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Influence of host weight and size on the prevalence and abundance of parasites of fish

[1] Abu Simon, [2] Okoye Ikem C, [3] Obiezue Ndunwanne NR, [4] Ofoezie Ifeanyi E

[2, 3] Parasitology and Biomedical Diseases Research Unit, Department of Zoology and Environmental Biology, University of Nigeria, Nsukka, Enugu State, Nigeria
[1] Kogi State College of Education, Ankpa, Kogi State, Nigeria.
[4] Institute of Ecology, Obafemi Awolowo University, Ile-Ife, Nigeria.

Abstract
A survey was undertaken to study the size and weight of fish hosts in relation to prevalence and intensity of parasites to determine the morphological constraints and other predicators that may influence their interactions. The guts of freshly caught fish were dissected in clean dissecting trays and the contents washed into petridishes using 4% formaldehyde for examination of helminth parasites under a dissecting microscope. The highest prevalence in the small sized group was 34.9% in respect
Of *Neoechinorhynchus sp.*1 infection and 0.2% for *Clinostomum tilapia* and *Camallanus sp.*1 infection the least (0.0%). Among the big fish groups, the highest prevalence was 31.1% for *Neoechinorhynchus sp.*1 infection and the least 0.2% for *Proteocephalus sp*. Infection. The total mean abundance for small fish was 7.29 and 9.80 for big fish group.

Keywords: *Neoechinorhynchus*, *Clinostomum tilapia*, functioning.

Introduction
The ever-increasing cost of beef leaves fish as the most feasible option in resolving protein shortage. Fish oil contains omega-3-essential fatty acids necessary for the proper functioning of the brain, heart and immune system (Hohn, 1999) [3].
There has been tremendous increase in the development of fish farming and culture attributable to this increased need for affordable animal protein especially in the tropics (Davies *et al*., 2006) [1]. Parasitic infections and diseases are some of the important problems confronting adequate productivity in fish farming (Ravichandran *et al*. 2007, Kayis *et al*., 2009) [13, 6] and adversely affect the amount of animal protein available for human consumption. It is important therefore to investigate factors enhancing parasites that affect production and quality
It is generally accepted that predator-prey interactions are determined by morphological constraints such as predator and prey body size (Paine, 1976) [12]. We therefore examined the size and weight of fish hosts in relation to prevalence and intensity of parasites to determine morphological constraints and other predicators that influence their interactions and to lay baseline parasitological and epidemiological data for further investigations.

The Study Area
Agulu lake is a natural lake found in Agulu, Southeast Nigeria. It is located between latitude $6^0$07' and $6^0$09'N and longitude $7^0$01' and $7^0$03'E. The climate of the area shows two distinct seasons namely, rainy season (April-September/October) and dry season (October/November – March). The mean annual rainfall is 215 cm, while the water surface temperature ranges from 24 – 34 ^{0}C. The vegetation is made up of riparian shrubs, sedges and grasses since the lake lies within the tropical rainforest region.

A study (Nwosu *et al*., 2009) [7] recorded the values of some physico-chemical characteristics of Agulu Lake such as surface area (16,081 m), Transparency (1.67m), Depth (5.30m), Nitrate nitrogen concentration (0.85 mg/l) and phosphate phosphorus concentration (0.65 mg/l). The other physico-chemical parameters such as temperature (mean = 25.86 ^{o}C), dissolved oxygen (mean = 4.69 mg/l), pH (9.00), alkalinity (mean = 18.54 ppm) and conductivity (mean = 48.66 um cm^{-1}) were generally moderately low.

Collection, identification and examination of specimens
Various species and sizes of fish in the lake were collected with the aid of cast nets, beach siene, gill nets and local bamboo traps. Skin smear of the fish was made by scrapping of the skin. This was then observed under the microscope. The collected fish samples were transported to the Parasitology and Biomedical Diseases Research laboratory, University of Nigeria, Nsukka (UNN) for analysis. The samples were identified using the Food and Agricultural Organization (FAO) identification sheet (Fischer and Branch (1984) [2], Olaosebikan and Raji, 1988 and Idodo-Umeh, 2003) [5] and sexed by visual observation of the gonads into males, females and immature groups. The guts of the fish specimens were dissected in clean dissecting trays and the contents washed into Petri dishes using 4% formaldehyde for examination of helminth parasites under a dissecting microscope. After identification, the parasites were fixed, photographed or preserved in 70% alcohol.

