TROPHIC SPECTRA AND RELATIONSHIP OF FISH SPECIES ASSEMBLAGES IN QUA IBOE RIVER, NIGER DELTA, NIGERIA

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ABSTRACT

The trophic relationship of fish species in a coastal river in Akwa Ibom State were investigated to show trends in the feeding activity and condition factor from July – October 2008. 356 specimens were sampled from the Qua Iboe River which composed of 20 species, making it a total of 12 families and 20 genera. Feeding activity varied thus: GRI (16.65% in Thysochromis ansorgii – 100% in Xenomystus nigri, Isichthys henrgii, Anaspidoglanis akiri, Pelvicachromis pulcher and Polycentropsis abbreviata); AGR (1.31 in Barbus callipterus – 14.57 in A. akiri) and mean GSI (0.06% in Th. ansorgii – 7.09% in Epiplatys bifasciatus). Least mean value (K = 0.26) of condition factor was observed in I. henrgii while the highest (K = 2.06) was obtained in Tilapia mariae. The proportion of fish with food in the stomachs were higher (199; 55.90%) than stomachs without food (157; 44.10%) but were statistically insignificant (P > 0.05). The fishes were found to ingest a wide spectrum of materials ranging from microscopic to macroscopic organisms made up of 10 major food items. Thus, the fish species were classified into three broad trophic groups: herbivores, predators and detritivores. However, overlaps existed; they were found to feed on more than one type of food item which reduced competition.

Keywords: gut contents, condition factor, food items, feeding intensity, freshwater

INTRODUCTION

The food of fishes constitutes a limiting factor and is competed for among the various species of fishes and other fauna in a given aquatic system (Royce 1984). Stomach content of many African inland water fishes have been studied with a view to ascertaining their dietary requirement in their natural habitats and biotic environments (Adebisi, 1981). Fish feed because they require energy for the processes of life which include reproduction, growth and development. The feeding habit of a fish is the search for and ingestion of food, while the food habit or diet refers to the materials that are habitually eaten by the fish. The food supplies are basic determining factors that influence the relative well being, growth rate, abundance and distribution of fishes. Fishes feed on a wide spectrum of materials ranging from microscopic to macroscopic organisms and/or detrital matter. Essential to such studies is the fact that the food of fishes varies for individual species with their age, locality and season (Ikpi and Okey, 2010; Adeniyi *et al*., 2012). The success of fishes in terms of their diversity and number is to a large extent the measure of their success in finding adequate food. According to Rao (1964), the magnitude of fish stocks in any region is a function of its food potentialities. In various studies aimed at understanding the feeding regimes, food preference, migrations, growth and breeding patterns of fish, diet has been found to be an important factor, especially in governing their growth, condition factor, fecundity and migration patterns (Adeyemi *et al*., 2009; Offem *et al.*, 2009; Ekpo *et al*., 2014).

The fishes in Qua Iboe River, Nigeria are exposited under subsistence and artisanal fisheries. In spite of the presence and abundance of important economic and commercial fish species in this river, there is no record on their food and feeding habits. The knowledge of the food and feeding habits of fishes provide answers to practical problems which arise in relation to human exploitation (Uwem *et al*., 2011; Ekpo *et al*., 2014) such as abundance. Studies on natural feeding of fish could provide useful information on the trophic relationships in aquatic ecosystems (Abdel-Aziz and Gharib, 2007), which could be used in formulating management strategy options in a multi species fishery (Khan *et al.*, 1988; Omondi *et al.*, 2013). Therefore, the present study on the food and feeding habits of common fish species in Qua Iboe River is conducted to make available this important information. The main objectives of this work are to study diet composition, trophic relationship, feeding activity, relationship between condition factor and diet/feeding activity.

MATERIALS AND METHODS

Description of the study area

Qua Iboe River (4^o 39′ 27.61″N; 7^o 52′ 42.18″E) (Fig. 1) is the dominant hydrographic feature in Akwa Ibom State, Nigeria. It drains a catchment area of about 7,092 km^2 and the river course covers a distance of C.151 km from its source at Umudike in Imo State to where it discharges into the Atlantic Ocean at the Bight of Bonny close to Ibeno (Upenekang Local Government Area). Hence, it lies within the tropical region in the South-eastern corner of Nigeria. The freshwater zone stretches from the outskirts of Umudike (its source) in Imo State and flows through the main channel southwards to Eket, Akwa Ibom State. It covers a distance of approximately C.111 km. The morphological and physiographic features in the river change downstream as the river channel widens. The riparian vegetation consists of freshwater plant species which shade the channel. The substrate is of the coarse type, consisting of cobbles, pebbles, coarse sand and gravels and fine sand/silt particularly at Eket. The channel morphology ranges from narrow shallow pools/riffles, open channel deep pools, wide deep flowing pools, to very wide channel with very deep pools at Eket. The shoreline characteristics comprise sandy edges with cobbles and gravels (Akpan, 1991).

Two seasons (dry and wet) are also experienced in this zone. The dry season ranges between November and April, while the wet season ranges between May and October. Rainfall is significantly lower at the headwater, but it increases downstream. The Qua Iboe River basin is subject to heavy rainfall with committing changes in the physical characteristics. The heavy rainfall in the river basin results in substantial leaching of the soil nutrients and the transport of large amounts of allochthonous organic matter into the river. Rainfall therefore, is the most important hydro-meteorological variable that affects its physical hydrology (Akpan, 1991). The study area has been described in more detailed elsewhere (Tabal Consultants, 1979; King and Akpan, 1998).

