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Impact of stomach state of fish on the intensity and abundance of parasites

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Abstract
The food and feeding habits and their possible effects on gastrointestinal parasite intensity and abundance of the fish of a natural lake in Southeast Nigeria was investigated as part of the measures to enhance the yield and management of inland water resources. The guts of freshly caught fish were dissected in clean dissecting trays and the contents washed into Petri dish using 4% formaldehyde for examination of food contents and helminth parasites under a dissecting microscope. The degree of fullness of each stomach was estimated by an arbitrary 0 –16 points scale thus 0, 8 and 16 points were allotted to empty stomach (ES), partially filled stomach (PS) and full stomach (FS) and then used to evaluate patterns in feeding activities. The percentage of full stomach varied from 0% in *C. guntheri* and *P. obscura* to 57.0 % in *T. zillii. T. zillii* had the highest percentage (52.7%) of partially filled stomach while *P. obscura* had the least (0%). The highest percentage (31.2%) for empty stomach was also found in *T. zillii* and the least (0.4 %) in *A. occidentalis.* The food items isolated were mud, sand, debris, plant parts, insect larvae, copepods and fish fries. The most frequently encountered food item was mud (78.4%) while the least was debris (0.3%). In *Neoechinorhynchus sp*.1, hosts with full stomachs had significantly higher prevalence and carried heavier parasite burden (5.2 ± 6.57) (F = 8.628, d.f. = 2, p =0.000) than those with either partially filled stomachs (3.4 ± 2.80) and or empty stomachs (2.8 ± 1.97). Mean abundance was also significantly higher in fishes with full stomach than in others for *Neoechinorhynchus sp*.1 (F = 16.359, d.f. =, p =0.000) and *Neoechinorhynchus sp*.2 (F = 9.600, d.f. =3, p= 0.000), but in terms of *Neoechinorhynchus sp*.2, abundance was higher among those with empty stomachs (12.73 ± 30.58) than those with either partially filled stomachs (5.27 ± 21.25) or full stomachs (3. 33 ±16.62).

Keywords: Stomach-state, Natural-lake, Parasite abundance, Fish parasites

1. Introduction

The role of freshwater fish in transmitting parasites to humans had been known for a long time. The fish get infected mainly through food chains and webs (trophic interaction) or life cycle. An instance of this can be seen in the lifecycle of an anisakid nematode (Klimpel and Harry (2011) [9]. The eggs hatch in seawater, and larvae are eaten by crustaceans. The infected crustacean is subsequently eaten by a fish or squid. The life cycle is completed when an infected fish is eaten by a marine mammal, such as a whale, seal or dolphin. The nematode excysts in the intestine, feeds, grows, mates and releases eggs into the seawater in the host's faeces. As the gut of a marine mammal is functionally very similar to that of a human, *Anisakis* species are able to infect humans who eat raw or undercooked fish.

Similarly, in tape worm, mammals or birds eat infected fish and the egested eggs hatch in freshwater. Crustaceans eat the eggs; freshwater fishes eat the crustaceans and so on. This implies that the type of food eaten by the fish may likely influence its vulnerability to parasitic infection.

Fish production in the tropics is strengthened by the availability of extensive inland water systems made up of streams, rivers and lakes which support a large number of fish species, many of which are of economic importance. There are however, various threats facing the over 200 fish species in West African inland rivers and floodplains (Craig, 2000, [2] Okoye, *et al*., 2014) [10]. To fully develop, conserve and manage (Skeleton, 2002) [12] these diverse and rich fish resources in these inland water bodies, there is need for adequate knowledge of parasites that infect them with a view to adopting preventive and control measures to improve fish yield.

The present research is part of a series of investigations aimed at provision of information on aspects of the biology of freshwater fish in the tropics, focused on the food, feeding habits and the gastrointestinal parasite status of the fish, to enhance their yield and management.

2. Materials and Methods

2.1 The Study Area

Agulu lake is a natural lake that lies within the tropical rain forest belt 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 the 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.

2.2 Collection, identification and examination of specimens

The fish specimens used in this study were collected with the aid of cast nets, beach siene and gill nets with mesh sizes ranging from 25 mm – 75 mm as well as Local traps, particularly bamboo traps using a planked canoe for the fishing operations. 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 [4]; Idodo-Umeh, 2003 [3] and sexed by visual observation of the gonads into males, females and immature groups.

