.,* (2018). This study was carried out to evaluate the morphometric indices and parasitic incidence of *Synodontis nigrita* and determine the effect of infestation on the morphometric indices/values of the fish.

2. Materials and Methods

2.1 Sample collection, identification and sex determination

One hundred and sixty fresh samples of *S. nigrita* comprising of eighty samples each of female and male sexes were obtained from catches of local fishermen along Lower River Benue at Wadata fish landing site, Benue State, Makurdi. The fish samples were collected monthly in batches of 20 for a period of four months and transported to the Department of Fisheries and Aquaculture, Joseph Sarwuan Tarka University, Makurdi, where they were properly identified using their distinctive morphological features.

Sexing of the fish samples was done by physical observation of the papillae with two openings on the female papillae and an opening on the male papilla (Adesulu and Sydenham 2007). The sexes were further confirmed after dissection with the presence of ovaries in female and testes in male.

2.2 Morphometric Studies of the fish samples

2.2.1 Measurement of the fish samples

The standard length of the fish samples was measured with a meter rule while the weight was measured using top loading sensitive weighing balance (Golden Mettler, Model: GW: 1.3kg, NW; 1kg- US).

2.2.2 Determination of Length – weight relationship (LWR) of the fish samples

The Length – weight relationship (LWR) of the fish samples was estimated by using the equation: $W = aL^b$.

Where W = Total weight (g), L = Total length (cm), a = intercept and b = regression coefficient.

2.3 Examination of fish samples for ecto and endo parasites

The freshly caught samples of *S. nigrita* were examined for parasites using procedures described by Arthur and Albert (1994) as follows:

2.3.1 Examination and identification of ectoparasites

The external surfaces (gills and skins) were gently brushed into a plastic Petri dish containing the normal saline solution (0.90% w/v of NaCl) and examined with a hand lens for the presence of ectoparasites. Scrapings from the skin, fins and gills of each fish were smeared on glass slides follow by addition of few drops of 0.9% saline solutions and examined under 10x magnification of a light binocular microscope for the presence of external parasites. Fish gills were later dissected out and each gill filament and arch was examined with a hand lens for the presence of parasites. Identification guidelines based on morphological features of parasites were used for the identification of parasites in this study (Paperna, 1996, Florio *et al.* 2009).

2.3.2 Examination and identification of endoparasites

The buccal cavity of each of the fish samples was washed with little amount of distilled water and brushed into a labeled test tube using a fine brush. The body cavity was thereafter opened ventrally with the aid of scissors. The mesentery and connective tissues, connecting loops of the gut and the liver were cut and the organs separated. The gut was then placed in a large Petri dish, stretched out and cut into two regions (stomach and intestine). Each section was then placed in a separate labeled dish. The separated gastro-intestinal tract sections were opened longitudinally to labeled test tubes. Each labeled test tube containing the residue from the stomach and intestine was then examined. A drop of the residue was placed on the slide, and observed under various magnifications of the light microscope for the parasites, this was repeated until the entire residue was examined.

The recognition of the parasites found was enhanced by their wriggling movement on emergence. Recovered parasites were counted, recorded and labeled with the serial number of the fish and placed in physiological saline water overnight to allow them stretch and relax; they were then fixed and stained for identification to species level. Infested fish samples were given separate serial numbers to differentiate them from those without parasites. Parasites recovered were identified using identification guidelines based on morphological features of parasites and parasites identification keys by (Paperna, 1996, Florio *et al.*, 2009).

2.3.3 Processing of recovered parasites

Recovered parasites belonging to cestode and nematode were stained using the procedure of (Khalil 1991) and fixed using Formalin acetic acid (FAA). The cestode parasites were stained using Acetocarmine; Nematodes were stained using Horen's trichome stain; while Acanthocephalans were stored in weak Erlich's haematoxylin solution overnight and dehydrated, cleared in methyl-salicylate and mounted on a slide in Canada balsam.

2.4 Parasitic indices/Statistical analysis

Parasitic indices (prevalence (%) rate, 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;

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

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

$$\text{Mean parasite intensity of the host sex} = \frac{\text{Sum of parasites of the sexes}}{\text{Sum of the infected samples of the sexes}}$$

Significant differences of parasitic infestation were tested using a non parametric (Npar.) statistical method, (Kolmogorov-Smirnov K-S test) at 95 % level of confidence using SPSS version 15.0 for Windows since infection and infestation of host by parasites were not normally distributed. Significant difference between the means of body weight; total length of infested fish samples were carried out using the student t- test (2-tailed) at 95 % level of confidence.

All statistical analyses were done using SPSS version 21.0 for Windows. Test for significance between the means of the condition factor (K) values of sexes was done using dependent Student t test at 95% level of confidence.

3. Results

3.1 Means of Morphometric parameters of *S. nigrita* from Lower River Benue

The means of means of morphometric parameters of infested and un-infested *S. nigrita* from Lower River Benue are presented in Table 1. The mean total length (28.53±5.53 cm), body weight (162.63±3.3.79 g), condition factor, K (0.62±0.07), regression coefficient, b (3.68) and correlation coefficient, R^2 (0.86) were higher for un-infested female samples of *S. nigrita* than the infested females with mean total length of 26.40±3.17, 123.56±3.47 body weight, 0.53±0.04 condition factor, 2.78 regression coefficient (b) and 0.18 correlation coefficient ($R^{2)}$. Similarly, the mean total length (26.61±3.11cm) body weight (140.96±3.34), condition factor, K (0.65±0.04), regression coefficient, b (3.90) and correlation coefficient, R^2 (0.75) were higher for un-infested samples of male *S. nigrita* than the infested male with mean total length of 25.82±3.02, 113.23±3.19 body weight, 0.56±0.04 condition factor, 2.90 regression coefficient (b) and 0.69 correlation coefficient (R^2).