Fish capture and identification

Fish sampling was conducted with the help of local fishermen using traditional fishing gear such as hook and line, set gillnets and basket traps from July – October 2008. A combination of these fishing methods was necessary since all of them were selective in one way or the other (Whyte, 1975). Pending examination, the specimens were preserved for not more than five days in a deep freezer or in 10% formalin to reduce post humus digestion to the minimum (Fagade and Olaniyan, 1973). Fish caught were identified with the aid of as Teugels *et al*., (1992); Idodo-Umeh (2005); and Adesulu and Sydenham (2007). Each specimen was measured, weighed, later dissected and the stomach slit open to remove its contents which were weighed, using a top loading mettle 'Ps 165' electron balance (Ekpo *et al*., 2014).

Fig. 1: Map of Qua Iboe River in Akwa Ibom State showing sampling station. Insert: Map of Nigeria showing the location of sampling station (Source: Google earth, 2014)

Gut contents analyses

Each slit stomach was assigned a number of points proportional to its degree of fullness according to an arbitrary 0-20 point scale (Hyslop, 1980). In this method, 0, 5, 10, 15 and 20 points were scored for empty, ¼ full, ½ full, ¾ full and full stomachs respectively. Intermediary points were also allotted where necessary according to the proportion of food in the stomach. Stomach contents were sorted out into categories using Needham and Needham (1962) and analyzed using Relative Frequency (%RF) methods (Hyslop 1980; King 1988a, b):

$$RF = \frac{F_i}{F_i} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where F_i = Frequency of item i; F_i = Frequency of the n^{th} item i.e. number of all F_i.

All RF values sum up to 100%. RF is unweighted by the actual amounts of items in the stomachs but is responsive to the frequency of each in relation to the frequencies of all others (King, 1988a, b).

The integrated importance of each food item was then expressed as an Index of Food Dominance (IFD) (King *et al*., 1990) according to the formula:

$$IFD = \frac{RF.PP}{\sum RF.PP} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, RF = % Relative Frequency of food item; PP = % Point Percentage

This index ranges from 0 - 100%. Food items with IFD ≥ 10% were arbitrarily considered as primary diets; those with IFD between 1 - 9.9% as secondary diets and those with IFD < 1% as incidental food items. The use of IFD to establish overall food preponderance is adequate as it incorporates the RF and PP data, thus minimizing the bias characteristic of cases in which results from different analytical methods are independently interpreted (King *et al*., 1990).

The Gastrosomatic Index (GSI) was calculated to show the trends in the feeding activity of the fish according to the formula (Khan *et al*., 1988):

GSI = 100Wf/Wt … … … … … (3)
Where, Wf = Weight (g) of food in the gut; Wt = Total weight (g) of the fish

The Gut repletion index (GRI) was calculated using the formula:

$$GRI = \frac{Number\ of\ non-empty\ guts}{Total\ number\ of\ specimens\ examined} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

In the point method, the points previously assigned to each stomach were shared among the various contents or food items, taking account of the relative proportions by volume. The mean points gained by each food item were determined. 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. Mean points per stomach were then computed to give the Average Gut Fullness (AGF) (King, 1988a) as:

$$AGF = \frac{\sum P}{\sum PP} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Fish condition factor was calculated according to Pauly (1983) as:

$k = 100TW/L^3$… … … …… … (6)

The condition factor of a fish is regarded as the fitness or relative well-being of the fish and it indicates the general metabolism of the fish (Sambilay, 1992). Condition factor depends on how well a fish feeds and generally, it is believed that small-sized individuals feed more than the larger ones. Therefore, fishes with condition factor values greater than one (≥ 1) were considered as high while those < 1 were low.

For fishes without stomachs, the anterior ends of the intestine were opened and the contents removed for analyses.

RESULTS

A total of 356 specimens comprising 20 species were examined for food and feeding habits. Table 1 shows fish families, species, total number of specimens, specimens with food and specimens without food. The number and proportion of fish with food in the stomachs were higher (199; 55.90%) than stomachs without food (157; 44.10%) but were statistically insignificant ($P > 0.05$).

Table 1: Families, species, total number of specimens sampled showing stomachs with and without food among the fish in Qua Iboe River, Nigeria

Fish families	Fish species	N	SF	SWF
Polypteridae	*Erpetoichthys calabaricus* (Smith, 1866)	24	21	3
Notopteridae	*Xenomystus nigri* (Gunther, 1868)	1	1	-
Mormyridae	*Brienomyrus brachyistus* (Gill, 1863)	45	3	1
	Isichthys henrgii (Gill, 1863)	3		-
Characidae	*Brycinus longipinnis* (Gunther, 1864)	20	14	6
Cyprinidae	*Barbus callipterus* (Boulenger, 1907)	125	34	91
Bagridae	*Anaspidoglanis fasciatus* (Geoffery St. Hilarire, 1827)	1	-	1
	Anaspidoglanis akiri (Rich, 1987)	7	7	1
	Chrysichthys aluuensis (Risch, 1985)	7	3	4
Malapterinidae	*Malapterurus electricus* (Gmelin, 1789)	30	21	9
Cyprinodontidae	*Epiplatys bifasciatus* (Steindachner, 1881)	9	8	1
	Epiplatys sexfasciatus (Gill, 1882)	21	10	11
Cichlidae	*Thysochromis ansorgii* (Boulenger, 1911)	6	1	5
	Hemichromis fasciatus (Peters, 1857)	12	4	8
	Chromidotilapia guntheri (Sauvage, 1882)	18	11	7
	Tilapia mariae (Boulenger, 1911)	12	10	2
	Pelvicachromis pulcher (Boulenger, 1901)	4	4	-
Channidae	*Parachanna africana* (Steindachner, 1897)	6	-	6
Anabantidae	*Ctenopoma nebulosum* (Gunther, 1864)	3	1	2
Nandidae	*Polycentropsis abbreviata* (Boulenger, 1901)	2	2	-
Total		**356**	**199**	**157**

