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Fish fauna of Agbokum waterfalls in South Eastern Nigeria

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Abstract

Knowledge of ichthyofauna of waterfalls is important in the development and management of conservation measures. In order to establish the fish composition and diversity of a tropical waterfalls monthly fish samples and physic-chemical parameters were investigated in wet and dry seasons, over a two year period in three regions along the length of Agbokum waterfalls. Water turbulence, size of river, flow velocity, water level, temperature, transparency and food availability explained the observed seasonal and spatial changes in fish abundance. Five thousand four hundred and eighty four (5484) fish representing 22 species belonging to 16 genera from 9 families were sampled in both dry and wet seasons, with 10 species being restricted to wet season and only 1 in the dry. Cichlidae, Clariidae and Cyprinidae were the most abundant families accounting for 56.7% of the total catch with *Tilapia zillii*, *Clarias gariepinus* and *Labeo coubie* dominating overall catch constituting 35.5%. Among the three dominant species, two benthic fishes (L. coubie and C. gariepinus) showed inverse distributional pattern with Clariid fish (*C. gariepinus*) most abundant downstream and least represented upstream. Cyprinid (L. *coubie*), on the other hand, dominated the upstream reaches and scarce downstream. Five species were site specific because of the association with only the midstream portion of the river (L. senegalensis), upstream (A. gardneri, A. filmentosus and E. sexfasciatus) and downstream reaches (H. fasciatus, A. occidentalis and C. nigrodigitatus). The two benthic species (*C. gariepinus* and L. *coubie*) produced a bimodal size class distribution in the three sites while *T. zilli* showed tri-modal size class. Equitability index (E) was generally low ranging from 0.03 (midstream) to 0.14 (downstream). Downstream reaches recorded highest diversity throughout the year with higher values for the wet season samples than dry. Wet season and Downriver region of the waterfalls were therefore critical in maintaining fish stock of the water falls.

Introduction

Waterfalls is a place where a stream or river falls from a high place example over a cliff or rock (Cano 2000). It is caused by gravity taking its effect on water and pulls it down a cliff (Chernicoff *et al.c* ,1997). Large amount of stream energy are expended at waterfalls. Waterfalls are associated with "tier," a free-fall water drop, beginning when the water leaves the bed of the river or contact with rock and ends when the water hits rock or the bed of the river again (Chester *et al*, 1999).

The water body is important in fisheries and aquaculture potentials, hydrology, biodiversity, biodiversity conservation, ecotourism and geological features (Fischer and Harris 2003). Waterfalls are known to form a rich biome for indigenous and exotic species which are swept upstream and swept over the waterfalls to settle downstream in a more quiescent environment. It may also be useful in the aquatic ecology by aerating water bodies that lack dissolved oxygen, represents significant barriers to upstream movement of fish, serve as natural monuments and source of revenue generation because of their tourism potentials (Ayodele 1988, Krinitskii 1972). Inhabitants of waterfalls use it for drinking, irrigation and other domestic purposes.

The Agbokim waterfall is a product of two rivers, River Ekim and River Bakue. River Ekim is divided into three streams, while River Bakue has four streams. These seven streams flow into a floodplain, from where they independently cascade over steep cliff which provides seven-faced falls into the casket or waterfalls. The waterfalls is locally called "Nnabikim", named after the goddess of the waterfalls or "Anigisa" meaning seven denoting the number of streams that flow to the casket. Waterfalls in many local communities are used as places of traditional and ancestral worship which militate against the development of fisheries in these water bodies. Also the intensity of waterfalls and pressure generated from it has given the impression of a lifeless zone. These reasons could be responsible for why data of Ichthyofuanal studies of water fall is scarce in Nigeria and other parts of Africa.

Knowledge of status of the ichthyofauna of waterfalls is important in the development and management of conservation measures. The fundamental attributes of an aquatic ecosystem are the number of species present and their abundance. Both attribute are dynamic and related (Tokeshi and Schmid, 2002). In aquatic ecosystems interaction between the environment and population processes affects the distribution and abundance patterns of species (Brown, 1984). Two environmental factors important in influencing aquatic assemblages and habitat structure are size and the flow regime (Schlosser, 1987).

The resources of the length of the waterfalls are yet to be tapped, more so due to the total neglect by stakeholders. This study on the ichthyofauna resources of Agbokim waterfalls serve to determine the rich resources of this biome and also reduce our over- dependence on estuarine and open water body systems.

Materials and methods

Study area

The study area is Agbokim Waterfalls in South Eastern part of Nigeria (Figure 1).

