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Studies on the food composition and feeding pattern of fish communities in Qua Iboe River, Niger Delta region of Nigeria

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Abstract

Trends in the diets and feeding activity of 21 families of fish comprising 37 species, 29 genera and 543 individuals from two ecologically distinct zones of Qua Iboe River were investigated from July – October 2008. The Relative Frequency, Percentage Point and Index of Food Dominance methods were used to determine their diets and feeding patterns. The proportion of fish with food were higher (339; 62.43%) than those without food (204; 37.57%) but were statistically not significant (P>0.05). Of the 356 specimens examined in Station 1, 198 (55.62%) had food while 158 (44.38%) were without food. Out of the 187 specimens in Station 2, 141 (75.40%) had food while 46 (24.60%) were without food. In all, 204 specimens (37.57%) had empty stomachs, 79 (14.55%) had full stomachs whereas 63 (11.60%), 89 (16.39%) and 82 (15.10%) were for ¾, ½ and ¼ respectively. The six specimens of *P. africana* had empty stomach. Among the fish species represented by single specimen, only *A. fasciatus* had empty stomach. Two of the remaining five species: *E. aeneus* and *S. barracuda* had fully distended stomachs while *T. goreensis* and *X. nigri* had their stomachs half full. The remaining two species, *P. peroteti* and *T. guineensis*) had three quarter full and one quarter full stomachs respectively. A total of thirteen major food items were identified: nine in Station 1 and twelve in Station 2. In Station 1, the dominant food item was sediments (75.16%) and the least was amphibians (5.10%). Fish and sediments were the dominant food items (15.63%) while unidentified food was the least (1.56%) in Station 2. However, high values of unidentified foods and in more species were recorded in Station 1 than Station 2. The food of these species were diversified containing both plant, animal and non-living materials.

Keywords

Stomach Contents, Food Habit, Feeding Intensity, Fish Communities, Nigeria

1. Introduction

Water is essential for all known forms of life, and is approximated to cover 70.9% of the earth surface [1, 2, 3, 4 and 5]. Fish is regarded as the cheapest source of protein among the urban and rural populace. The demand for fish as a source of protein increases as the human population grows [6]. Nutritionally, fish consumption is widely encouraged due to its high content of omega-3 polyunsaturated fatty acids and protein [7].

Since organisms do not live in isolation in any ecosystem but interact with one another through the food-web relationship [8], the feeding relationship of organisms of high trophic levels of the fish has become necessary to complement the series of ecological studies. Moreover, [9] postulated that the availability of the food of the fish species can also influence their distribution. The knowledge of food and feeding pattern of fish according to [8] is a prerequisite to the improvement and management of commercially important fish species.

Qua Iboe river is a major river that flows through the urban and rural villages and towns in Akwa Ibom State. Sited

at its estuarine zone is the popular oil producing Exxon Mobil at Ibeno, Eket Local Government Area. As a result of its location, it has attracted both national and international bodies, ecologists and other environmentalists over the years. Several publications are available on the Qua Iboe River and its estuary on food and feeding habits of single species of fish [10, 11, 12, 13, 14, 15], among others. But there is dearth of data on its multispecies' food and feeding habits. This study, therefore, focuses on the food and feeding patterns of the multispecies communities of the freshwater and estuarine zones in the river in order to bridge the gap on the above information.

2. Materials and Methods

2.1. Study Area

Fig. 1. *Maps of the sampling stations: (A) Nigeria showing the location of Qua Iboe River in Akwa Ibom State (B) Qua Iboe River showing sampling stations 1 & 2 [19].*

Qua Iboe River system (7^{o} 30′ – 8^{o} 20′W; 4^{o} 30′ – 5^{o} 30′N) is one of the three major hydrographic features in Akwa Ibom State, Nigeria [16] (Fig. 1). The study area was divided into two main zones: Station 1 is the freshwater zone while Station 2 is the estuarine zone. It is located in the rain forest belt. In spite of its present status as the capital of Akwa Ibom State, the city is still dotted with palm trees, banana, plantain and fruit trees with poor drainage. The area has warm humid climate condition but high temperature and heavy rains distributed almost all year round. The maximum temperature is between 26-28^{o}C and mean annual rainfall is 362.5mm. The climate presents two distinct seasons; a rainy season (April - October) and a dry season, (November - March) [17, 18].

2.2. Fish Sampling

Several fishing methods were used in a standardized manner to collect the maximum number of species and individuals in different sizes including gill nets (with stretched mesh size of 10–30mm), hooks and lines, and traps (which were set overnight prior to the sampling day). The unbaited gill nets and baited traps (using baits such as earthworms, fish and palm fruits) were set mainly at the vegetated marginal regions while hooks and lines (baited) were used both in vegetated areas and in the open water.

Fish samples collected were preserved in 10% formaldehyde solution in well-labeled containers to reduce microbial digestion to the minimum [20, 21] and taken to the laboratory for identification with the aid of identification keys [22, 23, 24].