N = No. of specimens sampled; SF = Specimens with food; SWF = Specimens without food

Size ranges

Table 2 highlights total length (TL, cm) and total weight (Wt, g) ranges of the species. The largest fish in terms of size was *Erpetoichthys calabaricus* (35.10 cm TL) whereas the smallest fish was *Epiplatys bifasciatus* and *E. sexfasciatus* (2.60 cmTL). The heaviest fish was *Erpetoichthys calabaricus* (55.30 g TW) while the lightest fish was *Barbus callipterus, Epiplatys bifasciatus* and *E. sexfasciatus* (0.10 g TW). Mean values of total length were higher in *Erpetoichthys calabaricus* (27.72) and lower in *Epiplatys bifasciatus* (3.14). Mean total weight was observed to be highest in *Erpetoichthys calabaricus* (28.03) and lowest in *Epiplatys bifasciatus* (0.14).

Table 2: Total number of specimens sampled (N) and size ranges of fish species in Qua Iboe River, Nigeria

Fish species	N	Total length (range) (g)	Total weight (range) (g)
Erpetoichthys calabaricus	24	27.72 - 35.10	28.33 - 55.30
Xenomystus nigri	1	16.20	25.60
Brienomyrus brachyistus	45	3.60- 11.70	0.30 - 12.10
Isichthys henrgii	3	4.70 - 11.10	0.30 - 3.50
Brycinus longipinnis	13	7.50 - 9.80	4.30 - 11.10
Barbus callipterus	125	4.60 - 8.00	1.00 - 6.40
Anaspidoglanis fasciatus	1	10.00	10.00
Anaspidoglanis akiri	7	6.50 - 10.00	3.30 - 12.10
Chrysichthys aluuensis	7	6.00 - 7.70	1.80 - 6.50
Malapterurus electricus	13	7.70 - 19.30	5.40 - 91.20
Epiplatys bifasciatus	9	2.60 - 3.60	0.10 - 0.30
Epiplatys sexfasciatus	21	2.60 - 6.10	0.10 - 1.60
Thysochromis. ansorgii	6	3.10 - 10.30	0.30 - 13.80
Hemichromis fasciatus	12	2.60 - 9.10	0.20 - 10.00
Chromidotilapia guntheri	18	3.70 - 11.40	0.60 - 25.10
Tilapia mariae	12	7.00 - 11.70	4.70 - 37.00
Pelvicachromis pulcher	8	6.60 - 10.20	4.40 - 12.30
Parachanna africana	6	7.50 - 20.60	3.60 - 40.50
Ctenopoma nebulosum	3	6.90 - 13.30	6.50 - 44.40
Polycentropsis abbreviata	2	3.90 - 8.00	0.70 - 9.80

Table 3 indicated mean total length (TL, cm), mean total weight (Wt, g), mean condition factor (K), gut repletion index (GRI %), average gut fullness (AGF) and mean gastrosomatic index (GSI %). Condition factor of each species showed variation thus: least mean value (K = 0.26) was observed in *I. henrgii* while highest mean value (K = 2.06) was obtained in *Tilapia mariae* as shown in Table 4. Feeding activity depicted in Table 3 varied thus: GRI (16.65% in *Th. ansorgii* – 100% in *X. nigri*, *I. henrgii, A. akiri, P. pulcher* and *P. abbreviata*); AGR (1.31 in *B. callipterus* – 14.57 in *A. akiri*) and mean GSI (0.06% in *Th. ansorgii* – 7.09% in *E. bifasciatus*).

Table 3: Mean size variation, mean condition factor (K) and feeding intensity of fish species in Qua Iboe River, Nigeria

Fish species	Mean TL (cm)	Mean Wt (g)	Mean K	GRI (%)	AGR	Mean GSI (%)
Erpetoichthys calabaricus	27.72	28.03	0.56	87.50	11.25	0.49
Xenomystus nigri	16.20	25.60	0.60	100.00	16.00	1.15
B. brachyistus	6.88	2.40	0.56	97.78	13.84	1.85
Brienomyrus brachyistus	8.23	1.83	0.26	100.00	13.33	4.24
Isichthys henrgii	8.46	7.78	1.21	30.77	10.15	1.25
Brycinus longipinnis	6.48	2.94	1.03	70.00	1.31	0.16
Barbus callipterus	10.00	10.00	1.00	27.20	-	-
Anaspidoglanis fasciatus	8.71	8.26	1.18	100.00	14.57	2.17
Anaspidoglanis akiri	6.76	2.26	1.02	-	6.43	0.20
Chrysichthys aluuensis	11.53	26.81	1.33	70.00	10.20	1.60
Malapterurus electricus	3.14	0.14	0.46	88.89	7.00	7.09
Epiplatys bifasciatus	4.41	0.50	0.49	47.62	5.88	2.31
Epiplatys sexfasciatus	5.43	3.75	1.35	16.65	3.00	0.06
Thysochromis. ansorgii	7.63	10.18	1.30	33.33	4.00	0.19
Hemichromis fasciatus	6.99	6.87	1.35	61.11	6.28	0.32
Chromidotilapia guntheri	8.23	13.09	2.06	83.33	12.83	1.42
Tilapia mariae	8.10	7.43	1.34	100.00	9.50	0.52
Pelvicachromis pulcher	14.20	22.75	0.62	-	-	-
Parachanna africana	9.73	21.80	1.95	33.33	3.33	0.10
Ctenopoma nebulosum	5.95	5.30	1.55	100.00	14.50	2.47

The diet of all the fish species showed that there were ten major food items as depicted in Fig. 2. Arranging them in descending order, these were: sediments (15; 75.16%), detritus (14; 70.15%), fish and insects (13; 65.14%), macrophytes (11; 55.11%), algae (9; 45.90%), nematodes (20.40%), crustaceans and unidentified foods (8; 40.90%), and amphibians (1; 5.10%).