Morphometric measurements and classifications
The Total Length (TL), Fork Length (FL) and Standard Length (SL) of fish were measured to the nearest 0.1 cm using a meter rule measuring board. The weights of the fish were measured to the nearest 0.1 g using a top loading Metler PC 2000 electronic weighing balance. The fish hosts were

classified arbitrarily into light weight (Weight ≤ 50.0 g) and heavy weight (Weight > 50.0 g) and, small size (TL <= 14.0 cm) and large size (TL > 14.0 cm) in terms of weight and size respectively to determine the prevalence, mean intensity and abundance according to the weights and sizes of the fish hosts.

Statistical Analysis

Relationships between parasite burden and other variables (length, weight and sex) were

Compared using correlation analysis, analysis of variance (ANOVA) and student t-test.

Results

Morphometric results

Table1 shows the pattern of distribution of the morphometric characteristics by fish species and sex. The overall mean total lengths (SL, FL and TL) were fairly comparable for male and female fish species. Total weight did not also vary significantly. In terms of individual species each length characteristic was also comparable between male and female fish species. In some species, mean length and weight were slightly higher in males than females (*T. mariae, C guntheric, H fasciatus*), and in others slightly higher in females than males (*T. zillii, C. auratus* and *A. occidentalis*) while in others they were fairly of equal lengths (*T. guineensis*). Similarly, mean lengths of the immature varied among species, being least in *C. guntheri.*

Mean body weight was also comparable among sexes of each species but was slightly higher in males of all species except *C. guntheri* and *C. auratus* for which the females were on average heavier than the males. In the immature group, the mean body weight varied from 12.5±2.8 in *C. guntheri* to 26.9±4.1 in *H. fasciatus* No immature fish was caught with respect to *T. mariae, A. occidentalis* and *P. obscura*.

Condition factor of the species was also fairly comparable (ranging from the lowest mean of 0.77 in male of *C. auratus* to a maximum of 2.24± 0.22 among males of *T. guineensis*) with an overall mean of 1.88± 1.31. As was recorded for lengths and weight, K- values were higher in males than females for some species and vice versa in others, although total mean was higher in females (1.95± 0.38) than males (1.95± 0.3). This difference was however not significant (p>0.05). In each species, the k-value for the immature fish was lower when compared with the values for either the males or females.

Prevalence, mean intensity and abundance in relation to host weight and size

Nine parasite species were recovered from the light weight fish hosts and ten species from the heavy ones. The highest prevalence in the light weight group was 34.9% in respect of *Neoechinorhynchus sp.*1 infection and 0.2% for *Clinostomum tilapiae* and *Camallanus sp*.1 infection the least, 0.0% (Table 1). Among the heavy weight group, the highest prevalence was 31.1% for *Neoechinorhynchus sp.*1 infection and the least 0.2% for *Proteocephalus sp*. infection.

The highest mean intensity was 73.6 ± 29.36 for the light weight fish and 78.4 ± 30.06 for the heavy weight fish. The intensity pattern of some individual species e.g. *Camallanus sp*.3 (P < 0.05) and *Neoechinorhynchus sp.*1 (P < 0.05) were significantly different between the two fish groups. The total mean abundance for light weight fish was 7.29 and 9.80 for the heavy weight group. The mean abundance is higher in the heavy weight fish group than in the light weight fish group. This difference is however not significant ($\chi^2 = 0.371$, df = 1, P ≤ 0.05). However, *Camallanus s*p3 was significantly more abundant (P = 0.010) in the heavy weight fish (0.95 ± 4.41) than in the light weight fish group (0.42 ± 1.94) Table 2.

On the basis of total length (TL), pattern of infection in the small size (TL ≤ 14.0 cm) and large (TL > 14.0cm) is summarized on Table 3. The patterns of infection were similar to those shown by fish of light and heavy body weight classifications. For instance, intensity of *Camallanus sp*.3 and *Neoechinorhynchus sp*.1 were significantly higher in large fish than in small fish groups (p = 0.036 and 0.009 respectively).