2.3. Statistical Analysis

The number of items ingested by an individual fish was considered as food richness. Several indices have been employed in expressing quantitative importance of different food items in fish diet [25, 26, 27, 28, 29, 10 and 30]. In this work, the indices used were: Frequency of occurrence of each food item was obtained by expressing the number of stomach each food item occurred as percentage of total number of stomach. The frequencies of the variety of items in the stomachs were noted and these data were used to evaluate their Relative Frequency (RF) by expressing the frequency of each as a percentage of the sum of all the frequencies of all the food items, all RF values sum up to 100%. The mean total points gained by each food item was computed and expressed as percentage of the grand total points (PP) gained by all stomach contents. The integrated importance of each food item, Index of Food Dominance (IFD) was then calculated as it incorporates the RF and PP, expressing them as percentages.

3. Results

3.1. Fish Species

Table 1. *Fish species sampled showing stomachs with and without food in Qua Iboe River, Nigeria.*

Fish species	Station 1		Station 2	
	WF	WOF	WF	WOF
Anaspidoglanis akiri (Rich, 1987)	6	1		
A. fasciatus (Geoffery St. Hilarire, 1827)	-	1	-	-
Bathygobius soporator (Valenciennes)	-	-	1	1
Barbus callipterus (Boulenger, 1907)	34	91	-	-
Brienomyrus brachyistus (Gill, 1863)	44	1	-	-
Brycinus longipinnis (Gunther, 1864)	14	6	-	-
Chromidotilapia guntheri (Sauvage, 1882)	11	7	-	-
Chrysichthys aluuensis (Risch, 1985)	3	4	-	-
C. nigrodigitatus (Lacepede, 1803)	-	-	3	2
Ctenopoma nebulosum (Gunther, 1896)	1	2	-	-
Epinephelus aeneus	-	-	1	-
Epiplatys bifasciatus (Steindachner, 1881)	8	1	-	-
E. sexfasciatus (Gill, 1882)	10	11	-	-
Erpetoichthys calabaricus (Smith, 1866)	21	3	-	-
Ethmalosa fimbriata (Bowdich, 1825)	-	-	12	3
Hemichromis fasciatus (Peters, 1857)	4	8	-	-
Isichthys henrgii (Gill, 1863)	3	1	-	-
Liza dumerili	-	-	21	-
L. falcipinnis (Valenciennes, 1836)	-	-	31	-
L. grandisquamis (Valenciennes, 1836)	-	-	45	7
Malapterurus electricus (Gmelin, 1789)	21	9	-	-
Mugil cephalus (Linnaeus, 1758)	-	-	2	3
Parachanna africana (Steindachner, 1897)	-	6	-	-
Pelvicachromis pulcher (Boulenger, 1901)	4	-	-	-
Pomadasys peroteti (Cuvier, 1830)	-	-	1	-
P. jubelini (Cuvier, 1830)	-	-	4	3
Pseudotolithus elongatus (Bowdich, 1825)	-	-	13	4
Polydactylus quadrifilis (Cuvier, 1829)	-	-	1	1
Polycentropsis abbreviata (Boulenger, 1901)	2	-	-	-
Sarotherodon melanotheron (Ruppell)	-	-	2	-
Sphyraena afra (Peters, 1844)	-	-	1	-
Thysochromis ansorgii (Boulenger, 1911)	1	5	-	-
Tilapia guineensis (Bleeker, 1862)	-	-	1	-
T. mariae (Boulenger, 1899)	10	2	-	-
Trachinotus goreensis (Cuvier, 1832)	-	-	1	-
T. teraia (Cuvier, 1832)	-	-	1	22
Xenomystus nigri (Gunther, 1868)	1	-	-	-
Grand Total	198	158	141	46

WF = Stomachs with food, WOF = Stomachs without food

In all, 543 specimens of fish belonging to 21 families, 29 genera and 37 species were examined in relation to their diets. A total of 37 species of fish were sampled: Station 1 had twenty species while Station 2 had seventeen species. The sample size ranged between one specimen in seven species (*A. fasciatus, E. aeneus, P. peroteti, S. barracuda, T. guineensis, T. goreensis* and *X. nigri*) and 125 specimens in *B. callipterus*. The total length varied from 2.60 cm (*E. bifasciatus, E. sexfasciatus* and *H. fasciatus*) to 35.10 cm (*E. calabaricus*).

The results of the food analysis showed that proportion of fish with food were higher (339; 62.43%) than those without food (204; 37.57%) but were statistically not significant (P>0.05) as depicted in Table 1. Of the 356 specimens examined in Station 1, 198 (55.62%) had food while 158 (44.38%) were without food. Out of the 187 specimens in Station 2, 141 (75.40%) had food while 46 (24.60%) were without food.

3.2. Feeding Intensity

The stomach fullness method shown in Table 2 revealed that of the 543 specimens examined, 204 (37.57%) had empty stomachs, 79 (14.55%) had full stomachs whereas the partially full: 63 (11.60%), 89 (16.39%) and 82 (15.10%) were for ¾, ½ and ¼ respectively. Among the fish species represented by single specimen, only *A. fasciatus* had empty stomach. Two of the remaining five species: *E. aeneus* and *S. barracuda* had fully distended stomachs while *T. goreensis* and *X. nigri* had their stomachs half full. The remaining two species, *P. peroteti* and *T. guineensis*) had three quarter full and one quarter full stomachs respectively. The six specimens of *P. africana* had empty stomachs. Thus, the result implied that percentage of stomachs with food was higher than those without food.