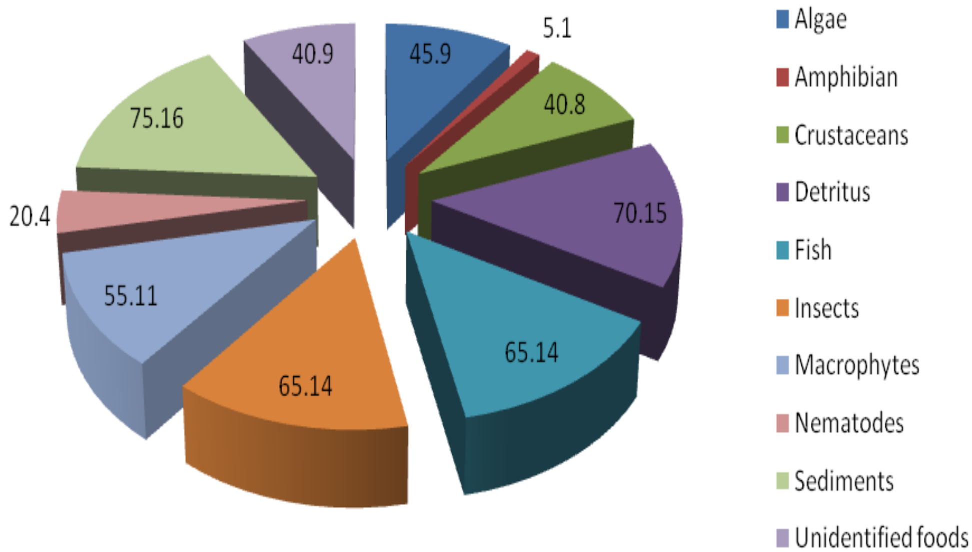

Fig. 2: Relative frequency (%RF) of the food items found in the guts of fish in Qua Iboe River, Nigeria

Feeding intensity and fish diets

Erpetoichthys calabaricus

Out of the 24 specimens examined for food, 3 had empty stomachs while 21 contained food (Table 1). TL and Wt ranges of the specimens are depicted in Table 2 while the mean TL and mean Wt are shown in Table 3. The overall stomach contents of *E. calabaricus* (Fig. 3) revealed that 9 major items were ingested, of which 4 (detritus, insects, sediments and unidentified foods) were of primary importance while 3 (algae, macrophyte materials and crustaceans) were of secondary importance and 2 (tadpoles and fish scales) were of incidental importance. The indices of feeding intensity viz: AGF, GSI and GRI were 11.25, 0.4% and 87.5% respectively suggesting that it was an active feeder but had low relative well-being (Table 3).

Xenomystus nigri

Only one specimen was examined and it had food in the stomach (Table 1). TL and Wt ranges of the specimens are depicted in Table 2 while the mean TL and Wt means are shown in Table 3. The trophic spectrum of *X. nigri* (Fig. 3) showed that 4 major food items were eaten; all (insects, detritus, sediments and unidentified foods) of which were of primary importance. The indices of feeding activity showed that AGF was 16, 1.15% GSI and 100% GRI indicating that it was an active feeder but had low relative well-being (Table 3).

Brienomyrus brachyistus

Of the 45 specimens examined, only one had an empty stomach (Table 1). The TL and Wt mean ranges and TL and Wt means were recorded in Tables 2 and 3 respectively. The gut contents of *B. brachyistus* revealed that 9 major items constituted its diet; 5 (algae, insects, crustaceans, detritus and sediments) were of primary importance while 4 (macrophyte materials, nematodes, fish and unidentified foods) were of secondary importance (Fig. 3). The trends in the feeding activity with respect to AGF, GSI and GRI were 13.84, 1.85% and 97.78% respectively which suggest that this species fed actively but had low relative well-being (Table 3).

Isichthys henrgii

All the three specimens examined contained food in their stomachs (Table 1). TL and Wt ranges and TL and Wt means were depicted in Tables 2 and 3 respectively. The IFD of *I. henrgii* (Fig. 3) showed that its diets were made up of 7 major items; 4 (algae, fish, detritus and sediments) off which were of primary importance while 3 (macrophyte materials, insects and nematodes) were of secondary importance. The indices of feeding activity viz: AGF, GSI and GRI were 13, 33, 4.24% and 100% respectively, suggesting that it was an active feeder with low condition factor (Table 3).

Brycinus longipinnis

Out of 20 specimens examined for food, 14 had empty stomachs while 6 contained food (Table 1). The TL and Wt mean ranges and TL and Wt means were recorded in Tables 3 and 4 respectively. The trophic spectrum of *B. longipinnis* (Fig. 3) revealed that 7 major items were ingested, 4 (algae, insects, sediments and unidentified foods) were of primary importance while 3 (macrophyte materials, crustaceans and detritus) were of secondary importance. The indices of feeding intensity revealed that AGF was 10.15, 1.25% GSI and 30.77% GRI which suggested that this species was not an active feeder but had high relative well-being (Table 3).