The guts of freshly caught fish were dissected in clean dissecting trays and the contents washed into Petri dishes using 4% formaldehyde for examination of food contents and helminth parasites under a dissecting microscope. After identification, the parasites were fixed, photographed or preserved in 70% alcohol.

2.3 Stomach content analysis

The stomach of each fish was opened and its degree of fullness estimated by an arbitrary 0 –16 points scale (Ezenwaji, 2002) [3] thus 0, 8 and 16 points were allotted to empty, partially filled and full stomachs respectively. The percentage of empty stomach (ES), partially filled stomach (PS) and full stomach (FS) were used to evaluate patterns in feeding activities. The contents of each stomach were sorted into categories and analyzed using frequency of occurrence and percentages. This was calculated as the frequency of each food taxon expressed as a percentage of the sum of the frequencies of all food taxa thus: $\%RF=100(ai/\sum A)$ (Hyslop, 1980) [5]. Where ai =frequency of food taxon a, and A=the frequency of the nth food taxon.

2.4 Statistical Analysis

Comparative analysis of parasite prevalence, mean intensity and abundance with respect to sex, size, seasons and parasite habitat(s) were carried out using Chi-square test, student t-test, ANOVA, or correlations as appropriate.

3. Results

3.1 Stomach Content Analysis

The monthly variation in the degree of stomach state in the 1191 fish specimens examined during the 12-month study period is shown in Figure 1 while Table 1 shows the variation in the degree of their stomach state. About half of the specimens examined had a partially filled stomach, about a fifth an empty stomach and others a full stomach. Comparing number of each species with full stomach, partially filled stomach and empty stomach, most of the species (*T.mariae* and *T. zillii*) had partially filled stomach. Most members of 5 species had empty stomach and only among *A. occidentalis* were most fish caught with full stomach. Computing degree of fullness on the overall number of fish specimens collected, the percentage of full stomach varied from 0% in *C. guntheri* and *P. obscura* to 57.0 % in *T. zillii*. *T. zillii* also had the highest percentage (52.7%) of partially filled stomach while *P. obscura* had the least (0%). The highest percentage (31.2%) for empty stomach was also found in *T. zillii* and the least (0.4 %) in *A. occidentalis.*

Table 2 presents the degree of stomach fullness among the sexes and the immature groups of all fish specimens examined. The males were found with the highest full stomach (52.1%), partially filled (44.4%) and empty stomach (42.9%) while the immature group had the least full (12.9%) and partially filled stomach (25.2%). The monthly changes in the degree of stomach fullness are presented in Table 3. Most fish species examined in each month had partially filled stomach except in December when full stomach predominated. Empty stomach did not prevail in any of the months although it was second most important in four months. Although the average percentage full stomach was higher (30.9%) in the dry season (November to march) than in the wet (26.2%) (April to October) the difference was not statistically significant (χ^2=3.841, d.f =1, $p < 0.05$). Similarly, there was no significant difference in the percentage of empty stomach between the dry (22.6%) and the wet (22.5%) seasons.

Table 4 presents the distribution of food types observed in fish stomachs examined. The food items isolated from the fish species were mud, sand, debris, plant parts, insect larvae, copepods and fish fries. The most frequently encountered food item was mud (78.4%) while the least was debris (0.3%). Mud was also the most frequent food item in *T. mariae* (95.1%) *T. zillii* (85.3%) and *T. guineensis* (98.3%) which respectively accounted for 60.2%, 32.1% and 7.4% of the mud recovered. Insect larvae were the most frequent food items in *C auratus* (55.6%) and *A. occidentails* (71.4%) and fish fries constituted the most frequent food item in *H. fasciatus* (98.7%) and *H. odoe* (75.0%). The most frequent food item in *C. guntheri* was copepods (50.0%).

In *Neoechinorhynchus sp*.1, hosts with full stomachs had significantly higher prevalence and carried heavier parasite burden (5.2 ± 6.57) (F = 8.628, d.f. = 2, p =0.000) than those with either partially filled stomachs (3.4 ± 2.80) and or empty stomachs (2.8 ± 1.97) (Table 5). Mean abundance was also significantly higher in fishes with full stomach than in others for *Neoechinorhynchus sp*.1 (F = 16.359, d.f. =, p =0.000) and *Neoechinorhynchus sp*.2 (F = 9.600, d.f. =3, p= 0.000), but in terms of *Neoechinorhynchus sp*.2 abundance was higher among those with empty stomachs (12.73 ± 30.58) than those with either partially filled stomachs (5.27 ± 21.25) or full stomachs (3. 33 ±16.62).