Table 1. Means of Morphometric parameters of *S. nigrita* from Lower River Benue

Fish status	Morphometric parameters and length-weight regression values				
	Total length (cm)	Weight (g)	Condition factor (K)	b	R^2
Female					

Infested	26.40±3.17	123.56±3.47	0.53±0.04	2.78	0.18
Uninfested	28.53±5.52	162.63±3.79	0.62±0.07	3.68	0.86
Male					
Infested	25.82±3.02	113.23±3.19	0.56±0.04	2.90	0.75
Uninfested	26.61±3.11	140.96±3.34	0.65±0.04	3.96	0.69

3.2 Parasite species incidence based on the site of infestation in female and male *S. nigrita* from Lower River Benue.

The compositions of parasite species incidence based on the site of infestation in female and male *S. nigrita* from Lower River Benue are presented in Tables 2 and 3, respectively.

From Table 2, a total of two hundred and fifty one (251) parasites belonging to ten (10) parasite species were recovered from 49(61.3%) infested female fish samples. Out of the 251 parasites, while the intestine accounted for the highest number/percentage (116/46.4%) parasite load, the least 2(0.8%) was recorded for the skin. Between the external parts (gill and skin) of the female fish samples, while the gill recorded the higher number of parasite load 28(12.8%), skin recorded 2(0.8%). Also, between the internal parts (intestine and stomach) of the female fish samples, while the intestine recorded the higher number/percentage (116/46.4%) parasite loads, stomach recorded 105(42.0%).

From Table 3, a total of one hundred and six (106) parasites belonging to nine (9) parasite species were recovered from 27(33.8%) infested male fish samples. Out of the 106 parasites, while the intestine accounted for the highest number/percentage (65/61.3%) parasite load, the least 9(8.5%) was recorded for the gill. Between the external parts (gill and skin) of the male fish samples, while the gill recorded 9(8.5%) number/percentage parasite load, no parasite was recovered from the skin, implying that the skin of the male samples were not infested with any parasite species. Additionally, between the internal parts (intestine and stomach) of the male samples, while the intestine recorded the higher number/percentage (65/61.3%) parasite loads, stomach recorded 32(30.2%).

Table 2. Parasite species incidence based on the site of infestation in female *S. nigrita* from Lower River Benue. Tnfe = 80

Parasite species	Pt	Ni	Pi	Number and percentage parasite of infested body parts								Tnpr (%)	Tnp(%)pt
				Gill	%	Skin	%	Intestine	%	Stomach	%		
Microsporidia sp.	Pr	6	7.5	14	5.6	0	0	18	7.2	7	2.8	35(13.9)	61(24.3)
Crtyptobia iunilans		4	5.0	3	1.2	0	0	7	2.8	16	6.4	26(10.4)	
Procamallanus laevionchus	Ne	2	2.5	0	0	0	0	5	2.0	2	0.8	7(2.8)	110(43.8)
Eustrongylids tubifex		10	12.5	0	0	0	0	21	8.4	26	10.4	47(18.7)	
Capillaria sp.		8	10.0	0	0	0	0	25	10.0	16	6.4	41(16.3)	
Contracaecum sp.		4	5.0	0	0	0	0	6	2.4	9	3.6	15(6.0)	
Clinostomum sp.	Tr	3	3.8	6	2.4	2	0.8	3	1.2	0	0.0	11(4.4)	11(4.4)
Polyonchobothrium sp.	Ce	5	6.3	0	0	0	0	23	9.2	8	3.2	31(12.4)	31(12.4)
Ergasilus lizae	Cp	2	2.5.0	9	3.6	0	0	0	0	0	0.0	9(3.6)	9(3.6)
Neoechinorhynchus rutili	Ac	5	6.3	0	0	0	0	8	3.2	21	8.4	29(11.6)	29(11.6)
Total		**49**	**61.3**	**28**	**12.8**	**2**	**0.80**	**116**	**46.4**	**105**	**42.0**	**251(100.0)**	**251(100.0)**

Note : what is Pt, Ni, Pi, Pr Ne, Tr. Ce. Cp. Ac?

Table 3. Parasite species incidence based on the site of infestation in male *S. nigrita* from Lower River Benue. Nfe = 80

Parasite species	Pt	Ni	Pi	Number and percentage parasite of infested body parts								Tnpr (%)	Tnppt
				Gill	%	Skin	%	Intestine	%	Stomach	%		
Microsporidia sp	Pr	4	5.0	0	0	0	0	13	12.3	6	5.7	19(17.9)	25(25.6)
Crtyptobia iunilans		1	1.3	1	0.9	0	0	2	1.9	3	2.8	6(5.7)	
Procamallanus laevionchus	Ne	2	2.5	0	0	0	0	7	6.6	0	0	7(6.6)	41(38.7)
Eustrongylids tubifex		5	6.3	0	0	0	0	8	7.5	13	12.3	21(19.8)	
Capillaria sp		3	3.8	0	0	0	0	9	8.5	4	3.8	13(12.3)	
Clinostomum sp	Tr	2	2.5	0	0	0	0	9	8.5	1	0.9	10(9.4)	10(9.4)
Polyonchobothrium sp	Ce	4	5.0	0	0	0	0	17	16.0	0	0	17(16.0)	17(16.0)
Ergasilus lizae	Cp	3	3.8	8	7.5	0	0	0	0	0	0	8(7.5)	8(7.5)
Neoechinorhynchus rutili	Ac	3	3.8	0	0	0	0	0	0	5	4.7	5(4.7)	5(4.7)
Total		**27**	**33.8**	**9**	**8.5**	**0**	**0**	**65**	**61.3**	**32**	**30.2**	**106(100.0)**	**100(100.0)**

