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The ichthyofauna of the upstream and downstream reaches of the KWA fall, Oban, Akamkpa L.G.A. cross River state, Nigeria

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Abstract
A study of the fish status of Kwa falls water body was carried out for three months (August-October) and a total of 562 fish representing 12 species belonging to 11 genera from 10 families and 6 orders were sampled. The family Clariidae was represented by *Clarias gariepinus*, Cichlidae by 2 species: *Oreochromis niloticus* and *Tilapia zillii*, Mockokidae by *Synodontis omias* and Schilbeidae by *Schilbe uranoscopus*. Claroteidae by 2 species: *Chrysichthys nigrodigitatus* and *Chrysichthys longipinnis*, Mugilidae by *Mugil falcipinnis*. The rest includes Paralichthyidae (*Citharichthys stamflii*), Characinidae (*Sarcodaces odoe*), Eleotridae (*Eleotris vittata*) and the Cyprinidae (*Barilius niloticus*). Siluriformes and Perciformes were the most abundant orders accounting for 72.2% and 14.8% of the total landings respectively while the species *Chrysichthys nigrodigitatus* (313), *C. longipinnis* (72) and *Oreochromis niloticus* (56) dominated the overall catch constituting 87.5%. Monthly differentiation in the diversity indices revealed higher values for the month of October than the month of August and September. The Shannon-wiener index (H') obtained were within the range of 0.75 to 1.74 and showed significant difference between reaches, with downstream reaches having higher diversity throughout the sampling period. Equitability values (E) were generally low in all the reaches sampled. The spatial and seasonal differences were significant at $p<0.05$.

Keywords: ichthyofauna, Kwa fall, fauna, sampling site and occasion

Introduction
Fish fauna of watershed are a valuable resource from ecological and economic viewpoints; for natural management and conservation of the fish resource, a critical survey of the fish faunal composition is important [1]. Fish fauna comprises over 40% of the earth's vertebrate species and are a vital link between primary producers and various levels of consumers in the food chains. Among the aquatic organisms, fish enjoys the prime position and is of considerable importance in providing proteins, vitamins, minerals, fats (Omega-3) and various other nutrients required for nourishment and growth of man[2]. Fishes, not only supplement to nutritious diet, but are also a source of income and employment opportunities for the skilled and unskilled workers [2]. A waterfall is a place where a stream or river falls from a high place example over a cliff or rock [3]. It is caused by gravity taking its effect on water and pulls it down a cliff [4] which is known to form a rich biome for indigenous and exotic species which are swept upstream and over the waterfalls to settle downstream in a more quiescent environment. The range of distribution of fish species from the source (upstream) to the discharge point (downstream) is determined by the ecological requirements of each fish species [5]. Kwa falls is a thrilling and spectacular waterfall located in a narrow, steep gorge on the headwaters of the Great Kwa River, in the Oban region of the Cross River National Park [6]. Waterfalls and their fisheries had received very little attention from researchers all over the world. In Africa, the reason being that, waterfalls were named after deities and were used as places of traditional and ancestral worships. In other places, the intensity of waterfalls and pressure generated from them due to gravity has given the impression of a lifeless zone [4]. Knowledge of waterfalls systems in Africa are therefore limited to hydrology and geological features [7], natural monuments for revenue generation because of their ecotourism potentials especially sport fishing, and as source for drinking, irrigation and other domestic purposes [8].

For sustainable exploitation of the fisheries resources of Kwa falls, knowledge of status of the Ichthyofauna of the waterfalls is important in the management and conservation of the resources. This research was to carried out with the aim of investigating the Ichthyofauna of the upstream and downstream reaches of the waterfall, determining the relative abundance and species diversity of the various fish groups and examine the distribution of the fish species in the different section of the waterfalls.

Materials and Methods

Kwa falls is located in a narrow, steep gorge on the headwaters of the Great Kwa River, in the Oban region of the Cross River National Park**,** between latitude 5°25'0''N/5.41667°N, and longitude 8°35'0''E/8.58333°E [9]. The climate of the study area is tropical-humid with wet and dry seasons, with temperatures ranging between 15°C – 30°C. The rainy season lasts from March to November, with annual rainfall of over 3,500mm. Relative humidity is high, between 80% and 100% [7].

Collection of samples

Samples were obtained from fishermen who uses a variety of fishing gear (gill net, seine net, cast net, local traps, hook and line) to catch them. Representative fish samples from the two sampling site (upstream and downstream) were preserved in 4% formalin in a labeled container (according to the collection site, date and time) and were transported to the Department of Zoology and Environmental Biology laboratory, in University of Calabar, for identification.