Barbus callipterus

Of the 125 specimens examined for food, the anterior parts of the small intestine of 91 specimens were empty while 34 contained food (Table 1). The TL and Wt mean ranges and TL and WL means were shown in tables 3 and 4 respectively. The overall stomach contents of *B. callipterus* (Fig. 3) showed that 6 major items constituted its diet, of which 4 (macrophyte materials, insects, detritus and unidentified foods) were of primary importance while 2 (crustaceans and fish) were of incidental importance. The trends in the feeding activity with respect to AGF, GSI and GRI were 1.31, 0.16% and 70% respectively, suggesting that this species fed actively and had high condition factor (Table 3).

Auchenoglanis fasciatus

Only one specimen with an empty stomach was examined (Table 1). The TL and Wt mean ranges and TL and Wt means were recorded in Tables 2 and 3 respectively. The trend in the feeding activity with respect of GSI (27.2%) indicated that it was not an active feeder but showed high relative well-being (Table 3).

Auchenoglanis akiri

Of the seven specimens examined for food, no specimen with empty stomach was encountered (Table 1). The TL and Wt mean ranges and TL and Wt means were recorded in Tables 2 and 3 respectively. The overall gut contents of *A. akiri* (Fig. 3) revealed that 3 major food items were ingested; 2 (macrophyte materials and fish) were of primary importance while or (sediments) occurred secondarily. The indices of feeding intensity viz: AGF, GSI and GRI were 14.57, 2.17% and 100% respectively indicating that it was an active feeder with high relative well-being (Table 3).

Chrysichthys aluuensis

Out of seven specimens examined for food, 4 had empty stomachs while 3 contained food (Table 1). The TL and Wt mean ranges and TL and Wt means were shown in Tables 2 and 3 respectively. The trophic spectrum of *C. aluuensis* (Fig. 3) showed that 4 major dietaries were ingested; 2 (crustaceans and fish) were of primary importance while 2 (detritus and sediments) were also of secondary importance. Trends in the feeding activity viz: 6.43 (AGF) and 0.20% (GSI) suggested that this species does not feed actively but has high condition factor (Table 3).

Malapterurus electricus

Of the 30 specimens examined, nine had empty stomachs while 21 contained food (Table 1). The TL and Wt mean ranges and TL and Wt means were shown in Tables 2 and 3 respectively. The IFD of *M. electricus* (Fig. 3) indicated that 7 major items were eaten, four of which (insects, crustaceans, detritus and unidentified foods) were of primary importance while 3 (macrophyte materials, nematodes and sediments) were secondarily ingested. The indices of feeding intensity viz: 10.2 AGF, 1.60% GSI and 70% GRI revealed that it is an active feeder with high condition factor (Table 3).

Epiplatys bifasciatus

Of the nine specimens examined for food, only one had empty stomach while others contained food (Table 1). The TL and Wt mean ranges and TL and Wt means were recorded in Tables 2 and 3 respectively. The overall stomach contents of *E. bifasciatus* (Fig. 2) revealed that three major items constituted its diet; of which only one (insect) was primary food item while two (detritus and unidentified foods) were of secondary importance. The indices of feeding activity viz: 7 (AGF), 7.09% (GSI) and 88.89% (GRI) showed that this species fed actively but had low relative well-being (Table 3).

Epiplatys sexfasciatus

Out of 21 specimens examined for food, 11 had empty stomachs while 10 contained food (Table 1). The TL and Wt mean ranges and TL and Wt means were depicted in Tables 2 and 3 respectively. The trophic spectrum of *E. sexfasciatus* (Fig. 3) showed that five major items were ingested; two (insects and nematodes) were primary importance while three (crustaceans, sediments and detritus) were of secondary importance. Trends in the feeding activity with respect to AGF (5.38), GSI (2.31%) and

GRI (47.62%) indicated that it was a less active feeder with low relative well-being (Table 3).

Thysochromis ansorgii

Out of six specimens examined for food, five had empty stomachs while only one contained food (Table 1). The TL and Wt means were depicted in Tables 2 and 3 respectively. The IFD of *Th. ansorgii* (Fig. 3) revealed that three 3 major dietaries were ingested; all of which (algae, crustaceans and detritus) were of primary importance. The indices of feeding activity with respect to AGF (3), GSI (0.06%) and GRI (16.65%) suggested that this species was not an active feeder but had high relative well-being (Table 3).

Hemichromis fasciatus

Out of 12 specimens of *H. fasciatus* examined for food, eight had empty stomachs while four contained food (Table 1). The TL and Wt mean ranges and TL and Wt means are shown in Table 2 and 3 respectively. The overall stomach contents of *H. fasciatus* (Fig. 3) showed that five major items constituted its diets; two of which (fish and detritus) were of primary importance while three (algae, insects and sediments) were of secondary importance. The trends in the feeding intensity viz: AGF (4), GSI (0.19%) sand GRI (33.33%) showed that it was not an active feeder but had high condition factor (Table 3).

Chromidotilapia guntheri

A total of 18 specimens were examined for; seven had empty stomachs while 11 contained food (Table 1). The TL and Wt mean ranges and TL and Wt means are shown in Tables 2 and 3 respectively. The trophic spectrum of *C. guntheri* (Fig. 3) revealed that 8 major items constituted its diets; of which 5 (algae, crustaceans, fish, detritus and sediments) were of secondary importance while one (macrophyte materials) was incidentally ingested. Trends in the feeding activity viz: 6.28 (AGF), 0.32% (GSI) and 61.11% (GRI) showed that it was a less active feeder but had high relative well-being (Table 3).