Table 2. *Degree of stomach fullness illustrating feeding intensity among fish species in Qua Iboe River, Nigeria.*

Fish species	N	Total length (TL, cm)		Stomach fullness									
				Station 1					Station 2				
		Min	Max	4/4	3/4	1/2	1/4	0	4/4	3/4	1/2	1/4	0
A.akiri	7	6.50	10.00	1	1	3	1	1					
A. fasciatus	1	10.00						1					
B. soporator	2	8.00	10.90						1				1
B. callipterus	125	4.60	8.00	4	2	21	7	91					
B. brachyistus	45	3.60	11.70	8	19	5	12	1					
B. longipinnis	20	7.50	9.80	2	1	8	3	6					
C. guntheri	18	3.70	11.40		2	4	5	7					
C. aluuensis	7	6.00	7.70	2		1		4					
C. nigrodigitatus	5	19.70	27.80						2		1		2
C. nebulosum	3	6.90	13.30			1		2					
E. aeneus	1	15.20							1				
E. bifasciatus	9	2.60	3.60	1		4	3	1					
E. sexfasciatus	21	2.60	6.10	1	2	4	3	11					
E. calabaricus	24	27.72	35.10	10	1	7	3	3					
E. fimbriata	15	13.20	17.80							2	2	8	3
H. fasciatus	12	2.60	9.10		2	1	1	8					
I. henrgii	3	4.70	11.10		1		2						
L. dumerili	21	10.10	23.50						8	5	2	6	
L. falcipinnis	31	8.50	20.00						15	3	10	3	
L. grandisquamis	52	10.90	23.7						12	10	15	8	7
M. electricus	30	7.70	19.30	3	1	10	7	9					
M. curema	5	10.90	16.80						1	1			3
P. africana	6	7.50	20.60					6					
P. pulcher	4	6.60	10.20		1	1	2						
P. peroteti	1	8.40								1			
P. jubelini	7	11.80	15.10						1	2		1	3
P. elongatus	17	11.40	21.50						3	1	7	2	4
P. quadrifilis	2	20.00	20.60							1			1
P. abbreviata	2	3.90	8.00			2							
S. melanotheron	2	10.70	18.5							1	1		
S. barracuda	1	23.20							1				
Th. ansorgii	6	3.10	10.30				1	5					
T. guineensis	1	14.20										1	
T. mariae	12	7.00	11.70	2		5	3	2					
T. goreensis	1	9.80									1		
T. teraia	23	6.20	9.50								1		22
X. nigri	1	16.2				1							
Grand total	543			79	63	89	82	204					

3.3. Food Richness

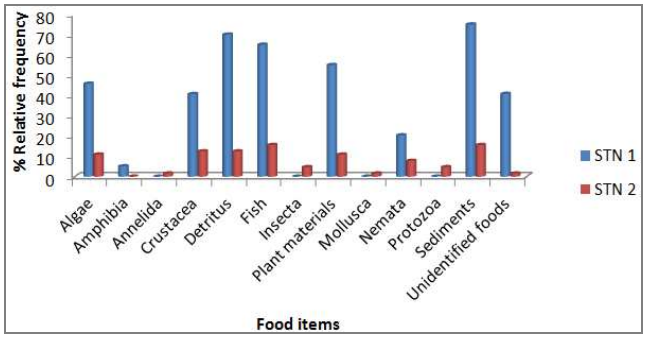

Fig. 2. *Relative frequency of food items found in the guts of fish in Qua Iboe River, Nigeria.*

A total of thirteen major food items (algae, Amphibia, Annelida, Crustacea, detritus, fish, Insecta, Mollusca, Nemata, plant materials, Protozoa, sediments and unidentified foods) were found in the stomachs of the fish. Of these, nine were recorded in STN 1 while STN 2 had twelve food items (Fig. 2). In STN 1, the dominant food item was sediments (75.16%) and the least amphibians (5.10%). Fish and sediments were the dominant food items (15.63%) while unidentified food was the least (1.56%) in STN 2. Amphibia was the only food item not found in STN 2 while in STN 1, four major items (Annelida, Insecta, Mollusca and Protozoa) occurring in STN 2 were absent.

3.4. Food Composition

The results of the gut contents analysis were carried out based on all the species encountered, with the exception of *P. africana* and *A. fasciatus* in which the six and one specimens caught had empty stomachs respectively (Tables 1 and 2). The tables showing the food items of the fish species were arranged according to stations: Tables 3 – 6 constituted those of Station 1 while Tables 8 – 11 were for Station 2. Table 7 was made up of the food items of three and one fish species of Stations 1 and 2 respectively.