Table 1: Length, Weight and Condition factor according to Sex of fish species from Agulu Lake, Nigeria

Species	Sex	N	Standard length (cm)		Forked length (cm)		Total length (cm)		Weight (g)		Condition factor (k)
			Mean ±SD	Range	Mean ±SD	Range	Mean ±SD	Range	Mean ±SD	Range	Mean±SD
T. mariae	M	139	12.6±1.3	9.1-16.7	-	-	16.3±1.7	11.9-21.2	94.6±25.3	39.5-166.6	2.14±0.23
	F	129	11.5±1.1	9.0-16.5	-	-	14.9±1.4	12.0-21.0	73.8±19.3	37.5-158.9	2.20±0.19
	I	0	0	0	-	-	-	-	-	-	-
T. zillii	M	235	12.0±3.0	7.8-21.2	-	-	15.7±3.8	10.1-27.2	92.3±73.0	20.4-402.6	2.03±0.21
	F	140	12.2±2.3	8.6-18.5	-	-	15.9±2.9	10.9-24.1	88.8±49.4	28.1-294.0	2.02±0.27
	I	210	7.8±0.75	6.0-9.8	-	-	10.2±1.0	6.9-12.7	20.9±7.1	9.4-39.2	1.9±0.28
C. guntheri	M	34	8.7±0.6	7.6-10.1	-	-	11.3±0.7	10.1-12.9	24.3±5.3	17.5-37.1	1.66±0.18
	F	20	8.6±0.8	7.4-11.1	-	-	11.0±1.1	9.5-14.3	24.8±9.4	14.3-54.2	1.79±0.27
	I	4	7.0±0.5	6.4-7.5	-	-	9.3±0.7	8.5-10.0	12.5±2.8	8.7-14.6	1.5±0.12
H. fasciatus	M	77	12.6±2.3	8.8-18.0	-	-	16.1±2.9	11.1-22.5	79.0±47.0	22.7-198.0	1.71±0.17
	F	48	12.1±2.0	9.0-16.5	-	-	15.2±2.5	11.5-21.0	68.5±32.4	25.2-155.7	1.81±0.14
	I	13	9.1±0.6	8.2-10.2	-	-	11.6±0.8	10.5-12.9	26.9±4.1	21.4-36.3	1.7±0.19
T. guineensis	M	39	9.4±1.0	7.7-11.9	-	-	12.2±1.2	9.9-14.9	42.2±14.0	22.9-75.0	2.24±0.22
	F	7	9.4±0.7	8.4-10.3	-	-	12.3±0.9	10.9-13.4	41.5±9.9	26.7-53.0	2.20±0.12
	I	28	7.3±0.8	6.1-9.1	-	-	9.5±1.1	7.5-11.7	17.7±6.8	3.6-33.4	2.1±0.2
C. auratus	M	15	15.1±2.3	12.3-20.4	14.8±4.5	13.1-20.1	20.4±2.5	17.3-26.0	69.8±34.8	32.9-164.0	0.77±0.15
	F	13	15.4±4.1	12.5-26.0	16.6±4.4	13.3-27.5	20.3±4.1	16.3-30.2	82.8±85.1	38.4-312.3	0.82±0.30
	I	18	10.7±1.3	7.9-12.9	11.6±1.4	8.8-13.9	14.7±2.2	10.4-17.8	22.9±8.1	9.9-38.6	0.7±0.13