Tilapia mariae

Of the 12 specimens examined for food, two had empty stomachs while 10 contained food (Table 1).The TL and Wt mean ranges and TL and Wt means were depicted in Table 2 and 4 respectively. The overall stomach contents of *T. mariae* (Fig. 3) revealed that five items constituted its diet; 3 (macrophyte materials, fish and sediments) were of primary importance while two (detritus and unidentified foods) were of secondary importance. The indices of feeding activity with respect to AGR (12.83), GSI (1.12%) and GRI (83.33%) showed that *T. mariae* was an active feeder with high relative well-being (Table 3).

Pelvicachromis pulcher

All the few specimens examined contained food (Table 1). The TL and Wt mean ranges and TL and Wt mean were shown in Tables 2 and 3 respectively. The IFD of *P. pulcher* (Fig. 3) revealed that five major items were ingested; three (fish, detritus and sediments) were of primary importance, one (algae) was ingested secondarily while one (insect) was incidentally ingested. Trends in the feeding activity with respect to AGF (9.5), GSI (0.5%) and GRI (100%) showed that this species fed actively, but had low condition factor (Table 3).

Parachanna africana

Of the six specimens examined for food, none contained food (Table 1). The TL and Wt mean ranges and TL and Wt means were shown in Tables 2 and 3 respectively. *P. africana* had low relative well-being of 0.62 (Table 3).

Ctenopoma nebulosum

There were three specimens examined for food, two stomachs were empty while only one contained food (Table 1). The TL and Wt mean ranges and TL and Wt means were shown in Tables 2 and 3 respectively. The trophic spectrum of *C. nebulosum* (Fig. 3) revealed that only one food item was ingested, i.e. insects. Trends in the feeding activity viz: AGR (3.33), GSI (0.10%) and GRI (33.33%) suggested that this species was not an active feeder but had high relative well-being (Table 3).

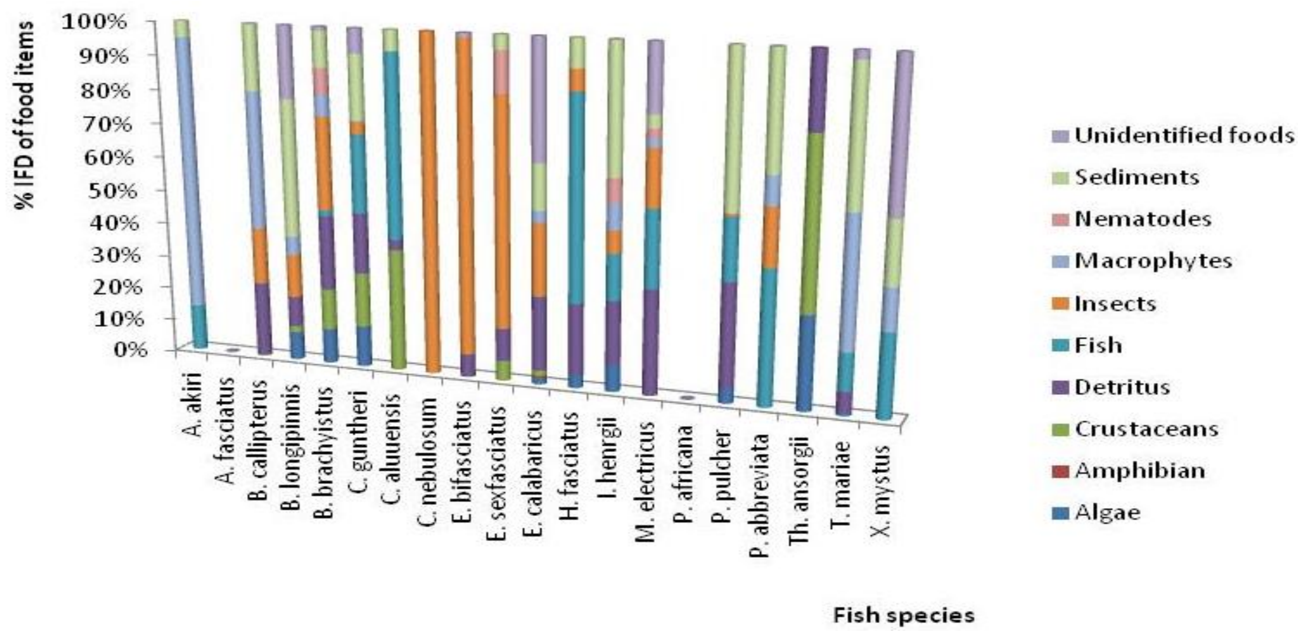

Fig. 3: Index of Food Dominance (%IFD) of food items occurring in the guts of fish species in Qua Iboe River, Nigeria

Trophic relationship

The fish species fed on many food sources. Trophic relationship of these species of fish showed that only one species (*C. nebulosum*) fed on only one major food item i.e. insects while three species (*A. akiri, E. bifasciatus* and *Th. ansorgii*) ingested three major food items. Other species utilized much diversity of food sources ranging from living to non-living matters. For instance, *M. electricus*, apart from the unidentified food item, feeds on plants, crustaceans, nematodes, insects, sediments and detritus. Thus, implying that this species was able to forage from plant and animal sources including non-living matter. This attribute helps to reduce competition for food resources among fish species.