Table 3. *Analysis of stomach contents of E. calabaricus, B. brachyistus, I. henrgii and X. nigri by (%RF), Point Percentage (%PP) and Index of Food Dominance (%IFD) methods in Station 1 in Qua Iboe River, Nigeria.*

Food items	*B. brachyistus*			*E. calabaricus*			*I. henrgii*			*X. nigri*		
	Percentages											
	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD
Algae												
Bacillariophyta	7.07	4.54	3.38	6.06	2.57	1.24	6.67	5.13	3.34			
Chlorophyta	5.46	4.48	3.08									
Myxophyta	8.04	8.45	5.47	3.03	1.47	0.71	13.33	5.13	6.67			
Plant materials												
Leaf fragments	5.15	5.26	5.27	4.04	4.41	2.82	13.33	7.69	9.99			
Root				1.01	1.10	0.18						
Seeds	2.25	2.31	1.01	2.02	1.47	0.47						
Insecta												
Insect wing	2.25	3.82	1.67									
Chironomid larvae	5.79	7.33	8.25	2.02	1.10	0.35	6.67	5.13	3.34			
Trichopteran pupae	1.61	1.59	0.50	4.04	2.57	1.65						
Insect remains	8.04	10.35	16.18	11.11	11.03	19.42	6.67	5.13	3.34	20.0	12.5	13.07
Coleopteran	1.61	1.12	0.35									
Crustacea												
Penaeid shrimp	2.25	2.07	0.91									
Macrobranchium sp				3.03	4.04	0.88						
Ostracods	4.18	3.82	3.11	2.02	2.21	0.71						
Cyclops	3.86	3.50	2.63									
Daphnia	5.47	5.73	6.10									
Amphibia												
Tadpoles				1.01	3.68	0.59						
Nemata	6.11	6.53	7.76				6.67	7.69	9.00			
Fish												
Scales	3.86	2.31	1.74	2.02	0.55	0.18	6.67	7.69	9.00			
Fish remains							6.67	10.26	6.67			
Detritus												
FPOM	6.75	5.97	7.84	12.12	8.46	16.25	6.67	7.69	9.00	20.0	6.25	12.50
CPOM	8.04	9.40	14.70	7.17	5.15	5.77	6.67	17.95	11.67	20.0	18.75	18.75
Sediments												
Mud	2.57	2.15	1.08	5.05	3.68	2.94						
Sand grains	7.72	6.29	9.45	11.11	6.07	10.69				20.0	18.75	18.75
Unidentified foods	1.93	3.03	1.14	13.13	16.91	35.18	20.0	20.51	39.99	20.0	43.75	43.75

FPOM = Fine Particulate Organic Matter; CPOM = Coarse Particulate Organic Matter

Table 4. *Analysis of stomach contents of A. akiri, C. aluuensis and M. electricus by %RF, %PP and methods in Station 1 in Qua Iboe River, Nigeria.*

Food items	*A. akiri*			*C. aluuensis*			*M. electricus*		
	Percentages								
	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD
Plant materials									
Leaf fragments							2.90	2.40	0.75
Roots							4.35	3.85	1.81
Palm fruit remains	50.0	69.81	81.45						
Fish									
Eggs	28.57	20.76	13.84						
Scales				18.18	33.33	30.30			
Flesh				18.18	26.67	24.25			
Insecta									
Dipteran larvae							11.59	6.73	8.45
Trichopteran larvae							11.59	6.73	8.45
Crustacea									
Shrimp				27.27	26.67	36.37	8.70	18.75	17.66
Copepods							5.80	21.64	13.59
Nemata							5.80	4.33	2.72
Detritus									
FPOM				9.09	2.22	1.01	8.70	2.40	2.26
CPOM				9.09	4.44	2.02	15.94	12.02	20.75
Sediments									
Sand grains	21.43	9.43	4.72	18.18	6.67	6.06	8.70	3.13	2.95
Stone							1.45	5.77	0.91
Unidentified foods							14.49	12.56	19.71

FPOM = Fine Particulate Organic Matter; CPOM = Coarse Particulate Organic Matter

Table 5. *Analysis of stomach contents of C. guntheri, H. fasciatus, T. mariae and Th. ansorgii by %RF, %PP and %IFD methods in Station 1 in Qua Iboe River, Nigeria.*

Food items	*C. guntheri*			*H. fasciatus*			*T. mariae*			*Th. ansorgii*		
	Percentages											
	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD
Algae												
Bacillariophyta	6.00	3.13	2.40				3.33	2.35	0.50	20.0	16.65	16.67
Chlorophyta	4.00	9.38	7.18	11.11	6.90	4.17	3.33	2.35	0.50			
Myxophyta	4.00	5.21	2.66							20.0	11.11	11.11
Plant materials												
Leaf fragments	2.00	1.04	0.27				20.00	30.59	38.91			
Insecta												
Insect remains	4.00	7.29	3.72	11.11	10.35	6.27						
Crustacea												
Cyclops	6.00	7.29	5.58									
Daphnia	14.00	9.89	10.63							20.0	50.0	50.0
Fish												
Eggs							3.33	1.18	0.25			
Scales	14.00	13.02	23.25	11.11	17.24	10.42	13.33	12.94	10.97			
Flesh				22.22	41.38	50.0						
Detritus												
FPOM	8.00	13.51	13.78				6.67	3.53	1.50	20.0	5.56	5.56
CPOM	4.00	8.33	4.25	22.22	17.24	20.83	10.00	7.06	4.49	20.0	16.67	16.67
Sediments												
Mud							13.33	7.06	5.99			
Sand grains	12.00	12.50	19.13	22.22	6.90	8.34	20.00	27.06	34.42			
Unidentified foods	6.00	9.38	7.18				6.67	5.88	2.47			