Table 1: Stomach fullness in relation to total number of fish examined per species in Agulu Lake, Nigeria

Species	Stomach State	FS	PS	ES	
T. mariae	Frequency (f)	103	146	19	268
	Percentage (%)	30.12 (38.4)	25.04 (54.5)	7.14 (7.1)	
T. zillii	Frequency (f)	195	307	83	585
	Percentage (%)	57.02 (33.3)	52.66 (52.5)	31.20 (14.2)	
C.guntheri	Frequency (f)	0	10	48	58
	Percentage (%)	0.0 (0)	1.72 (17.2)	18.05 (82.8)	
H. fasciatus	Frequency (f)	21	55	62	138
	Percentage	6.14 (15.2)	9.43 (39.9)	23.31 (44.9)	
T. guineensis	Frequency (f)	12	46	16	74
	Percentage (%)	3.51 (16.2)	7.89 (62.2)	6.02 (21.6)	
C. auratus	Frequency (f)	3	11	32	46
	Percentage (%)	0.88 (6.5)	1.89 (23.9)	12.03 (69.6)	
H. odoe	Frequency (f)	1	3	3	7

	Percentage (%)	0.29 (14.3)	0.51 (42.9)	1.13 (42.9)	
A. occidentalis	Frequency (f)	7	5	1	13
	Percentage (%)	2.05 (53.8)	0.86 (38.5)	0.38 (7.7)	
P. obscura	Frequency (f)	0	0	2	2
	Percentage (%)	0.0 (0)	0.0 (0)	0.75 (100)	
Total	Frequency (f)	342	583	266	1191
	Percentage (%)	100 (28.7)	100 (49.0)	100 (22.3)	100 (100)

Table 2: The degree of Stomach fullness in different sex groups of fish specimens from Agulu Lake, Nigeria.

Sex	Stomach State	Frequency	Percentage (%)
Male	FS	178	52.1
	PS	259	44.4
	ES	114	42.9
Female	FS	120	35.1
	PS	179	30.7
	ES	67	25.2
Immature	FS	44	12.9
	PS	145	24.9
	ES	85	32.0
Total	FS	342	100.0
	PS	583	100.0
	PS	266	100.0

NB:FS = full stomach; PS = partially filled stomach; ES = empty stomach.

Table 3: Monthly variations in the percentage degree of stomach fullness of fish species from Agulu lake, Nigeria

	Degree of stomach fullness (%)		
Month	**Full Stomach**	**Partially Filled Stomach**	**Empty Stomach**
June	32.9	50.0	17.1
July	37.3	43.2	19.5
August	15.7	48.7	35.7
September	11.6	55.1	33.3
October	26.5	50.6	22.9
November	18.9	43.3	37.8
December	50.5	34.2	15.3
January	22.5	50.5	27.0
February	36.5	44.3	19.1
March	26.1	60.4	13.5
April	41.1	47.4	11.6
May	18.4	63.1	18.4
Total	28.7	49.0	22.3

Table 4: Frequency and percentage occurrence of food groups in fish species from Agulu Lake, Nigeria.

	Food Items															
Species	**Mud**		**Sand**		**Debris**		**Plant Parts**		**Insect Larvae**		**Cyclops/ Copepods**		**Fishes/ Fries**		**Total**	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
T. mariae	250	95.1	0	0	0	0	0	0	12	4.6	1	0.3	0	0	263	100
T. zillii	469	85.3	2	0.4	3	0.5	30	5.5	46	8.4	0	0	0	0	550	100
C. guntheri	2	20.0	2	20.0	0	0	1	10.0	0	0	5	50.0	0	0	10	100
H. fasciatus	0	0	0	0	0	0	0	0	0	0	1	1.3	75	98.7	76	100
T. guineensis	58	98.3	0	0	0	0	0	0	1	1.7	0	0	0	0	59	100
C. auratus	0	0	2	11.1	0	0	4	22.2	10	55.6	2	22.1	0	0	18	100
H. odoe	0	0	1	25.0	0	0	0	0	0	0	0	0	3	75.0	4	100
A. occidentalis	0	0	0	0	0	0	4	28.6	10	71.4	0	0	0	0	14	100
P. obscura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
OVERALL TOTAL	779	78.4	7	0.7	3	0.3	39	3.9	79	7.9	9	0.9	78	7.8	994	100