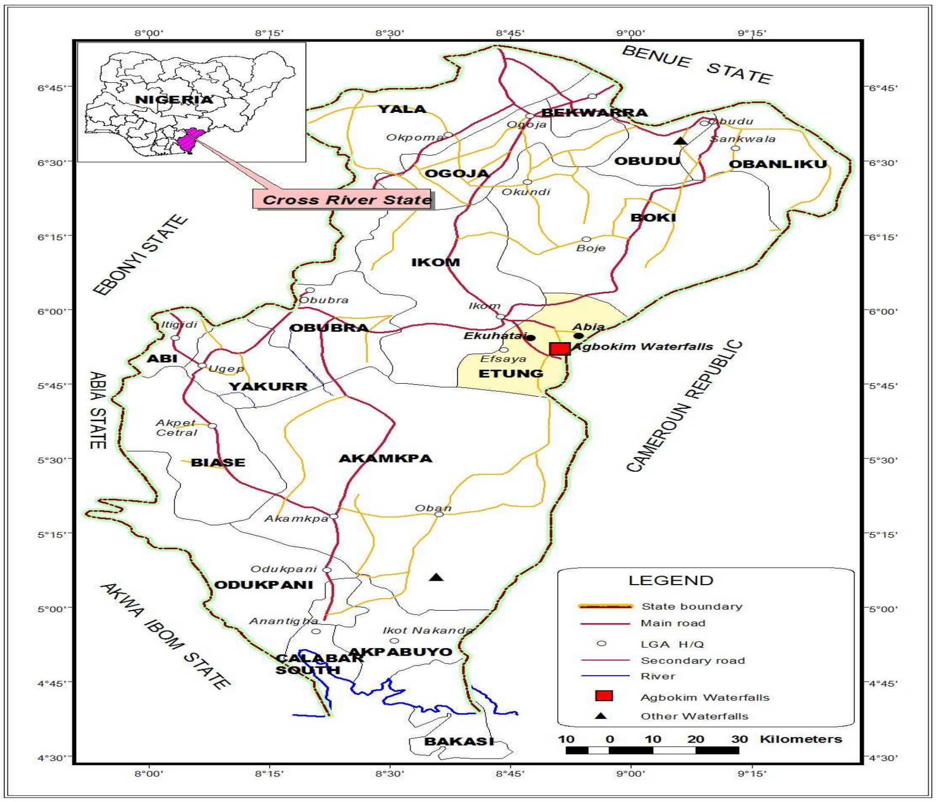

Figure 1:Map of Cross River State showing Agbokim Waterfalls.

Agbokim Waterfalls is located in latitude $5^0$59’ North and longitude $8^0$45’ East. It is bounded in the West by the Cross River and in the North by the Cameroon high forests. The climate of Agbokim Waterfalls is the tropical hinter-land type, with wet (May-November) and dry (December-April) seasons. Mean annual temperature ranged between 20^0C and 32^0C and annual total average rainfall, from 1450mm to 3015mm. The vegetation is the rainforest type with Soil consisting of deep laterite and dark fertile, clayey and loamy soils. Agbokim Waterfalls is drained by two small rivers, Ekue and Bakue, which are tributaries of the Cross River system. Of ecological importance are numerous small pools and swamps which are found along the length of the waterfalls. The high annual discharge and rainfall of the Agbokim Waterfalls provide excellent buffers against natural ecological stresses such as drought (Teugels et al 1992) which can lead to the loss of important fish taxa. The total length of the waterfalls is 6817.73m. For the purpose of this study the waterfalls is divided into upstream, midstream and downstream reaches. Upstream is close to cocoa farms with high forest cover along its shoreline and moderately fast water currents during the dry season and very fast water current during the wet season. Midstream has heavy water turbulence during the wet season and moderate water turbulence during the dry season with shoreline sparsely shaded with vegetation while downstream water current is low with an extensive wide area. The length upstream is 2003.13m, midstream 807.42m and downstream 4007.18m. Mean width upstream, midstream and downstream are 26.34±2.2m, 32.84m and 40.52±10.9m, respectively. Upstream mean height is 31.87+3.4m while the depths upstream and downstream are dependent on variation of the volume of water from rainfall and water discharge.