H. odoe	M	5	23.4±5.2	16.6-28.6	25.0±5.5	17.6-30.8	28.6±5.7	21.5-34.0	196.3±121.5	57.4-327.9	0.72±0.10
	F	1	29.6	29.6	31.8	31.8	30.0	36.0	375.9	375.9	0.81
	I	1	16.6	16.6	18.4	18.4	20.5	20.5	58.1	58.1	0.7
A. occidentalis	M	7	21.7±4.9	14.1-28.0	8.8±11.6	15.2-27.5	27.2±5.8	18.4-34.1	235.0±141.4	55.7-443.1	1.01±0.14
	F	6	24.8±1.8	22.7-28.1	4.8±11.8	0-28.8	31.2±2.1	28.7-34.9	344.7±63.4	242.8-423.5	1.13±0.11
P. obscura	M	0	-	-	-	-	-	-	-	-	-
	F	2	24.0±0.8	23.4-24.5	-	-	28.8±1.5	27.7-29.8	200.9±16.5	189.2-212.5	0.85±0.06
Total	M	551	12.2±3.1	7.6-28.6	0.7±3.8	13.1-30.8	15.8±3.9	9.9-34.1	85.4±62.6	17.5-443.1	1.95±0.37
	F	366	12.1±3.0	7.4-29.6	0.8±3.9	13.3-31.8	15.7±3.7	9.5-36.0	81.8±56.7	14.3-423.5	1.98±0.38
	I	274	8.0±1.2	6.0-16.6	0.8±3.1	0-18.4	10.5±1.7	6.9-20.5	21.0±7.6	3.6-58.1	1.8±0.41
Overall total		1191	11.2±3.3	6.0-29.6	0.7±3.7	0-31.8	14.5±4.1	6.9-36.0	69.7±59.62	3.6-443.1	1.9±1.31

Table 2: Prevalence, Mean intensity and Abundance of parasite species in Light weight and Heavy weight fish from Agulu Lake, Nigeria.

LIGHT (wt. <= 50.0 (g))							HEAVY (wt. >50.0 (g))						P - Value	
PARASITE SPP.	**N.E.**	**N.I.**	**N.P.**	**P (%)**	**M.I. ± SD**	**MA ± SD**	**N.E.**	**N.I.**	**N.P.**	**P (%)**	**M.I ± SD.**	**MA ± SD**	**M.I.**	**M.A.**
Clinostomum tilapiae	541	1	2	0.2	2.0 ± 0.0	0.004 ± 0.09	650	4	6	0.6	1.5 ± 0.58	0.01 ± 0.12	0.495 (NS)	0.380 (NS)
Clinostomoides sp.	541	29	95	5.4	3.3 ± 4.73	0.18 ± 1.31	650	52	130	8.0	2.5 ± 1.57	0.20 ±0.81	0.303 (NS)	0.716 (NS)
Clinostomum sp.	541	5	5	0.9	1.0 ± 0.0	0.01 ± 0.10	650	4	5	0.7	1.3 ± 0.71	0.01 ±0.10	1.000 (NS)	0.788 (NS)
Proteocephalus sp.	541	0	0	0.0	0.0	0.0	650	1	1	0.2	1.0 ± 0.0	0.002 ±0.04	_	0.362 (NS)
*Camallanus sp.*1	541	3	26	0.6	8.7 ± 9.29	0.05 ± 0.86	650	5	34	0.9	6.8 ± 5.22	0.05 ±0.72	0.722 (NS)	0.926 (NS)
*Camallamus sp.*2	541	1	4	0.2	4.0 ± 0.0	0.01 ± 0.17	650	0	0	0.0	0.0	0.00	_	0.273 (NS)
*Camallanus sp.*3	541	38	229	7.0	6.0 ± 4.48	0.42 ± 1.94	650	61	617	9.4	10.1 ±10.79	0.95 ±4.41	0.029 (S)	0.010 (S)
Oxyuroid (adult)	541	0	0	0.0	0.0	0.0	650	2	7	0.4	3.5 ± 3.54	0.01 ±0.24	_	0.294 (NS)
Spironoura sp.	541	7	9	1.3	1.3 ± 0.76	0.02 ± 0.17	650	7	7	1.1	1.0 ± 0.0	0.01 ±0.10	0.337 (NS)	0.456 (NS)
*Neoechinorhynchus sp.*1	541	189	627	34.9	3.3 ± 2.65	1.16 ± 2.23	650	202	934	31.1	4.6 ± 5.85	1.44 ±3.90	0.005 (S)	0.138 (NS)
*Neoechinorhynchus sp.*2	541	40	2945	7.4	73.6 ± 29.36	5.44 ± 20.83	650	59	4627	9.1	78.4 ± 30.06	7.12 ±24.27	0.433 (NS)	0.207 (NS)
Total	541	313	3942	57.9	12.6	7.29	650	397	6368	61.1	16.0	9.80		

NB: N.E=Number of host examined, N.I. =Number infected, P=Prevalence, M.I. =Mean intensity & MA= Mean abundance
N=Significant, NS=Not significant

Table 3: Prevalence, Mean intensity and Abundance of parasites in Small and Large fish species from Agulu Lake, Nigeria.