NB: F= Frequency of occurrence

Table 5: Prevalence, mean intensity and abundance of parasites according to stomach states of fishes from Agulu Lake, Nigeria

Parasite species	Stomach state	N. E.	N. I.	P. L.	Prev. (%)	M. I. ± SD	M. A. ± SD
Clinostomum tilapiae	Empty (1)	266	2	4	0.8	2.0 ± 0.00	0.02 ± 0.17
	Half full (2)	583	1	1	0.2	1.0 ± 0.00	0.002 ± 0.04
	Full (3)	342	2	3	0.6	1.5 ± 0.71	0.01 ± 0.12
	P- Value					0.417 (NS)	0.395 (NS)
	Total	1191	5	8	0.4	1.6 ± 0.55	0.01 ± 0.11
Clinostomoides sp.	1	266	13	26	4.9	2.0 ± 1.16	0.10 ± 0.50
	2	583	35	113	6.0	3.2 ± 4.19	0.19 ± 1.27
	3	342	32	85	9.4	2.7 ± 2.06	0.25 ± 0.99
	P -Value					0.454 (NS)	0.382 (NS)
	Total	1191	80	224	6.7	2.8 ± 3.10	0.19 ± 1.06
Clinostomum sp.	1	266	0	0	0.0	0.0	0.0
	2	583	5	5	0.9	1.0 ± 0.00	0.01 ± 0.09
	3	342	5	5	1.5	1.0 ± 0.71	0.01 ± 0.14
	P- Value					1.000 (NS)	0.363 (NS)
	Total	1191	10	10	0.8	1.0 ± 0.47	0.01 ± 0.10
*Camallanus sp*1	1	266	2	23	0.8	11.5 ± 10.61	0.09 ± 1.19

	2	583	6	37	1.0	6.2 ± 5.15	0.06 ± 0.79
	3	342	0	0	0.0	0.0	0.0
	P- Value					0.670 (NS)	0.542 (NS)
	Total	1191	8	60	0.7	7.5 ± 6.41	0.05 ± 0.79
*Camallanus sp*3	1	266	50	454	18.8	9.1 ± 7.59	1.72 ± 4.84
	2	583	36	310	6.2	8.6 ± 11.75	0.53 ± 3.55
	3	342	13	82	3.8	6.3 ± 5.63	0.24 ± 1.61
	P- Value					0.623 (NS)	0.000 (S)
	Total	1191	99	846	8.3	8.5 ± 9.10	0.71 ± 3.52
Spironoura sp.	1	266	3	5	1.1	1.7 ± 1.16	0.02 ± 0.20
	2	583	9	9	1.5	1.0 ± 0.00	0.02 ± 0.12
	3	342	2	2	0.6	1.0 ± 0.00	0.01 ± 0.08
	P- Value					0.162 (NS)	0.646 (NS)
	Total	1191	14	16	1.2	1.1 ± 0.54	0.01 ± 0.14
*Neoechinorhynchus sp*1	1	266	42	116	15.8	2.8 ± 1.97	0.44 ± 1.28
	2	583	203	685	34.8	3.4 ± 2.80	1.18 ± 2.31
	3	342	146	760	42.7	5.2 ± 6.57	2.22 ± 5.00
	P- Value					0.000 (S)	0.000 (S)
	Total	1191	391	1561	32.8	4.0 ± 4.63	1.31 ± 3.25
*Neoechinorhynchus sp*2	1	266	44	3361	16.5	76.4 ± 27.28	12.73 ± 30.58
	2	583	40	3072	6.9	76.8 ± 33.24	5.27 ± 21.25
	3	342	15	1139	4.4	75.9 ± 28.63	3.33 ± 16.62
	P- Value					0.995 (NS)	0.000 (S)
	Total	1191	99	7572	8.3	76.5 ± 29.72	6.36 ± 22.78