Physico- chemical sampling

Physico-chemical parameters were determined once every month for two years (August, 2007 to July, 2009). Standard methods for the examination of water and waste water (APHA, 1987) were used for all measurements. Monthly rainfall data for the study area was obtained from weather meteorological stations, located in each of the three reaches. Habitat variables; water level and river width were measured on site. Water velocity (flow velocity) was determined with Wagtech current flow meter, model WFM001 with 125mm diameter impella. Water discharge was determined as in Fischer and Harris (2003) using the formula: WTD = CSA x WD x WV. Where WTD = Water discharge (m^3s^{-1}), CSA = Cross Sectional Area (m); WD = Water dept (m) and WV = Water velocity (ms^{-1}).

Fish sampling

The fish of the river was sampled at the same time of physico-chemical sampling in all the reaches using variety of fishing gears which included; gill net (22-76mm stretched mesh size), seine net (10mm stretched mesh size) and cast net (10mm stretched mesh). On each occasion sampling was between 09.00 and 12.00am. Fish weights were measured to nearest 0.1g and total length (TL) to nearest 1mm. Genus and species identifications was carried out following Elvira (1987) for the Cyprinids; Erkakan et al (2007) for the Bagrids, Teugels (1982) for the Clariidae; Fisher et al (1987) for the Clupeidae and Mugilidae. Length distribution was analysed for three of the most abundant species: Tilapia zilli, African catfish; *Clarias gariepinus* and *Labeo coubie*

Species abundance and diversity

Species abundance of each reach was presented as a numerical contribution by each species. This was determined by calculating the ratio each species represented of the total catch for each reach based on the number of species and relative abundance.

Data treatment and analysis

The mean and standard deviation of each of the physico-chemical parameters were calculated. Analysis of variance (ANOVA) was used to test for statistical differences between the means of the physical and chemical parameters of the sampling sites. To calculate mean abundance, numbers in different samples were summed for each species and averaged across all sampling sites. Physico-chemical parameters were correlated with the abundances of fish species using Pearson product moment correlation coefficient analysis. Shannon-Wiener diversity function (H) was used to calculate heterogeneity for each site. Richness index was expressed using Margalef's richness index.

$d = (S - 1) / \log N$ (Clarke and Warwick 1994)

$$H' = -\sum_{i=1}^{S} P_i \; Ln \; Pi \quad \text{(Krebs 1978)}$$

$E = d / S$ (Zar 1996).

E = Equitability

d = Margalef's richness index and H´ = Shannon-Wiener Diversity Function

S = total species number

p_i= proportion of each species in each sample

Relative abundance % = (n/N) × 100,

n refers to the number of individuals of the species in the samples and N to the total number of individuals of fish caught.

Results

Physic-chemical parameters

Among all the physico-chemical parameters measured, water discharge, dissolved oxygen and water level values were significantly different between reaches ($P < 0.05$) with higher values of Water discharge Midsteam ($2071.91 \pm 207.06 m^3 s^- 1$) than Upstream reaches ($242.91 \pm 84.41 m^3 s^-$) and downstream reaches ($279.97 \pm 95.8 m^3 s^{-1}$). Dissolved oxygen had highest value midstream Midstream (9.61±0.2) and lowest downstream (5.34±0.5). Water level was highest downstream (4.8±0.6m) and lowest upstream (2.4±0.7m) and was positively correlated ($r = 0.885$, 10df, $p < 0.05$,) with rainfall (Table 1). There was no significant difference in water velocity ($P > 0.05$) between the study sites but was influenced by the water level which was also influenced by rainfall and the gradient of the study sites. Variation in the transparency, conductivity, temperature, hydrogen ion concentration, and pH values between reaches were not significant ($p > 0.05$). Significant seasonal variations in the physico-chemical parameters of the river were observed with the wet season values of flow velocity, water discharge, dissolved oxygen, water level and width higher than the dry season ($p < 0.05$). Dry season transparency and temperature were higher than the wet while seasonal hydrogen ion concentrations and conductivity remain relatively constant (Table 2).

Fish species composition and abundance

A total of 5484 fish representing 22 species belonging to 16 genera from 9 families were sampled during both dry and wet seasons, with 10 species being restricted to wet season and only 1 in the dry, which was of very rare taxa (Table 3). The number of taxa and individuals present at upstream, midstream and downstream reaches were 16 (2003), 13 (1034), 17 (2447) respectively (Table 4). Cichlidae, Clariidae and Cyprinidae were the most abundant families accounting for 56.7% of the total catch. *Tilapia zillii*, *Clarias gariepinus* and *Labeo coubie* dominated overall catch constituting 35.5%. Among the three dominant species, two benthic fishes (L. coubie and C. gariepinus) showed inverse distributional patterns. Clariid fish (*C. gariepinus*) was most abundant downstream and least represented in upstream. Cyprinid (L. *coubie*), on the other hand, dominated the upstream reaches and scarce in downstream. Five species were site specific because of the association with only the midstream portion of the river (L. senegalensis), upstream (A. gardneri, A. filmentosus and E. sexfasciatus) and downstream reaches (H. fasciatus, A. occidentalis and C. nigrodigitatus). Two species occur both midstream and downstream reaches only (D.rostratus and D. engycephalus) and one upstream and downstream (H. longifilis). Distribution of other species revealed no distinct trends.