SMALL (TL <= 14.0 (cm))							LARGE (TL >14.0 (cm))						P _ Value	
PARASITES	**N.E.**	**N.I.**	**N.P.**	**P (%)**	**M.I±. SD**	**MA ± SD**	**N.E.**	**N.I.**	**N.P.**	**P (%)**	**M.I ± SD.**	**MA ± SD**	**M.I.**	**M.A.**
Clinostomum tilapiae	584	1	2	0.2	2.0 ± 0.0	0.003 ±0.08	607	4	6	0.7	1.5 ± 0.58	0.01 ± 0.13	0.495 (NS)	0.303 (NS)
Clinostomoides sp.	584	34	108	5.8	3.2 ± 4.38	0.18 ±1.28	607	47	117	7.7	2.5 ± 1.62	0.19 ± 0.80	0.354 (NS)	0.924 (NS)
Clinostomum sp.	584	5	5	0.9	1.0 ± 0.0	0.01 ±0.09	607	4	5	0.7	1.3 ± 0.71	0.01 ± 0.11	1.000 (NS)	0.953 (NS)
Proteocephalus sp.	584	0	0	0.0	0.0	0.0	607	1	1	0.2	1.0 ± 0.0	0.002 ± 0.04	_	0.327 (NS)
*Camallanus sp.*1	584	1	319	0.2	19.0 ± 0.0	0.03 ±0.79	607	7	41	1.2	5.9 ±4.78	0.07 ± 0.79	0.042 (S)	0.442 (NS)
*Camallanus sp.*2	584	1	4	0.2	4.0 ± 0.0	0.01 ±0.17	607	0	0	0.0	0.0	0.0	_	0.308 (NS)
*Camallanus sp.*3	584	32	185	5.5	5.8 ± .62	0.32 ±1.69	607	67	661	11.0	9.9 ± 10.37	1.09 ± 4.61	0.036 (S)	0.000 (S)
Oxyuroid (adult).	584	0	0	0.0	0.0	0.0	607	2	7	0.4	3.5 ± 3.54	0.01 ± 0.25	_	0.259 (NS)
Spironoura sp.	584	7	9	1.2	1.3 ± 0.76	0.02 ±0.16	607	7	7	1.2	1.0 ± 0.0	0.01 ± 0.11	0.337 (NS)	0.621 (NS)
*Neoechinorhynchus sp.*1	584	212	728	36.3	3.4 ±2.81	1.25 ±2.36	607	179	833	29.5	4.7 ± 6.07	1.37 ± 3.92	0.009 (S)	0.497 (NS)
*Neoechinorhynchus sp.*2	584	35	2596	6.0	74.2 ±30.80	4.45 ±19.13	607	64	4976	10.5	77.8±29.29	8.20 ± 25.70	0.569 (NS)	0.004 (S)
Total	584	328	3656	56.2	11.1	6.26	607	382	6654	62.9	17.4	11.0		

Discussion

The study area is known to harbor fish that are highly infected by a variety of parasitic agents (Okoye *et al*., 2014) [8]. The study revealed that the larger and bigger fish hosts haboured more helminth species, and had higher prevalence, intensity and abundance. The findings of this study corroborates those of Ibiwoye *et al*. (2004) [4], Olofintoye, (2006) [10] and Oluorin and Somorin, (2006) [11].

The probable reason for the differential infection of light/heavy and small/large fish could be attributed to change in diet from plant based (weeds, seeds, phytoplanktons) in juveniles to animal based (insect larvae, Snails, Crustaceans, worm and fish) foods in adulthood (Olofintoye, 2006) [10].

This was however not investigated in this study but, it is supported by Olofintoye (2006) [10]. Besides, the adults or larger fishes ingest more prey items (Steinauer and Font, 2003) [14] and are exposed to infection for a longer period than their juvenile counterparts. An interplay of these factors would definitely increase the probability of parasite-host contact in larger fishes which translates to higher values of the different parameters in the bigger/large fish.

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