FPOM = Fine Particulate Organic Matter; CPOM = Coarse Particulate Organic Matter

Table 6. *Analysis of stomach contents of B. callipterus, B. longipinnis, C. nebulosum and P. abbreviata by %RF, %PP and %IFD methods in Station 1 in Qua Iboe River, Nigeria.*

Food items	*B. callipterus*			*B. longipinnis*			*C. nebulosum*			*P. abbreviata*		
	Percentages											
	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD
Algae												
Bacillariophyta				10.0	3.53	1.43						
Chlorophyta				10.0	12.12	9.39						
Plant materials												
Leaf fragments	24.64	30.06	40.96	10.0	7.58	7.55				14.29	10.35	8.58
Seeds				1.67	1.52	0.25						
Insecta												
Dipteran larvae										14.29	10.35	8.58
Wing ant				1.67	3.54	0.59						
Insect remains	18.84	16.56	16.80	11.67	13.13	15.26						
Coleopteran										14.29	10.35	8.58
Crustaceans												
Crab remains				1.67	4.04	0.67						
Penaeus sp	1.45	0.61	0.05									
Ostracods				3.33	6.57	2.18						
Cyclops	2.90	1.23	0.19									
Daphnia	1.45	1.84	0.14									
Fish												
Bones	1.45	1.23	0.10									
Scales										14.29	6.90	5.72
Fish remains							100	100	100	14.29	41.90	34.28
Detritus												
FPOM	14.49	12.88	10.05	5.00	2.02	1.01						
CPOM	17.39	14.72	12.17	10.00	8.08	8.05						
Sediments												
Sand grains				21.67	20.71	40.86				28.57	20.69	34.28
Unidentified foods	17.39	20.86	19.54	13.33	17.17	22.79						

FPOM = Fine Particulate Organic Matter; CPOM = Coarse Particulate Organic Matter

Table 7. *Analysis of stomach contents of E. bifasciatus, E. sexfasciatus and P. pulcher in Station 1 and T. guineensis in Station 2 by %RF, %PP and %IFD methods in Qua Iboe River, Nigeria.*

Food items	*E. bifasciatus*			*E. sexfasciatus*			*P. pulcher*			*T. guineensis*		
	Percentages											
	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD
Algae												
Bacillariophyta										40.0	13.32	60.60
Chlorophyta							10.57	7.90	4.66			
Dinophyta										10	6.67	3.03
Myxophyta										20.0	26.67	12.13
Plant materials												
Leaf fragments										10.0	33.33	15.16
Insecta												
Insect wing										10.0	13.33	6.06
Chironomid larvae							5.26	2.63	0.77			
Trichopteran larvae	46.67	72.22	89.94	29.17	48.67	67.25						
Insect remains	13.33	5.56	1.90	4.17	3.54	0.70						
Crustacea												
Shrimp remains				8.33	15.04	5.93						
Nemata				16.67	15.49	12.23						
Fish												
Scales							15.79	21.05	18.53			
Detritus												
FPOM	13.33	5.56	1.90	4.17	2.66	0.53	15.79	6.58	5.79			
CPOM	20.0	9.26	4.94	20.83	9.29	9.17	21.05	21.05	24.70			
Sediments												
Mud							10.57	3.95	2.33			
Sand grains							21.05	36.84	43.23	10.0	6.67	3.03
Unidentified foods	6.67	7.41	1.32	16.67	5.31	4.19						

FPOM = Fine Particulate Organic Matter; CPOM = Coarse Particulate Organic Matter

Table 8. *Analysis of stomach contents of C. nigrodigitatus, E. fimbriata, S. barracuda and S. melanotherodon by %RF, %PP and %IFD methods in Station 2 in Qua Iboe River, Nigeria.*

Food items	*C. nigrodigitatus*			*E. fimbriata*			*S. barracuda*			*S. melanotherodon*		
	Percentages											
	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD
Algae												
Bacillariophyta				49.60	47.11	57.04				36.36	25.0	23.63
Chlorophyta				4.13	2.89	2.54						
Dinophyta				4.74	7.22	6.24						
Myxophyta										9.09	8.33	5.26
Plant materials												
Leaf fragments	11.11	4.65	3.77				22.22	6.67	6.67	18.18	33.33	42.10
Insecta												
Dipteran larvae				2.48	3.47	1.83						
Crustacea												
Penaeid shrimp	33.33	34.88	39.64									
Ostracods				1.65	1.78	0.61						
Calanoids				9.91	14.38	11.48						
Crab remains	11.11	27.91	22.65	14.87	22.01	4.07						
Molluscs												
Bivalve	22.22	9.30	15.09									
Neritina sp	11.11	6.98	5.66									
Nemata										9.09	16.67	10.53
Protozoans												
Foraminifera				4.13	4.05	3.56						
Tinitinnida				4.96	3.76	3.97						
Fish												
Fish remains	11.11	16.28	13.21				66.60	93.33	93.33			
Detritus												
FPOM				4.13	3.18	2.79				9.09	4.17	2.63
CPOM				3.31	2.31	1.63						
Sediments												
Sand grains				4.96	4.05	4.27				18.18	12.5	15.79