Richness and Diversity indices

The Shannon-Weiner diversity index showed significant difference between reaches, with downstream reaches having highest diversity throughout the year (Figure 5). Seasonal differentiation in the diversity indices revealed higher values for the wet season samples than dry season. Table 5 shows values of the diversity function for downstream (1.8±0.3 (F: 2.46, $p < 0.05$), midstream (0.8±0.1) and upstream (1.7±0.3). Equitability index (E) was generally low ranging from 0.03 (midstream) to 0.14 (downstream).

Length-frequencies

T. zilli exhibited a tri-modal size class distribution in the three reaches. The modal size class upriver was 50-65cm compared with 30-40cm in the middle reach and 25-35cm downriver (Figure 2). Mean size ranges were significantly different ($p < 0.05$) between reaches. The other two benthic species (*C. gariepinus* and L. *coubie*) produced a bimodal class distribution in the three sites. The modal size class for *C. gariepinus* was 50-55cm in both upriver and mid-river and 60-70cm downriver (Figure 3). *L. coubie* length frequency distribution revealed a right skewed size class distribution in the middle river with the modal size class (80-90cm) The size class distribution upriver was similar with those downriver with same modal class of 30-40cm (Figure 4).

Discussion

Marked variations in the physico-chemical parameters of water observed at the three sampling stations, according to Adebisi 1981, indicate different environmental conditions. Secchi disc transparency and pH of the three sites were within the range considered suitable for fish growth indicating adequate nutrients in Agbokim Waterfalls (Ugwumba and Ugwumba, 1993; Boyd (1979). Mean values of water level and water velocity were influenced by intensity of rainfall and the steep gradient of the area. An increase in flow velocity increases the speed of the flow pattern which in turn increases water discharge and water turbulence. Midstream ecology

Table 1: Mean variation and F-values of the analysis of variance (ANOVA) of physico-chemical parameters of water measured at three sampling sites. I: Upriver, II: Mid-river, III: Downriver

Properties	**Upriver**	**Midriver**	**Downriver**	**F-value**	**ANOVA**
Physical					
Conductivity ($uScm^{-1}$)	36.6±11.0	38.1±11.5	25.3-58.2	0.77	
Water temperature (ºC)	26.0±1.1	26.6±1.2	27.2±0.8	3.36	P<0.05
Water depth (m)	2.4±0.7	2.2±0.5	4.8±0.6	4.32	P<0.05
Water discharge(m^3s^{-1})	156.71±124.2	1496.46±825.9	189.84±133.8	5.8	p<0.05
Water velocity (m/s)	0.94±0.25	1.01±0.26	1.59±0.14	4.32	p<0.05
Transparency (cm)	26.6±13.9	29.5±14	28.8±13.4	1.56	p>0.05
Chemical					
Dissolved oxygen (mg/l)	6.6±0.3	9.61±0.2	5.34±0.5	0.98	p>0.05
pH	7.0±0.2	7.0±0.2	7.1±0.2	1.43	p>0.05

Table 2 Seasonal variation in the physico-chemical parameters and the t-values of the student's t-test in the Cross River.

Parameters	Wet season	Dry season	t-value	t-test
Physical				
Temperature (^{0}C)	25.8±0.928.8±2.02.78			p<0.05
Transparency (m)	22.6±6.837.4v16.3		5.22	p<0.05
Water level (m)	4.5±0.4m	1.8±0.156.14		p<0.05
Water discharge (m^3s^{-1})	864±77.0	390.73±186.8	5.99	p<0.05
Water velocity (ms^{-1})	0.83±0.0	1.26±0.12.87		p<0.05
Conductivity($uScm^{-1}$)	30.2±7.6	49.2±3.6	3.66	p<0.5
Chemical				
Dissolved oxygen (mgl^{-1})	8.3±0.2	4.8±0.3mgl^{-1}	2.66	p<0.05
Hydrogen ion concentration (pH)	7.1±0.3	6.9±0.1	0.78	p>0.05