Pt = Parasitic taxa, Pr = Protozoa, Ne = Nematode, Tr = Trematode, Ce = Cestode, Cp = Copepod, Ac = Acanthocephala, Tnfe = Total number of fish examined, Ni = Number of infested fish, Pi = Prevalence of infested fish, No. = Number, % = percentage, Tnpr = Total number of parasite recovered, Tnp(%)pt = Total number/percentage of parasite per tata.

3.3 Prevalence and intensity of parasite infection of *S. nigrita* based on sex from Lower River Benue

The prevalence and intensity of parasite infection of female and male *S. nigrita* from Lower River Benue are presented in Table 4. Out of the 80 samples of female *S. nigrita,* 49(61.25%) were infested with 251 parasites while 31(38.75%) were free from parasitic infestation. However, out of the 80 samples of male *S. nigrita*, while 27(33.75%) were infested with 106 parasites, 53(66.25%) were not infested with any parasite.

Prevalence (61.25) and intensity (5.10) of parasite infection were higher for female samples compared to the male with the prevalence and intensity of parasite infection of 33.80 and 3.90, respectively. Also, female samples of *S. nigrita* had higher number of parasite (251) than the male samples. However, the chi square value shows that there was no significant difference ($p>0.05$) between the prevalence and intensity of parasite infection the sexes.

Table 4. Prevalence and intensity of parasite infection of female and male *S. nigrita* from Lower River Benue

Host sex	Ne	Ni	Tpr	Prv (%) inf	Ip
Female	80	49	251	61.25	5.10
Male	80	27	106	33.80	3.90
Total	**160**	**76**	**357**	**47.50**	**4.70**

Ne = Number of examined fish, Ni = Number of infested fish, % = Percentage, Tpr = Total parasite recovered, Prv (%) inf = Prevalence of infection, Ip = Intensity of parasite, Mpi = Mean parasite intensity.

3.4 Prevalence and intensity of parasite infection of *S. nigrita* based on total length and body weight

The prevalence and intensity of parasite infection of female and male *S. nigrita* based on total length are presented in Table 5a while Table 5b presents the prevalence and intensity of parasite infection of female and male *S. nigrita* based on body weight.

From Table 5a, in the female samples of *S. nigrita,* the highest prevalence (26.25%) and total number of parasite (111) were recorded for total length group of 25.1-29.0cm while the least prevalence (16.25%) and total number of parasite (91) were recorded for total length group of 29.1-34cm. Additionally, while intensity of parasite was highest (7.0) for total length group of 29.0-34cm, the least (3.27) was recorded for total length group of 19.0-25.0cm. Similarly, in the male samples of *S. nigrita*, the highest prevalence (15.00%%) and total number of parasite (46) were recorded for total length group of 29.1-34.0cm while the least prevalence (7.50%) and total number of parasite (26) were recorded for total length group of 19.0-25.0cm; while intensity of parasite was highest (4.33) for total length group of 19.0-25.0cm, the least (3.67) was recorded for total length group of 25.1-29.0cm

From Table 5b, in the female samples of *S. nigrita*, the highest prevalence (30.00%) and total number of parasite (113) were recorded for the body weight group of 100.1-125.0g while the least prevalence (13.75%) and total number of parasite (46) were recorded for the body weight group of 50.0-75.0g. Additionally, while intensity of parasite was highest (6.57) for the body weight group of 75.1-100.0g, the least (4.18) was recorded for the body weight group of 50.0-75.0g. Also, in the male samples of *S. nigrita,* the highest prevalence (15.00%) and total number of parasite (47) were recorded for the weight group of 100.1-125.0g while the least prevalence (8.75%) and total number of parasite (28) were recorded for the weight group of 75.1-100.0. Intensity of parasite was highest (4.00) for the weight group of 75.1-100.0 but lowest (3.89) for the weight group of 50.0-75.0g.

It was generally observed that longer and heavier sized fish of both sexes were more infested with higher number of parasites than the smaller sized samples of both sexes.