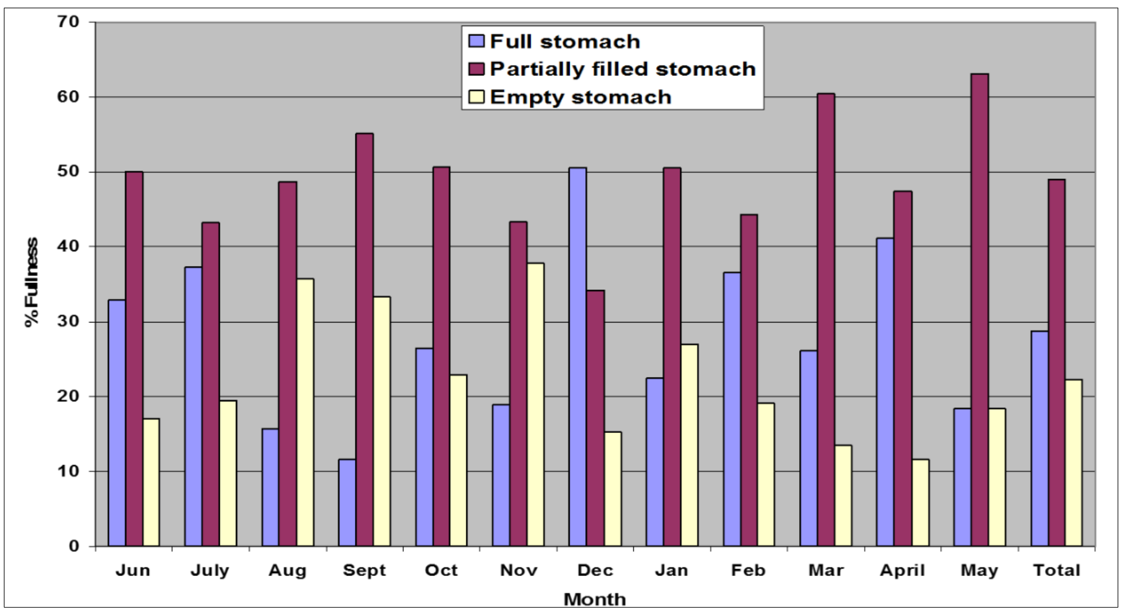

Fig 1: Monthly variation in the degree of stomach fullness of fish species in Agulu lake, Nigeria

4. Discussion

The most abundant fish species observed in this survey was *Tilapia zillii*, *Tilapia mariae* and *Hemichromis faciatus*. The abundance of *T. zillii* is expected considering the food profile in the lake. Mud accounted for over 78% of food items in fish stomachs and constituted the major food component in *Tilapia sp*. Most importantly, however, most fish examined had either full or partially full stomach except *C. guntheri, C. auratus* and *P. obscura* for which empty stomach predominated. This trend is a clear indication of food richness and high productivity potential of Agulu Lake as shown by the positive allometric growth pattern in most of the fish species.

The variation in the degree of stomach fullness explains the differences in the feeding intensity among various fish species and time. The high rate of feeding activities in the heart of the rainy season could be explained by a probable abundance due to allochtonous movement of food items from the catchment area. However, the dry season, especially the December peak could be explained in terms of high human activities observed in the lake (viz. washing of maize and beans seeds, fermentation of cassava, appeasement sacrifices, etc) at such period.

This stomach contents analysis showed that the fish species of the natural lake have mixed diet and explore different trophic levels and habits for feeding. The prominence of mud and sand in the stomachs of *T. mariae*, *T. zillii* and *T. guineensis* are indications that these species are bottom feeders. Both this study and Achife (2004) [1] agree that mud is a major food item in many fish species particularly cichlids in this lake. Some species are purely carnivorous, feeding on other fish, copepods and insect larvae. This is the case with *Hemichromis fasciatus* and

Hepsetus odoe which rely heavily on smaller fish, for which *Tilapia sp* particularly constituted major food item. This observation indicates that the two fish species are mid-water feeders in the lake. This study is in line with the findings of Imevbore and Bakore (1970), who reported that *C. auratus* feed on a variety of food items including bivalve molluscs, trichopteran larvae and coarse sand, suggesting flexible feeding habits depending on food availability and environmental conditions.

The higher mean intensity of *Neoechinorhynchus sp.*1 in fishes with full stomach and the higher mean abundance of *Neoechinorhynchus sp.*1 and the *Neoechinorhynchus sp.*2 in the fish host with empty stomach is rather unusual. However, nutritional status which is an expression of food taken over a long period could manifest in the ‘condition or welfare’ state of a fish and this could affect the likelihood of a fish being infected. Thus, this study has shown that the condition of infected fish hosts were worse than those of the uninfected. On the assumption that infected and uninfected fishes are equally exposed to the same food items, it can be argued that parasitism could be responsible for the discriminate conditions. Kabata (1985) observed that trematode infection could cause necrotic tissue change, displacement of organs, functional morbidity and retarded growth. In addition, Olofintoye (2006) noted that fish species could suffer malnutrition due to parasitic infections.

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