Table 3: Seasonal variation in the relative abundance (%) of fish species in Cross River

Seasons Family/species	Wet season	Dry season
Cichlidae:		
Oreochromis niloticus	7.7	1.9
Talipia zilli	2.0	-
Hemichromis fasciatus	1.9	-
Pelmatochromis guntheri	-	0.1
Cyprinodontidae		
Aphyosemion gardneri	1.9	-
Aphyosemion filamentosum	1.8	-
Epiplatys sexfasciatus	1.4	-
Hepsetidae:		
Hepsetus odae	1.0	1.6
Characidae:		
Hydrocynus vittatus	1.8	-
Alestes nurse	3.0	-
Alestes macrocephalus	0.7	0.6
Distichodontidae:		
Distichodus rostratus	0.4	-
Distichodus enegycephalus	0.3	
Clariidae:		
Clarias anguillaris	5.9	2.7
Clarias gariepinus	3.3	1.3
Heterobranchus longifilis	2.0	0.5
Bagridae:		
Chrysichthys nigrodigitatus	10.4	4.3
Auchenoglanis occidentalis	0.5	-
Mochokidae:		
Synodontis clarias	2.1	-
Cyprinidae:		
Labeo coubie	0.9	0.4
Labeo senegalensis	0.5	0.5
Labeo parvus	0.2	0.1

is therefore affected negatively in respect of fish composition, abundance and diversity during wet season.

Seasonal and spatial variations in the Ichthyofauna of Agbokum waterfalls during the period of study supports findings by Jackson & Harrey (1993) that various fish communities exhibited non-random patterns in composition over time and space. The 22 fish species 16 genera and nine families recorded in Agbokum waterfalls is far less than 165 species, 97 genera and 41 families identified (King 1996) in Cross River basin and 46 species in 28 genera and 16 families recorded (Offem et al 2007) from the three vegetational zones of the Cross River inland wetlands. In the three studies conducted, however, Cichlidae and Cyprinidae appear to be among the most abundant families identified. Rahel (1990) explained that the differences in species relative abundance could be used as a measure of community composition. In addition, the fact that the study show similar relationships in respect of species dominance, provides additional evidence for non-random structuring of fish communities (Jackson *et al* 2001).

Table 4: Relative proportions of fish species (p_i), Shanon-Wiener diversity (H´) and equitability (E) indices for the three zones (January 2006 to December, 2007).

Reaches	Up-river	Mid-river	Down-river
Family/species	p_i	p_i	p_i
Cichlidae:			
Oreochromis niloticus	0.042	0.008	0.040
Tilapia zilli	0.110	0.238	0.098
Hemichromis fasciatus	0.000	0.000	0.011
Pelmatochromis guntheri	0.010	0.006	0.024
Hepsetidae:			
Hepsetus odae	0.022	0.008	0.006
Characidae:			
Hydrocynus vittatus	0.012	0.004	0.005
Alestes nurse	0.062	0.005	0.031
Alestes macrocephalus	0.011	0.002	0.006
Distichodontidae:			
Distichodus enegycephalus	0.134	0.000	0.223
Distichodus rostratus	0.001	0.000	0.002
Clariidae:			
Clarias anguillaris	0.031	0.005	0.057
Clarias gariepinus	0.023	0.014	0.315
Heterobranchus longifilis	0.000	0.000	0.111
Bagridae:			
Chrysichthys nigrodigitatus	0.000	0.000	0.013
Auchenoglanis occidentalis	0.000	0.000	0.003
Mochokidae:			
Synodontis clarias	0.015	0.004	0.018
Cyprinidae:			
Labeo coubie	0.388	0.121	0.003
Labeo senegalensis	0.000	0.044	0.000
Barbus occidentalis	0.034	0.003	0.001
Cyprinodontidae			
Aphyosemion gardneri	0.034	0.000	0.000
Aphyosemion filamentosum	0.018	0.000	0. 000
Epiplatys sexfasciatus	0.110	0.000	0.000
Mean±SD	1.7±0.4	0.8±0.1	1.8±0.3
Equitability Index	0.12	0.03	0.14