Table 5a. Prevalence and intensity of parasite infection of *S. nigrita* based on total length

	Host sex									
	Female					**Male**				
Total length groups (cm)	Ne	Ni	Prv (%)	Tpr	Ip	Ne	Ni	Prv (%)	Tpr	Ip
19.0-25.0	21	15	18.75	49	3.27	30	6	7.5	26	4.33
25.1-29.0	25	21	26.25	111	5.29	27	9	11.3	46	3.67
29.1-34.0	15	13	16.25	91	7.00	23	12	15.0	33	3.83
Total	**80**	**49**	**61.25**	**251**	**5.12**	**80**	**27**	**33.8**	**106**	**3.93**

Table 5b. Prevalence and intensity of parasite infection of *S. nigrita* based on body weight

	Host sex									
	Female					**Male**				
Weight groups (g)	Ne	Ni	Prv (%)	Tpr	Ip	Ne	Ni	Prv (%)	Tpr	Ip
50.0-75.0	26	11	13.75	46	4.18	22	8	10.00	28	3.50
75.1-100.0	24	14	17.50	92	6.57	27	7	8.75	31	4.43
100.1-125.0	30	24	30.00	113	4.70	31	12	15.00	47	3.92
Total	**80**	**49**	**61.25**	**251**	**5.12**	**80**	**27**	**33.8**	**106**	**3.93**

cm = centimeter, Ne = Number of examined fish, Ni = Number of infested fish, Prv (%) = Prevalence of infection, Tpr = Total parasite recovered, Ip = Intensity of parasite, g = gram.

4. Discussion and conclusion

4.1 Morphometric Indices of *S. nigrita*

This current study has demonstrated the variations in the condition factor, growth pattern, length-weight relationship and parasitic composition of both sexes (female and male) of *Synodontis nigrita* from Lower River Benue, Makurdi. The slopes (b) of the fish length weight regression lines from the Lower River Benue were (2.78 and 3.68) for infested and uninfested female; (2.90 and 3.96) for infested and uninfested male, respectively with uninfested female and male samples having higher slopes (*b*) than the infested female and male samples of *Synodontis nigrita*.

The lower "b" values recorded for the infested fishes of both sexes compared to the unifested fish samples of both sexes in this study could be attributed to the effect of parasitic infestation on the growth in weight of the samples. This agrees with the reported work of Ajala and Fawole (2019). However, the combined regression coefficient (b) recorded for female and male samples were greater than 3 when the b values of the infested and uninfested were not segregated. The regression coefficient (b) values recorded for the combined infested and uninfested sexes of the fish samples in this work is lower compared to the regression coefficient value (7.74) recorded by Davies *et al.*, (2013) but higher than the regression coefficient value (2.49) recorded by Roberts and Janovy (2000). Nonetheless, the regression coefficient values recorded for the combined infested and uninfested sexes of the fish samples in this work is in agreement with the reported work of Ajala and Fawole (2019). Differences in the regression coefficient (b) value could be attributed to the combination of one or more factors such as number of specimens, gonad maturity, sex, health status of the fish, habitat, seasonal effect, water temperature, trophic level and food availability in the community. This assertion is in agreement with the reported work of Ahmed *et al.*, (2017) who reported differences in b values of five freshwater fish species in Roseires Reservoir, Sudan.

The correlation coefficient (R^2) recorded for the combined infested and uninfested female in this study was lower than the correlation coefficient (R^2) recorded for the male implying that the values for the female were not in good fit to the line of regression compared to the female samples. Differences in the correlation coefficient (R^2) recorded in this study could be attributed to the differential feeding habit, inadequate availability of food or food scarcity and parasitic infestation of the fish samples. Similar observation had been made by Ajala and Fawole (2019).

Variation in the mean condition factor (K) existed between the infested and uninfested samples of *Synodontis nigrita* and between the sexes. The condition factor of the male samples of *Synodontis nigrita* was higher than the female. However, there was no significant difference ($p>0.05$) between the mean condition factor (K) of the infested and uninfested samples of *Synodontis nigrita* and between the sexes. The higher mean condition factor (K) recorded for the male samples compared to the female could be attributed to the use of metabolic energy by the females for the purpose of body building in spawning activities. This finding is in line with the reported works of Ajala and Fawole (2019), Fawole and Adewoye (2004).

4.2 Incidence of parasites in *S. nigrita*

This study investigated 160 samples comprising of 80 each of female and male of *S. nigrita* for parasitic infection. Out of the 160 samples, 76(47.5%) were infested with 357 parasites while 84(52.0%) were not infested with any parasite. Out of the 80 samples of female *S. nigrita*, 49(61.3% were infected with 251 parasites being recovered while in male samples, 106 parasites were recovered from 27(33.8%) infested fish.

The overall high prevalence (47.5%) recorded for the infested fish in this study could be attributed to many factors such as feeding habit of fish, pollution of water bodies, and availability of intermediate hosts (copepods, insects, molluscs, to mention but a few) which harbor the infective larval stage of some of these parasites making them available to fish in the water (Afolabi *et al.* 2020, Kawe *et al.* 2016). Also, Hoffman (1998) stated that wild populations of animals have greater parasite species diversity due to larger home ranges compared to domesticated ones. 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) and 61.00 and 62% recorded for *O. niloticus* from River Nile and drainage branch, respectively in Egypt (Sami *et al* 2020). Variations in the prevalence of infection between this study and other studies may be due to the differences in environmental fluctuation, availability of parasitic intermediate hosts and the life history patterns of parasites (Marcogliese 2005).

The parasites recovered from the different body parts of *S. nigrita* used for this study have been previously recorded by other researchers from same species or other freshwater fish species elsewhere (Omeji *et al.* 2022; Afolabi *et al.* 2020; Imam and Dewu 2010; Keremah and Inko-Tariah 2013; Eyo *et al.* 2013; Uruku and Adikwu 2017).