FPOM = Fine Particulate Organic Matter; CPOM = Coarse Particulate Organic Matter

Majority of the fish species in STN 1 were mostly predators (11 species; 61.11%) and the least (3 species; 16.67%) were herbivores. Nine (50.0%) species constituted detritivores. Similar pattern also occurred in STN 2 but with slight variation: the most abundant feeding habit was predators (9 species; 52.94%) and the least (I species; 5.88%) was herbivore. Algivore were made up of three species (17.65%) and detritivores were observed in four species (23.52%). Generally, most of the fishes were predators.

Table 3 showed significant %IFD of the food items considered to be of primary importance in *B. brachyistus* to be algae (11.92), insects (26.95), crustaceans (12.75), detritus (22.54), sediments (10.53); in *E. calabaricus,* insect (21.42), detritus (22.02) and sediments (13.63); in *I. henrgii,* algae (10.01), fish (15.67) and detritus (20.67) and in *X. nigri,* insects (13.07) and sediments (18.75).

Table 4 depicted the significant %IFD of food items considered to be of primary importance in *A. akiri* to include plants (81.45) and fish (13.84); in *C. aluuensis,* fish (54.55) and crustaceans (36.37) and in *M. electricus*, detritus (23.01) and crustaceans (31.25).

IFD (%) values of food items considered to be of primary importance in *Th. ansorgii, T. mariae, H. fasciatus* and *C. guntheri* were algae (27.78), crustaceans (50.00), detritus (22.23); algae (38.91), fish (11.22), detritus (40.41); fish (60.42) and detritus (20.83); and algae (12.24), crustaceans (16.21), fish (23.25), detritus (18.06) and sediments (19.13) respectively as illustrated in Table 5.

Table 6 showed the %IFD of food items considered as primary importance in *B. callipterus* to be plants (40.96), insects (16.80) and detritus (22.22); in *B. longipinnis,* algae (10.82), insects (15.85) and sediments (40.86); in *C. nebulosum,* fish (100) and in *P. abbreviata* as insects (17.16), fish (40.00) and sediments (34.28).

The IFD (%) values of food items considered to be of primary importance in *E. bifasciatus, E. sexfasciatus, P. pulcher and T. guineensis* were insects (91.84); insects (67.95) and crustaceans (18.16); fish (18.53), detritus (30.49) and sediments (45.56); and algae (75.76) and plants (15.16) respectively as shown in Table 7.

IFD (%) values of food items considered to be of primary importance in *C. nigrodigitatus, E. fimbriata, S. barracuda* and *S. melanotherodon* were crustaceans (62.29), molluscs (20.75) and fish (13.21); algae (65.82) and crustaceans (16.16); fish (93.33); and algae (28.89), plants materials (42.10) and nemata (10.53) respectively as seen in Table 8.

IFD (%) values of food items considered to be of primary importance in *P. jubelini, P. peroteti, T. goreensis* and *T. teraia* were crustaceans (53.17), annelids (11.40) and fish (32.28); fish (86.67) and detritus (13.33); crustaceans (88.89), sediments (11.11) and detritus (13.33); and sediments (100) respectively as shown in Table 9.

Table 9. *Analysis of stomach contents of P. jubelini, P. peroteti, T. goreensis and T. teraia by %RF, %PP and %IFD methods in Station 2 in Qua Iboe River, Nigeria.*

Food items	*P. jubelini*			*P. peroteti*			*T. goreensis*			*T. teraia*		
	Percentages											
	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD
Crustacea												
Penaeid shrimp	11.77	10.00	7.60				50.00	88.89	88.89			
Crabs	17.65	40.00	45.57									
Annelida												
Polychaetes	23.54	15.00	11.40									
Fish												
Bones	17.65	25.00	28.48									
Scales	11.77	5.00	3.80									
Fish remains				33.33	86.67	86.67						
Detritus												
FPOM	11.77	3.33	2.53	33.33	10.00	10.00						
CPOM	5.88	1.67	0.63	33.33	3.33	3.33						
Sediments												
Sand grains							50.00	11.11	11.11	100	100	100

FPOM = Fine Particulate Organic Matter; CPOM = Coarse Particulate Organic Matter

Table 10. *Analysis of stomach contents of B. soporator, E. aeneus, P. elongatus and P. quadrifilis by %RF, %PP and %IFD methods in Station 2 in Qua Iboe River, Nigeria.*