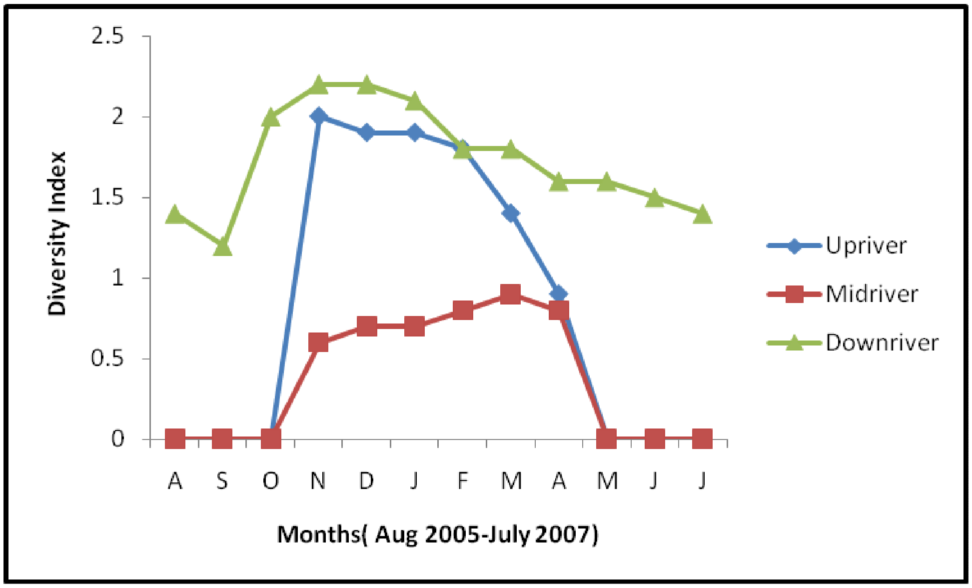

Fig 5 Shanon Weanner Diversity Index for Agbokom Water Falls (August 2005-July 2007)