In terms of the number of parasite recovered from female *S. nigrita* by taxa, while nematode species were the most abundant with *Eustrongylids tubifex* being the highest species encountered, the least was copepod (*Ergasilus lizae*). Also, among the number of parasite recovered from male samples while nematode species were the most abundant with *Eustrongylids tubifex* being the highest species the least was *Neoechinorhynchus rutili.*

Recovery of Acanthocephalan (*Neoechinorhynchus rutili*) though in small number in this study may be majorly due to the presence of suitable intermediate host required for transmission. This finding disagrees with the work of Afolabi *et al.,* (2020) who reported the absence of Acanthocephalan in their study adding that the absence of Acanthocephalan in their work could be due to the absence of suitable intermediate host required for transmission

In addition, *S. nigrita* are bottom dwellers, which feed on almost everything that is available and close to them such as detritus, water invertebrates like arthropods, molluscs, and mud, and among these invertebrates, there may be intermediate hosts of various parasites which may develop into adults in the gut of fish after consumption. The recovery of these species of parasites in this study could also have serious physiological consequences as they interfere with the absorption of food nutrients in the fish intestines. Similar observation was made by Biu *et al.,* (2014); Iboh and Ajang (2016). The authors added that such interference could reduce the food intake of fishes.

The prevalence of parasites in relation to sexes of *S. nigrita* as reported by this study was not significant. This finding was a deviation from the studies of other authors for same or other fish species elsewhere. For example, a higher prevalence of parasites in female *C. gariepinus* compared to male has been reported by Omeji *et al.* (2013) and Ogonna *et al.* (2017). Both authors recorded higher parasitic infections in female compared to male. Similar reports of Ayanda 2009 and Emere 2000 at different locations reported higher parasitic infections in female species than the males. In addition, Emere and Egbe (2006) also reported higher infection in females than males and opined that it could be due to the physiological state of the females as most gravid females could have reduced resistance to infection by parasites; this is because the immune system of the females is highly compromised during pregnancy. Omeji *et al.* (2013)

noted that female fish need increased food intake to meet their food requirements for the development of eggs and that this may have exposed them to more contact with the parasites, which subsequently increased their chance of being infected. Contrastingly, the report of Oniye *et al.* (2004) recorded a higher prevalence of infection in male (15.0%) than the female catfishes (4.17%) and Tachia *et al.* (2010) who also recorded higher infection in males (65.12%) than the females (34.89%). Generally, feeding in catfishes is attributed to their quest for survival and differential feeding either by quantity or quality of food and not by sexes (Ogonna *et al.* 2017).

The highest number of parasites recorded in the intestine of the infected samples compared to the rest of the body parts (gill, skin and stomach) in this work agrees with the findings 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), Afolabi *et al.,* (2020), Absalom *et al.* (2018) and Akinsanya *et al.* (2016). 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 probably lacked digestive systems which must have compelled them to depend on the digested food which they absorbed through thin body tegument in the intestine of their host for survival. These parasites might have found an acid medium as presented by the stomach not conducive, hence their preference for making the intestine their place of habitation.

The high prevalence is further supported by the findings from other studies that reported high prevalence in the wild population of *Clarias gariepinus"* (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".

In relation to the body size (total length) and weight of both sexes of *S. nigrita* from Lower River Benue, differences in the prevalence of parasite infection existed. It was generally observed that the percentage infection increased with increasing size; being higher in the longer and heavier sized fish samples than the smaller sized counterpart. The differences in the prevalence of parasite infection could be attributed to the quest for survival of the longer and heavier sized fishes which might have probably exposed them to infection by parasites. Similar observations were reported by Ayanda (2009), Omeji *et al.* (2010) and Abba *et al.* (2018). The authors, reported that the longer and heavier the fish is, the greater the susceptibility to parasitic infection. According to Abdel-Gaber *et al.,* (2015), the higher prevalence of parasite infection associated with the longer and heavier fishes could be due to the fact that the longer and heavier fishes cover wider areas in search of food than the smaller ones and as a result, they take in more food than the smaller ones and this could expose them more to infestation by parasites. Also change in dietary preference from phytoplankton and zooplankton to insects, larvae, snails, worms and crustaceans for food may predetermine trophic acquisition and infection levels of helminth parasites among fishes (Alyssa *et al.* 2016).

References

Abba, M.A., Emere, M.C. and Appah, J. (2018). Comparative Study on Helminth Parasites of *Oreochromis niloticus* and *Clarias gariepinus* in Ajiwa Earth Dam Katsina State, Nigeria**.** *World Journal of Fish and Marine Sciences 10 (1): 05-11*

Abdel-Gaber, R., M. El-Garhy and K. Morsy, 2015. Prevalence and Intensity of Helminth Parasites of African Catfish Clariasgariepinus in Lake Manzala, Egypt. Advances in Bioscience and Biotechnology, 6: 464-469.

Absalom, K.V., Makpo, J.K. and Mustapha, A.J. (2018). prevalence of gastrointestinal helminth parasites of *Clarias gariepinus* at River Gudi, Akwanga Local Government Area of Nasarawa State, Nigeria. *International Journal of Fisheries and Aquaculture Research* 4(1):9-15.

Adegoroye, F., Omobhude, M. and Morenikeji, O. (2019). Helminth parasites of *Synodontis clarias*(Linnaeus, 1758), *Chrysichthys nigrodigitatus* (Lacepede 1802) and *Chrysichthys auratus* (Geoffrey Saint – Hilaire, 1808) in Asejire Dam, South – West Nigeria. *Int J Aquat Sci*. 10(1):37-47.