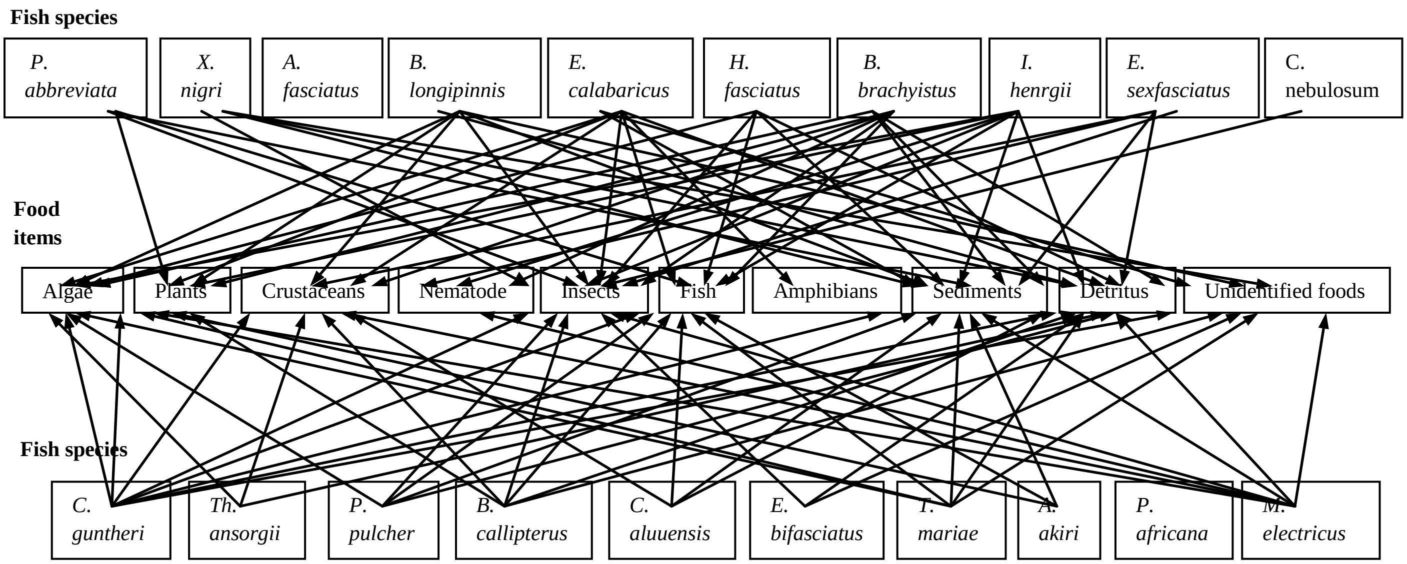

Fig. 4: Trophic relationship of freshwater fish species in Qua Iboe River, Nigeria

DISCUSSION

The fishes were found to ingest a wide spectrum of materials ranging from microscopic to macroscopic organisms made up of 10 major food items. This shows that majority of the fishes were non-selective in feeding and it appeared that each species was capable of utilizing many sources of food. Similar results have been observed by many authors in which such fish species which feed on wide diet spectrum have been described as being euryphaguous (Oribhabor and Ogbeibu, 2012; Olojo *et al.,* 2003). Though the feeding habits of these fishes appear to be similar, there are, however slight changes. The fact that these fishes can subsist on a wide variety of food materials as revealed in this study, indicate that the species can adapt themselves to changes in food availability. This ability of the species to swift to other food resources seems to be important in fish culture; hence, some of them could be utilized in aquaculture.

It is possible to categorize the fishes into three broad trophic groups: those feeding mainly on macrophytes (herbivores), macroscopic animals (predators) and bottom deposits or detritus (detritivores). However, overlaps exist among many species.

The results of the index of food dominance show that varying percentages of macrophyte materials were ingested by different species classified to as herbivores. For instance, *M. electricus* (2.56%); *B. brachyistus* (6.28%); *I. henrgii* (9.99%); *B. longipinnis* (7.80%) and *E. calabaricus* (3.47%); but the major herbivores are *B. callipterus* (40.96%) and *A. akiri* (81.45%). Fagade (1971) reported that fragments of higher plants were unimportant in the diet of *T. guineensis* but in *T. mariae*, leaf fragments occur as primary food item. This could be due to differences in the littoral morphology of the Lagos lagoon and Qua Iboe River. However, Fagade and Olaniyan (1973) noted that fragments of higher plants were also included in the diet of tilapias. Results of index of relative importance emphasized the importance of plants as a major food resource in the stomach of Nile tilapia, *O. niloticus* (El Gamal and Ismail, 2005). The ingestion of other sources of dietaries by the 2 herbivores reduces possible competition between them to the minimum.

Predatory species include fish that feed on macro-animals and can be sub-divided into three main sub-groups: piscivorous species, i.e. those feeding principally on fish; insectivorous species, i.e. those whose diets were dominated by insects; and planktophagus species; those crustaceans dominated their diets.