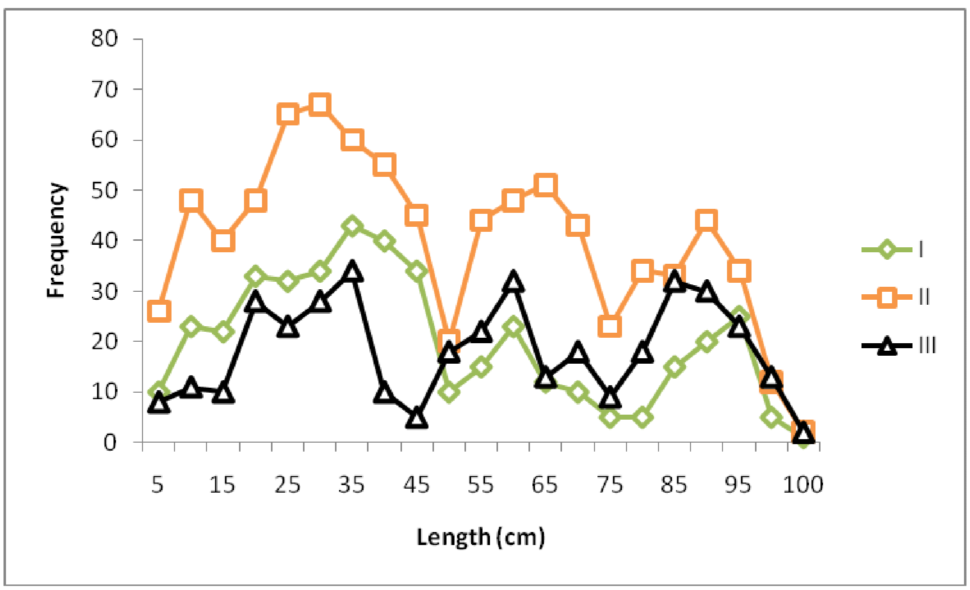

Fig 6 Length- frequency distribution and multimodal analysis of T. *zilli*

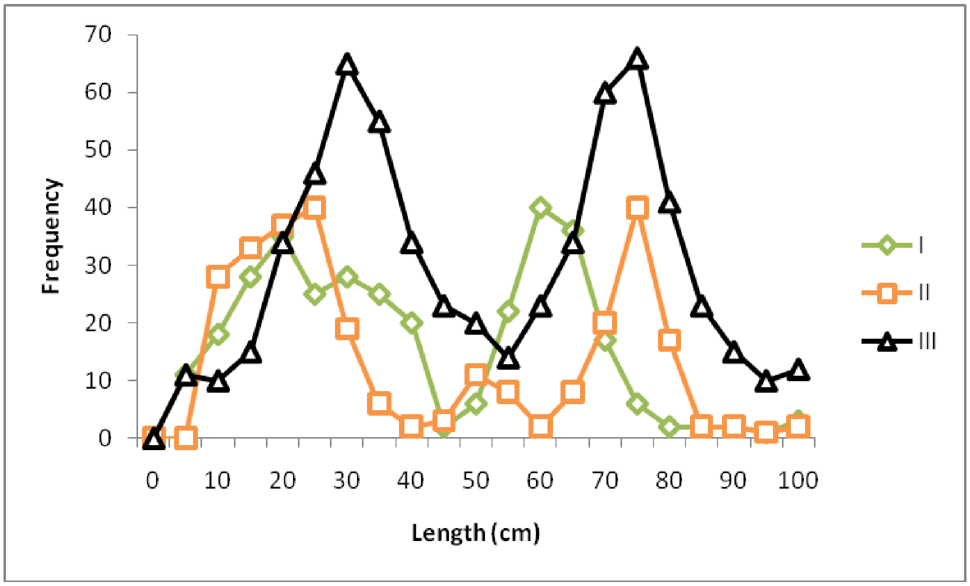

Figure 7 Length- frequency distribution and bimodal analysis of *C. gariepinuss.*

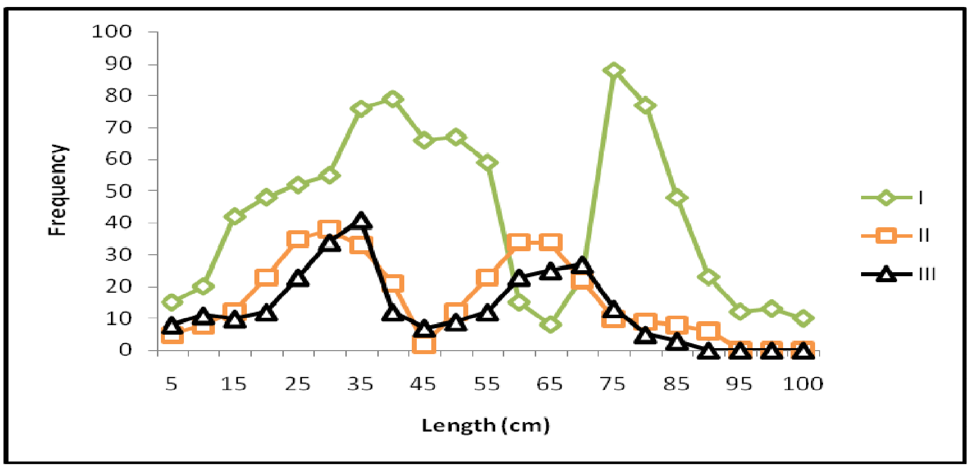

Figure 8 Length- frequency distribution and bimodal analysis of L. *coubie*

Seasonal differentiation evident in higher number of species and individuals caught during wet months of the study period, agree with results of Harrison & Whitefield (1995) who described larger ichthyofaunal densities in water bodies in Grahamstown in the rainy season. Reasons for the variation were ascribed to the connection of the water bodies to the sea which allows free movement of species across the two habitats during flood and these species being able to recruit during flood condition (Cowley and Whitefield 2001). Agbokim Waterfalls being drained by two small rivers, Ekue and Bakue, which are tributaries of the Cross River system with linkage to Cross River estuary from the lower reaches, could have exhibited the same variation. Vorwerk *et al* (2001) subscribed to these findings in a survey of some Eastern Cape estuaries. Also because of the considerable seasonal differences in dissolved oxygen concentration in the system both at low water and during the floods this factor appears to have played an essential role in determining the distribution of fish within the system. In general the more active the species the more it tends to avoid de-oxygenated areas (Welcomme 1996). Most species encountered downstream of the waterfalls during dry season have adaptation for survival in low dissolved oxygen conditions like formation of dormant eggs (Aphyosemion) and presence of external gills (Clarias, Heterobranchus). These species form a group that is well adapted to swamps life and tend to concentrate in the more de-oxygenated small pools and swamps of the floodplain during low water, when other more active species like Tilapia and carp are to be found the mid-stream (water fall) and upstream respectively.