Adesulu, E.A and Sydenham, D.H.J. (2007). The Freshwater Fishes and Fisheries of Nigeria. Macmillan Nigeria Publishers Ltd., Nigeria, 397 p.

Afolabi, O.J., Olususi, F.C. and Odeyemi, O.O. (2020). Comparative study of African catfish parasites from cultured and natural habitats. Bulletin of the National Research Centre (2020) 44:163

Ahmed, E.O., Ali, M.E., Aziz, A.A. and Rafi, E.M.K. (2017). Length-Weight Relationships and condition factors of five Freshwater fish species in Roseires Reservoir, Sudan. *European Journal of Physical and Agricultural Sciences.* Vol. 5 No. 2, 2017.

Ajala, O. O. and Fawole, O. O. (2014). Multiple Infections of Helminths in the Stomach and Intestine of *Clarias gariepinus* (Burchell,1822) In Oba Reservoir, Oyo State, Nigeria. *Journal of Pharmacy and Biological Sciences*, **9**(3):05-12.

Ajala, O.O. and Fawole, O.O. (2012). A study of helminth species assemblages at different host scales *Clarias gariepinus* (Burchell, 1822) as a bio-indicator of aquatic water quality. *World Acad Sci Eng Technol* (WASET), Singapore, September, 2012. conference Proc. 2012; 66:741-50.

Ajala, O.O. and Fawole, O.O. (2019). Morphometric Indices and Enteroparasitic Infestation of *Clarias gariepinus* (Burchell, 1822) in a Tropical Reservoir. *Agricultural Sciences*, 10, 1286-1297. https://doi.org/10.4236/as.2019.1010095.

Akinsanya, B., Kuton and M.P. (2016). Bioaccumulation of heavy metals and parasitic fauna in *Synodontis clarias* (Linnaeus, 1758) and *Chrysichthys nigrodigitatus*(Lacepede, 1803) from Lekki Lagoon, Lagos, Nigeria. *Asian Pac J Trop Dis*. 6(8):615-21.

Alyssa, R.C., B.S. Daniel, P. Robert and L. Clément, 2016. Are Parasite Richness and Abundance Linked To Prey Species Richness And Individual Feeding Preferences In Fish Hosts? Parasitology, 143: 75-86.

Anyanwu, P.E., Okoro, B.C., Anyanwu, A.O., Matanmi, M.A., Ebonwu, B.I., Ayaobu-Cookey, I.K., Hamzat, M.B., Ihimekpen, F. and Afolabi, S.E. (2007) LengthWeight Relationship, Condition Factor and Sex Ratio of African Mudcatfish (*Clarias gariepinus*) Reared in Indoor Water Recirculation System Tanks. *Research Journal of Biological Sciences*, 2, 780-783.

Arthur, J.R. and Albert, E. (1994). A survey of the parasites of Greenland halibut *Reinhardtius hippoglossiodes* caught off Atlantic Canada, with notes on their zoogeography in this fish. *Can. J. Zool*. 72: 765-778

Ayanda, I.O., 2009. Comparison of parasitic helminthes infection between sexes of Clarias gariepinus from Asa dam Ilorin, northcentral Nigeria. Scientific Research and Essay, 4(4): 357-360.

Ayanda, O.I. (2009) Comparison of Parasitic Helminthes Infection between the Sexes of *Clarias gariepinus* from Asa Dam Ilorin, North-Central, Nigeria. Scientific. Research and Essay, 4, 357-360

Bagenal, T. (1978) Method for Assessment of Fish Production in Fresh Waters. Third Edition, IBP Handbook No 3, Blackwell Scientific Publication, Oxford, 365 p.

Bagenal, T.B. and Tesch, F.W. (1978) Age and Growth of Fish in Methods for Assessment of Fish Production in Freshwaters. Blackwell Scientific Publication. Oxford, London, 365 p.

Bibi, F., Qaisrani, S.N., Ayaz, M., Nazir., M, Ahmad, A.N. and Muhammad, A.M. (2018). Occurrence of endoparasites in some selected fishes of Chenab River, Pakistan. *Bangladesh J Zool.* 46(1):53-61.

Bichi, A.H. and Yelwa, S.I. (2010). Incidence of piscine parasites on the gills and gastrointestinal tract of *Clarias gariepinus* (Teugels) at Bagauda Fish Farm, Kano. *Bayero Journal of Pure and Applied Sciences*, 3(1): 104 – 107

Biu, A.A., M.Y. Diyaware, W. Yakaka and E. Joseph, 2014.Survey of Parasites Infesting the Nile Tilapia (*Oreochromis niloticus* Linnaeus, 1758) from Lake Alau, Maiduguri, Nigeria. Nigerian Journal of Fisheries and Aquaculture, 2(2): 6-12.

Danba, E.P., David, D.L., Wahedi, J.A., Buba, U., Bingari, M.S., Umaru, F.F., Ahmed, M.K., Tukur, K.U., Barau, B.W., Dauda, U.D., Thomas T, L. (2015). Microbiological analysis of selected catfish ponds in Kano metropolis, Nigeria. *J Agricult Vet Sci* 8(8):74–78.