Food items	*B. soporator*			*E. aeneus*			*P. elongatus*			*P. quadrifilis*		
	Percentages											
	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD
Crustacea												
Shrimp							15.79	25.11	32.76			
Crab remains							7.90	12.55	8.19			
Mysis							15.80	12.14	7.92	50.00	77.78	77.78
Copepods							5.26	2.51	1.09			
Fish												
Bones	100	100	100				13.16	19.25	20.93			
Scales							10.53	10.53	9.47			
Flesh							15.71	20.55	16.37	50.00	22.22	22.22
Fish remains				100	100	100						
Detritus												
FPOM							7.90	2.51	1.64			
Sediments												
Sand grains							7.90	2.51	1.64			

FPOM = Fine Particulate Organic Matter; CPOM = Coarse Particulate Organic Matter

Table 10 illustrated the significant values of IFD (%) of food items considered to be of primary importance for *B. soporator* to include fish (100); in *E. aeneus,* fish (100); in *P. elongatus,* crustaceans (49.96) and fish (46.77); and in *P. quadrifilis,* crustaceans (77.78) and fish (22.22).

The %IFD of food items considered to be of primary importance in *L. dumerili, L. falcipinnis, L. grandisquamis* and *M. curema* included algae (19.06), plants (10.65), detritus (11.78) and sediments (57.95); algae (21.86), detritus (15.21) and sediments (67.36); algae (10.91), detritus (14.15) and sediments (63.34); and algae (41.30) and sediments (38.71) respectively as shown in Table 11.

However, high values of unidentified foods were recorded in STN 1 for *E. calabaricus* (35.18), *I. henrgii* (39.99), *X. nigri* (43.75), *M. electricus* (19.71), *B. callipterus* (19.54), *B. longipinnis* (22.79) and *S. melanotherodon* (15.79) but low

value was observed only in *L. falcipinnis* (0.07) in STN 2.

Table 11. *Analysis of stomach contents of L. dumerili, L. falcipinnis, L. grandisquamis and M curema by %RF, %PP and %IFD methods in Station 2 in Qua Iboe River, Nigeria.*

Food items	*L. dumerili*			*L. falcipinnis*			*L. grandisquamis*			*M. curema*		
	Percentages											
	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD	RF	PP	IFD
Algae												
Bacillariophyta	28.75	19.58	11.76	29.75	16.71	9.49	31.54	17.87	9.80	61.12	44.83	39.38
Chlorophyta	7.18	5.26	2.62	4.01	2.08	0.47	2.57	1.74	0.32			
Dinophyta	7.79	5.16	1.88	5.63	3.09	11.33	1.54	0.70	0.13	5.56	3.45	2.15
Myxophyta	2.99	6.59	2.80	3.61	2.08	0.57	4.36	3.37	0.66			
Plant materials												
Leaf fragments	8.98	9.07	10.65	4.82	3.38	2.07	9.23	9.07	10.18			
Insecta												
Chironomid larvae				1.21	1.42	0.22						
Insect remains				1.61	0.87	0.19						
Crustacea												
Conchoecia				3.21	1.96	0.80	1.54	1.13	0.21			
Calanoids copepod				2.41	1.31	0.26						
Mysis	0.60	0.83	0.07									
Harpaticoid copepod				1.61	0.87	0.19	2.05	1.31	0.33			
Protozoa												
Foraminifera				3.41	1.64	0.39	1.54	0.96	0.18			
Tintinnida							4.11	2.88	0.52			
Nemata	0.60	0.41	0.03	2.41	1.53	0.47	1.28	1.05	0.16	5.56	3.45	2.15
Fish												
Scales	1.80	2.06	0.49	4.02	2.84	1.42	1.54	1.05	0.20			
Detritus												
FPOM	5.99	3.30	2.59	10.04	11.56	14.71	9.48	8.81	10.16	5.56	10.35	6.46
CPOM	8.98	7.83	9.19	2.01	1.96	0.50	6.16	5.32	3.99	5.56	3.45	2.15
Sediments												
Mud	8.38	9.27	10.16	6.43	5.45	4.44	11.53	30.51	42.79	5.56	6.90	4.31
Sand grains	11.98	30.39	47.79	12.44	39.91	62.92	11.53	14.65	20.55	11.11	27.59	34.40
Unidentified foods				0.80	0.65	0.07						

FPOM = Fine Particulate Organic Matter; CPOM = Coarse Particulate Organic Matter

4. Discussion

The knowledge of the diet of a species in nature is important for the establishment of its nutritional needs and of its interaction with other organisms [31], and the presence of various food types (plants, animal, detritus and sediments) in their stomachs is an indication of their feeding habits. The food items have their origins from all habitats of the aquatic system – surface, mid-water and bottom; from within and outside the river system. Mud, sand grains and sediments were picked from the bottom of the river. [32] in agreement with these observed trends showed that *C. tamandua* in Anambra River was able to exploit all food niches (bottom, mid-water and water surface) in its habitats; thus exhibiting wide plasticity (i.e. high trophic flexibility) in its feeding behaviours. [33 and 34] had in agreement with this finding reported that autochthonous and allochthonous insects constituted important proportion of food of many fish species inhabiting the Anambra river system. However, this report however is in consonance with the reports of [35, 36 and 32] that many tropical fresh water fishes have a broader trophic spectrum during the rainy (flood) season.