Although on a community basis the three reaches did not separate out, some species when analysed individually revealed specific range preferences. Two heterologous species between two genera, *C. gariepinus* and *L. coubie*, the two most common and economically viable benthic fishes, found in this study, demonstrated opposite habitat preference, with *C. gariepinus* dominating the lower reach and *L. coubie* more abundant in the upper reach. This opposing habitat preference and the attendant ecological and trophic heterogeneity reduces competition, and may be responsible for the overwhelming success of the two species in the Agbokum waterfalls. The relatively higher number of *C. gariepinus* in the lower reach during this study may be due to the fact that being mud-dwelling species, most individuals found their natural habitat downriver. The common carp *L. coubie* adapted to live in shallow rocky bottom assemble in the rocky upriver. Another dominant freshwater species (T. *zilli)* demonstrated great preference to the turbulent well aerated midstream reaches. This distributional trend, in a similar study (Whitfield & Blaber 1979) was attributed to several factors including fast water current, suitable breeding area, marginal vegetation and the absence of competitors and piscivorous predators. Also, the distribution and abundance of fish species in Agbokum waterfalls, as the results showed, were probably affected by physico-chemical qualities such as river size and flow velocity. These parameters correlated significantly with all the fish species (Whitefield 1990, Marais 1988, Offem et al 2007). Suggestions have been made (Schoener 1988) that it was not the river proportions that influence the trend but more likely the hydrological consequences (increased nutrient inputs and turbidity) of the dimensions. The author explained that increased habitat heterogeneity as a result of increased size provides greater variety of resources for species, possibly reducing competition through resource partitioning. Our study showed that habitat size and heterogeneity were associated positively with Upriver to downriver gradient but flow variability decreased at lower river localities.

The larger modal size of the common carp (L. coubie) species upriver may be indicative of a more suitable habitat and higher survival rate of individuals upriver. Upriver with undulating floodplains and high forest littoral area provide suitable habitat for the species and individuals. The trend of larger individuals of *C. gariepinus* downriver than upriver may be a feature of resource availability. Downriver is often plankton rich due to runoff nutrients inputs and muddy bottom (Froneman, 2000). The length frequency distributions of the two common benthic fishes (*C. gariepinus* and *L. coubie)* showed similar trends in all the reaches. The cichlid T. zilli appears to be most adapted to live in the waterfalls (middle reach) probably due to the high dissolved oxygen in this region occasioned by high water turbulence and upwelling effect.

The entry into the waterfalls by small stream from the Cameroon forests, has introduced less common species of *Aphyosemion filamentosum* (Mills *et al*, 1982). *Aphyosemion gardneri* is the common species in Nigerian waters including the Agbokim waterfalls (Field-survey 2005-2007). Appearance of the new species upriver of the Water Falls has ecological implication on the conservation of the resources of the system. The movement of species between habitats can reduce the rate of local extinction and can also permit re-colonization following local extinctions, which has important implications ranging from population genetics to community composition (Jackson *et al* 2001).

Relatively higher fish densities and species richness values in the upstream and downstream reaches, was probably because being mainly forest flood plains, as explained by Leigh (1990), they offer considerable habitat heterogeneity leading to a large number of potential ecological niches of fish species than the high turbulence nature of midstream especially in the waterfalls region. The surrounding forest floodplain areas are therefore significant in maintaining the fish stock of Agbokum waterfalls. However, Huston (1979) predicts diversity to be highest where competitive displacement and disturbance frequency or intensity is low which could be another possible reason why in our study, the Upper reach with its shoreline harboring cocoa farmlands, had lower species richness and lower species diversity than downstream. Equitability values were generally low in all the reaches sampled indicating high dominance by a few species (e.g. T. *zilli, C. gariepinus and L. coubie*) in the overall catch and relatively high Shanon- Wienner diversity indices for the three sampling sites. The downstream value of Shannon Weaner diversity function in Agbokim Waterfalls (1.8±0.3) was higher than the value (0.982) recorded for Oguta Lake and Otanmiri river (1.359) both in Nigeria (Okorie 2004). However, the midstream values of the index was low (0.8±0.1) probably as a result of the turbulent nature of the reach.

If observations by Marais (1988) that distribution and composition of species in each habitat was closely related to food availability, breeding sites and water depth and by Goodman (1975) that; the more stable community is one with more diversity and equitability in numerical distribution of individuals among species were true, then the environmental condition upriver and downriver were better and more stable than middle reaches of the river. Higher richness index and diversity function in the wet season indicates more stability in the wet season population than the dry

Conclusion

Physico-chemical variability occurred in the three reaches and their relationship with the fish abundance and community structure of these systems had been established. The calculated Margelef's species richness index downriver was higher than that calculated for the upper portion of the river. The same trend was identified when using the Shanon-Weaner diversity function. The length frequency differences in fish species between reaches are probably related to the variable access these species have to other water bodies, predation effects and the differences in the foraging strategies in the various taxa.

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