Davies, O.A., Tawari, C.C. and Keme-Iderikumo, K. (2013) Length-Weight Relationship, Condition Factor and Sex Ratio of *Clarias gariepinus* Juveniles Reared in Concrete Tanks. *International Journal of Scientific Research in Environmental Sciences*, 1, 324-329. https://doi.org/10.12983/ijsres-2013-p324-329

Ekanem A.P., Eyo V.O. and Sampson A.F. (2011) Parasites of landed fish from Great Kwa River, Calabar, Cross River State, Nigeria. *International Journal of Fisheries and Aquaculture*, 3: 225–230.

Emere, M.C. (2000) Parasitic Infection of the Nile Perch Lates niloticus (L) in River Kaduna. *Journal of Aquatic Sciences*, 15, 51-54. https://doi.org/10.4314/jas.v15i1.19988.

Emere, M.C. and Egbe, N.E.L. (2006) Protozoan Parasites of Synodontis clarias (A Fresh Water Fish) in River Kaduna. *The Best Journal*, 3, 58-64.

Eyo, J. E. Iyaji, F. O. and Obiekezie, A. I. (2013) Parasitic infestation of Synodontis batensoda (Rüppell, 1832, Siluriformes, Mockokidae) at Rivers Niger-Benue Confluence, Nigeria. *Afr. J. Biotechnol*. Vol. 12(20), pp. 3029-3039

Fawole, O.O. and Adewoye, S.O. (2004) Aspect of the Biology of Clarias gariepinus (BURCHELL, 1822) in Oba Reservoir, Ogbomoso, Nigeria. *Science Focus*, 8, 96-100.

Fawole, O.O. and Adewoye, S.O. (2004) Aspect of the Biology of *Clarias gariepinus* (BURCHELL, 1822) in Oba Reservoir, Ogbomoso, Nigeria. *Science Focus*, 8, 96-100.

Florio, D., Gustinelli, A., Caffara, M., Turci, F., Quaglio, F., Konecny, R., Nikowitz, T., Wathuta, E.M., Magana, A., Otachi, E.O., Matolla, G.K., Warugu, H.W., Liti, D., Mbaluka, R., Thiga, B., Munguti, J., Akoll, P., Mwanja, W., Asaminew, K., Tadesse, Z. and Fioravanti, M.L. (2009). Veterinary and public health aspects in tilapia (*Oreochromis niloticus*) aquaculture in Kenya , Uganda ed Ethiopia. *Ittiopatologia* (6): 51–93.

Froese, R. (2006) Cube Law, Condition Factor and Weight-Length Relationships: History, Meta Analysis and Recommendations. *Journal of Applied Ichthyology*, 22, 241-253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

Froese, R. and Pauly, D. (2011). FishBase. World Wide Web Electronic Publication. http://:www.fishbase.org

Haquea, M. A. Paula, S. Jewela, M. A. S. Atiqueb, U. Paula, A. K. Iqbalc, S. Mahboobd, S. Al-Ghanimd, K. A. Al-Misnedd, F. and Ahmed, Z. (2020). Seasonal analysis of food items and feeding habits of endangered riverine catfish Rita rita (Hamilton, 1822). *Brazilian Journal of Biology*, 2022, vol. 82, e237040.

Hoffman, G.L. (ed) (1998). Parasites of North American freshwater fishes. Cornell University Press, Ithaca, New York.

Iboh C.I. and Ajang, R.O. (2016) Helminths parasitic infection of Clarias gariepinus from great kwa river, Cross river State, Nigeria. *Eur J Pharmaceut Med Res* 3(12): 101–105.

Imam, T.S. and Dewu, R.A. (2010). Survey of Piscine ecto and intestinal parasites of *Clarias sp*. sold at Galadima road fsh market, Kano metropolis, Nigeria. *Bioscience Research Communication*. 2010;22(4):209.

Imaobong E.E, Mandu, A.E and Joseph N.N. (2014) Food and feeding habits and condition factor of fish species in Qua Iboe River estuary, Akwa Ibom State, southeastern Nigeria. *International Journal of Fisheries and Aquatic Studies* 2(2): 38-46.

Kawe, S.M., God'spower, R.O., Balarabe, M.R., Akaniru, R.I. (2016). Prevalence of gastrointestinal helminth parasites of *Clarias gariepinus* in Abuja, Nigeria. *Sokoto J Vet Sci* 14(2):26–33.

Keremah, R.I., Inko-Tariah, M.B. (2013) Comparative study of ectoparasites on Nile tilapia *(Oreochromis niloticus)* cultured under integrated and unintegrated pond systems. *Afr J Biotechnol* 12(19):2711–2714.

Khaing, M.M., Khaing, K.Y.M. (2018) Food and Feeding Habits of Some Freshwater Fishes from Ayeyarwady River, Mandalay District, Myanmar. IOP Conf. Series: Earth and Environmental Science 416 (2020).

Khalil, L. and Polling, L. (1997). Checklist of the Helminth Parasites of African Freshwater Fishes. *Sovenga*: University Of Limpopo; 185 p.

Khalil, L.F. (1991) Techniques for Identification and Investigative Helminthology. Helminthology Manual. International Institute of Parasitology, St. Albans, UK, 156.

Mahmoud, M.M., Hassan, E.S., Haridy, M., Nour, E.L., Deen, E.A., Kuraa, H.M.M. and Hanna, H.N.S. (2018). Parasitic infections of the gills of wild African sharptooth catfish (*Clarias gariepinus). Assiut Veterinary Medical Journal*. 64(158):31-9.

Marcogliese, D.J. (2005). Parasites of the super organism: Are they indicators of ecosystem health? *Int J Parasitol*. 35(7):705-16.