The piscivorous include *H. fasciatus, P. abbreviata, C. aluuensis* and *C. guntheri*. The fish materials found in the stomachs ranged from fish scales to whole fish whose advanced stages of digestion prevented identification. *H. fasciatus* had been shown to feed on juvenile *E. fimbriata* (Fagade and Olaniyan, 1973) while Adebisi (1981) reported that this species feeds on *B. chlorotaenia* and *B. callipterus* and nymphs of cladoceran and plecopteran. The six stomachs of *P. africana* investigated were all empty. Adebisi (1981) classified *P. obscura* as piscivore, although the stomachs of the 2 specimens caught were empty. Uwem *et al.,* (2011) reported that *P. obscura* has its diet mainly from animal origin: polychaete worm 110 (11.77%), shrimps 84 (8.99%), shrimp parts 33 (3.55%), juvenile fish 33 (3.33%), fish bones 44 (4.71%), fish scales 40 (4.28%), bivalves 61 (6.53%), insect larvae 2 (0.21%), adult insects 2 (0.21%), daphnia 62 (6.63%) and water snails 2 (0.21%). Hence, the authors classified the species as a voracious carnivore. 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.

Insectivorous species ingested large amounts of insects in their diet. These insects are allochthonous introduced into the water from the surrounding vegetations. Such species include *B. brachyistus, E. bifasciatus, E. sexfasciatus* and *C. nebulosum*, whose index of food dominance showed high percentages of insects. These species are characterized by upturned or oblique mouth type. Hence, they wait at near the water surface to catch an incoming insect falling into the water. Insects constitute a large class of invertebrate animals. Thus, they are available to these fish in large numbers ranging from the larval stages to adults.

Different numbers and types of phytoplankton and zooplankton were utilized as food by different species of fish. *M. electricus* and *Th. ansorgii* were observed to include one form of plankton or the other in their diets respectively. Others whose IFD showed less percentages of planktonic organisms in their diet include *C. guntheri, T. mariae, P. pulcher, C. aluuensis, B. callipterus, B. longipinnis*, etc. The zooplanktons are mainly the class crustacean, e.g. copepods, some ostracods, *Daphnia*, *Cyclops*, etc and they constitute a great number when compared to the phytoplanktons which are mainly algae (diatoms, blue-green algae and green algae). Fagade and Olaniyan (1973) stated that algal filaments and diatoms constituted the diet of tilapias as is obtained in this work.

These include *E. calabaricus, X. nigri, I. henrgii, B. longipinnis, T. mariae* and *P. pulcher* which had higher compositions of sediments and detritus in their diets. The tilapiine species feed mainly by picking up food particles from the substratum or from attached surfaces, although they may stir up the bottom and filter the particles brought into suspension with their gills (Fagade and Olaniyan, 1973). Fagade (1971) showed that the tilapia species of the Lagos lagoon fed mainly on algal filaments, diatoms, sand grains and unidentified organic matters. However, fish scales are important in the food of tilapiine species as shown in the work of Fryer and Iles (1972) but disagrees with Fagade (1971) in the Lagos lagoon. Agbabiaka (2012) showed that *Tilapia zillii* is an omnivorous fish with dietary preference for algae (71.05% and 59.52%), vegetative matter (10.52% and 50.00%), detritus (0% and 11.90%) and aquatic invertebrate larvae (52.63% and 47.61%) and chironomid larvae (31.58% and 21.43%) for juveniles and adult *Tilapia* respectively. Sediments like sand grains have microbes and nutrients attached or adhered to their surfaces.

The proportion of fish with food in the stomachs were higher (199; 55.90%) than stomachs without food (157; 44.10%). This result agrees with the findings of Fagade and Olaniyan (1973) and Oribhabor and Ogbeibu (2012), who attributed higher stomachs with food to the fact that predatory fishes have irregular feeding habit and tend to take a large meal when their prey is available. The larger chunks of food will take a longer time to digest, thus, predators will rarely go in search of food. The findings of Odum and Anuta (2001) differed from this present study where high empty stomach in *Phractolaemus ansorgii* was attributed to intermittent feeding.

From the results on the food found in the stomachs of fishes occurring, it is possible to represent the trophic interrelationship of the fish species as shown in Fig. 4. The diets of some of the predators consist of detritus and sediments in addition to their various preys. The planktophaguous species also ingest some sediments in addition to the algal materials while the detritivores ingest some insects and macrophyte materials while feeding on the detritus and sediments. This work agrees with that of El Gamal and Ismail (2005) where *O. niloticus*, a major herbivore, was found to ingest other types of food items like molluscs and crustaceans. Wooton (1979) commenting on trophic flexibility said it has ecological advantage which enables a fish to switch from on e category of food to another in response to fluctuation. The advantage is the ability of the species to utilize many different food objects effectively (Fryer and Iles, 1972) and Jobbling (1981) listed; age, size of fish, sex, season, water temperature, habitat and competition as some of the factors responsible to changes in the feeding habit of fish. Morphological changes in the feeding apparatus of the fish as a result of age may also lead to change in feeding habit (Wooton, 1979). However, changes or shifts in fish diets had be attributed to differences in habitats, relative abundance of prey organisms and individual species food habitat (Sarker *et al*., 1980; Alfred-Ockiya, 2000; Offem *et al.,* 2009; Uwem *et al.,* 2011; Oribhabor and Ogbeibu, 2012) and physiological conditions.

CONCLUSION

The food and feeding habits of the commonly occurring fishes in the Qua Iboe River show a great diversity in pattern and have been grouped into planktophaguous, predatory and deposit feeding. Overlaps exist which ensures reduced competition among the fishes and ensures a wider spectrum of dietaries. The planktophaguous species feed mainly on phytoplankton and zooplankton. The predators have been sub-divided into insectivorous and piscivorous species while the deposit feeders feed on the bottom sediment and detritus. From the tropic relationships established, it can be concluded that the fish species in the Qua Iboe River utilize more than one source of food. These species depended largely on allochthonous food items. It had been noted that this type of specialization was only possible where there was a stable terrestrial environment that ensured constant supplies of specific food items.

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