Of the 543 specimens examined, 204 (37.57%) had empty stomachs, 79 (14.55%) had full stomachs whereas the partially full: 63 (11.60%), 89 (16.39%) and 82 (15.10%) were for ¾, ½ and ¼ respectively. In all, the proportion of fish with food in the stomachs were higher (339; 62.43%) than stomachs without food (204; 37.57%). This implies there is a higher percentage of full stomachs and hence, a high feeding intensity. The abundance of a rich food resource enabled the fish to have a wide variety of choices to make particularly in the estuarine zone. This agrees with the observations of [8, 37] but this finding is not in consonance with [38] in which a higher number of empty stomachs was reported in Anambra River.

Food dominance varied from one species to another and from one station to another. Generally, the dominant food items were fish and sediments. Some species were found to ingest different fish parts and whole fish in their diets; for instance, *B. soporator* (100%), *C. nebulosum* (100%) and *S. barracuda* (93.33%). A greater number of the species fed on mud/sand grains; which must have been incidentally taken along with other targeted food items. Sediment constitutes important food resource since they have attached microbes and nutrients. [37] reported that inclusion of sand / mud as food item is an indication that the species feed close or even at the bottom of the water. However, unspecialized feeders

(feeding on both plants and animals) have been reported to be a feeding pattern according to abundance of items in the environment [36 and 39].

High food richness was recorded in this research as revealed by the forty-two food items ingested which was re-grouped into thirteen different major items. The ingestion of diversified and non-selectivity of food items by fish species confirms the findings of [9, 40, 41 and 37]. More food items occurred in estuarine than in freshwater zones. Estuaries have been considered as feeding, spawning and nursery grounds as a result of abundance of food materials. They have been linked with high productivity partly due to the mixing of the freshwater with the high saline water and leaf litter decomposition. Food item availability is dependent on several factors: type of water body, species type and [8] reported that seasonal diversity of food items could influence food habits, diet and feeding intensity of fish.

Fish can broadly be classified into categories based on their predominant feeding habits [36] and these could be determined by their primary food item(s). The feeding habits of the fish in the two zones appeared to be similar but there are, however, slight variations. In the freshwater zone, three broad trophic groups (herbivores, predators, and detritivores) and in the estuarine zone, four broad groups (algivores, herbivores, predators and detritivore) were identified. Considering all, most of the species were predators feeding on insects, crustaceans and fish. This finding deviates from the findings of [30] in which most of the freshwater fishes in Cross River inland wetlands were detritivores. Findings in this study that the mugilids are "detritivore-algivores" feeding mostly on sediments, detritus and algae agree with observations by [11] who described them as detrital feeders. The high percentage of plant materials, algae, and detritus agree with findings of [42, 9, 43 and 30] who reported that members of this family were plankton, higher plants and algae feeders or macrophagous as well as mud suckers. However, the observations of [44] are at variance with this result who reported that they were euryphagous except for bottom feeders in the family's Cichlidae and Mugilidae. Also, [45] reported that analysis of trophic niches of the available fish species in River Ganga basin indicated dominancy of carnivorous (19 species) in Ken and omnivorous (23 species) in Betwa.

The six stomachs of *P. africana* investigated were all empty. However, [46] classified *P. obscura* as piscivore, although the stomachs of the 2 specimens caught in Upper Ogun River were empty. Fish and sediments were the dominant food items. The high IFD values derived from other fish, such as chunks of fish flesh among the stomach contents of *H. fasciatus* and *C. aluuensis* suggest that they are more of scavengers than piscivores. This type of food item is probably derived from dead or dying fish caught in set nets or discarded fish found scattered about in the beach especially in the estuarine zone. Higher values of unidentified food items (ranged from 15.79% in *S. melanotherodon* – 43.75% in *X. nigri*) and a greater number of species (7) were recorded more in the freshwater zone than (only one species: *L. falcipinnis*, 0.07%) in the estuarine zone. The inability to identify these materials might be due to the fact that digestion had gone far. But they constitute very important matter in the gut since they occupied space agreeing with several authors working on food and feeding habits of fish species [9, 47, 48 and 34].

The ingestion of various sources of dietaries by these fish species help to reduces possible competition between them to the minimum and encourages healthy coexistence. The fish species are euryphagous, feeding on several food items ranging from plant and animal to non-living matters. Interrelationship existed between the freshwater and estuarine fish which were classified as algivores, herbivores, predators and detritivores; implying a balanced system and which all the species could generally be described as omnivores.

5. Conclusion

Thirteen major items made up of forty-two simpler food items occurred in the stomachs of these fish species. Food dominance varied from one species to another and from one station to another with fish and sediments being the highest and dominant. The six specimens of *P. africana* had empty stomachs. Percentage of stomachs with food was higher than those without food. Feeding interrelationship existed between the freshwater and estuarine fish species which were classified as algivores, herbivores, predators and detritivores. These wide feeding habits aid in reduction of possible competition between them to the minimum and encourage healthy coexistence. This work has bridged the gap by furnishing information on multispecies food and feeding habits of fish in this river. There is an urgent need to study the ecosystem's functioning which lays in the analysis of the energy flow among the fish species.

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