Margolsis, L., Esch, GW., Holmes, JC., Kuris, AM., Scad, GA. (1982). The use of ecological terms in parasitology. (Report of an Ad-hoc committee of the American Society of Parasitology). *J. Parasitol*., 68(1): 131–133.

Mashego, S. Re–description of *Proteocephalus glanduliger* (Janicki, 1928) Fuhrmann, 1933 (Cestoda: Proteocephalidae: Proteocephalinae. *Annals of the Transvaal Museum.* 2001;38:13–17.

Mitiku, M.A., Konecny, R. Haile, and A.L. (2018). Parasites of Nile tilapia (*Oreochromis niloticus*) from selected fish farms and Lake Koftuin central Ethiopia. *Ethiop Vet J.* 22(2):65-80.

Ogonna, C.A., Emmanuel, I.N., Michael, D.A. (2017). Survey of ectoparasites of cultured fish from selected farms in Ebonyi State: potential for food and nutrient security. *Int J Res Pharm Biosci* 4(7):1–6

Olagbemide T Peter, Akharaiyi Fred Coolborn (2019). Effect of microbes on proximate contents of stored smoke dried African Cat Fish **(***Clarias gariepinus*) sold in Ibadan Markets. *International Journal of Scientific and Technology Research* Volume 8, Issue 09. Pp 1502 -1507.

Olajide J. A., Olususi, F.O. and Olasumbo, O.O. (2020). Comparative study of African catfish parasites from cultured and natural habitats. Bulletin of the National Research Centre pp 44:163.

Omeji, S, Solomon, S.G. and Uloko, C. (2013). Comparative study on the Endoparasitic infestation in *Clarias gariepinus* collected from earthen and concrete ponds in Makurdi, Benue State, Nigeria. *Journal of Agriculture and Veterinary Science, 2(1).*

Omeji, S., Kolndadacha, O.D. and Adadu, M.O. (2022). Evaluation of Parasitofauna of Four Economically Important Fish Species (*Synodontis Budgetti, Chrysichthys Nigrodigitatus, Bagrus Docmac and Heterobranchus Bidorsalis*) From River Okpokwu, Apa, Nigeria. *International Journal of Research and Review.* Vol. 9; Issue: 8. Pp 753-765

Omeji, S., S.G. Solomon and R.A. Obande, 2010.A Comparative Study of the Common Protozoan Parasites of Heterobranchus longifilis from the Wild and Pond Environments in Benue State. Pakistan Journal of Nutrition, 9: 865-872.

Omoike, A. (2021). The Food and Feeding Habits of Asejire Reservoir Fish Species Diversity in South Western Nigeria. *European Journal of Scientific Research*. Vol. 159 No 2. Pp.40 – 56.

Oniye, S. J., Adebote, D. A., and Ayanda, O. I. (2004). Helminth Parasites of *Clarias gariepinus* (TEUGELS) in Zaria, Nigeria. *Journal of Aquatic Sciences*, 1: 71–75. https://doi.org/10.4314/jas.v19i2.20027

Onyedineke, N.E., Obi, U. and Ofoegbu, P.U. (2010) Helminth Parasites of some Freshwater Fish from River Niger at Illushi, Edo State, Nigeria. *Journal of Animal Science*. 6(3):16–21.

Paperna, I. (1996) Parasites, Infections and Diseases of Fishes in Africa: An Update. CIFA Technical Paper, 31, 157-170.

Roberts, L.S. and Janovy, J. (2000) Gerald D. Schmidt and Larry S. Robert's Foundations of Parasitology. 6th Editions, McGraw-Hill International, Boston, MA.

Sami, S., Marwa, M.A., Magdy, I.H., Al-Bassel, D.A. and Khalid, H.Z. (2020). Survey on ectoparasites infestation of Nile tilapia (*Oreochromis niloticus*) collected from different Aquatic habitats in Egypt. *Res J Pharm Biol Chem Sci*. 2020;11(2):79-92. 47.

Shinkafi, B.A. Argungu, L.A. and Akanbi, H.S. (2010). Food and Feeding Habits of Catfish (*Synodontis nigrita* Cuvier And Valenciennes) In River Rima, Sokoto, Nigeria. *Nigerian Journal of Basic and Applied Science* (2010), 18(2): 304-307.

Sogbesan, O.A., Tukura, E.E. and Ekundayo, T.M. (2018). Parasitic infection and prevalence in *Clarias gariepinus* in Lake Gerio, Yola, Adamawa state. *MOJ Anat Physiol.* 2018;5(6):376–381.

Solomon, J. R., Olawale, O. G., and Wilfred-Ekprikpo, P. C. (2021). The Prevalence of Ecto and Endo Parasites in some Fresh Water Fishes from Jabi Lake, Abuja, F.C.T. *Direct Research Journal of Veterinary Medicine and Animal Science.* Vol. 6(2), Pp. 15-26.

Tachia, M.U., Omeji, S., Odeh, L. (2010). A survey of ectoparasites of *Clarias gariepinus* caught from the University of Agriculture Research fish farm, Makurdi. *J Res Forestry Wildlife Env* 4(2):30–37

Ukuru, N. N. and Adikwu, I. A. (2017). Seasonal Prevalence of Parasites of Clariids Fishes from the Lower Benue River, Nigeria. *Nigerian Journal of Fisheries and Aquaculture*, **5**(2): 11-19.