Identification/classification of fish samples

All preserved samples were removed from the formalin, rinsed in clean water and placed slanting with the mouth down to drain out excess fluid for about 10 minutes prior to identification. The fishes were identified using appropriate identification key guides [10-12]. After the identification of fish species, numerical data obtained from the field for each fish species were recorded accordingly to determine the total number of samples per sampling site and occasion. Photographs of the identified samples were taken using a camera.

Determination of species composition, abundance and biodiversity indices

Species composition and abundance per sampling site and occasion were determined in percentage. Margalef's Index (*d*), Shannon-Weiner Index (H') and Simpson's Index (*D*) were used to determine the species diversity and richness.

Statistical analysis

Analysis of variance (ANOVA) was used to see if there were any significant differences in the data at the two sampling stations.

Results

During the study a total of 562 fish representing six (6) orders, ten (10) families, eleven (11) genera and twelve 12 species were sampled between the month of August and October 2017. The family Clariidae was represented by *Clarias gariepinus*, the Cichlidae was represented by 2 species; *Oreochromis niloticus* and *Tilapia zillii*, the Mackokidae was represented by *Synodontis omias* and the Schilbeidae was represented by *Schilbe uranoscopus*. The Claroteidae was represented by 2 species; *Chrysichthys nigrodigitatus* and *Chrysichthys longipinnis*. The Mugilidae was represented by *Mugil falcipinnis*. The Paralichthyidae was represented by *Citharichthys stamflii*. The Characinidae was represented by *Sarcodaces odoe*. The Eleotridae was represented by *Eleotris vittata* and the Cyprinidae was represented by *Barilius niloticus* (Table 1).

Table 1: Checklist of species sampled during the study

S/N	Species	Common Name	Family	Order
1	*Schilbe uranoscopus*	Butter Catfish	Schilbeidae	Siluriformes
2	*Clarias gariepinus*	Catfish	Clariidae	
3	*Chrysichthys nigrodigitatus*	Silver Catfish	Claroteidae	
4	*Chrysichthys longipinnis*	Big eye Catfish		
5	*Synodontis omias*	Squeakers	Mochokidae	
6	*Mugil falcipinnis*	Mullet	Mugilidae	Mugiliformes
7	*Citharichthys stamflii*	Smooth Flounder	Paralichthyidae	Pleuronectiformes
8	*Sarcodaces odoe*	African Pike	Characinidae	Characiformes
9	*Oreochromis niloticus*	Nile tilapia	Cichlidae	Perciformes
10	*Tilapia zilli*	Red belly tilapia		
11	*Eleotris vittata*	Sleepers	Eleotridae	
12	*Barilius niloticus*	Nile minnow	Cyprinidae	Cypriniformes

Species composition per sampling site and sampling occasion

The total number of species sampled at each of the sampling site is shown in Fig. 1. The number of taxa at upstream and downstream reaches were 9 and 12 respectively. *Citharichthys stamflii*, *Mugil falcipinnis* and *Eleotris vittata* were recorded only at the downstream section and absent at the upstream section. In each of the sampling occasion, the total number of species sampled is shown in Fig. 2. September and October recorded the highest number of species. *Chrysichthys nigrodigitatus, Chrysichthys longipinnis, Oreochromis niloticus* were the only fish species recorded in August. *Citharichthys stamflii* was only recorded in September and absent in both August and October, while *Eleotris vittata* was recorded only in October and absent in August and September.

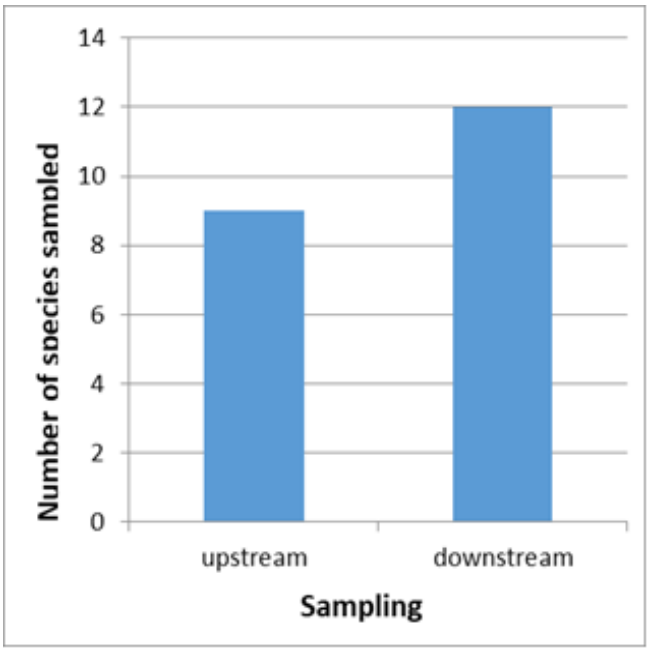

Fig 1: Species composition per sampling site

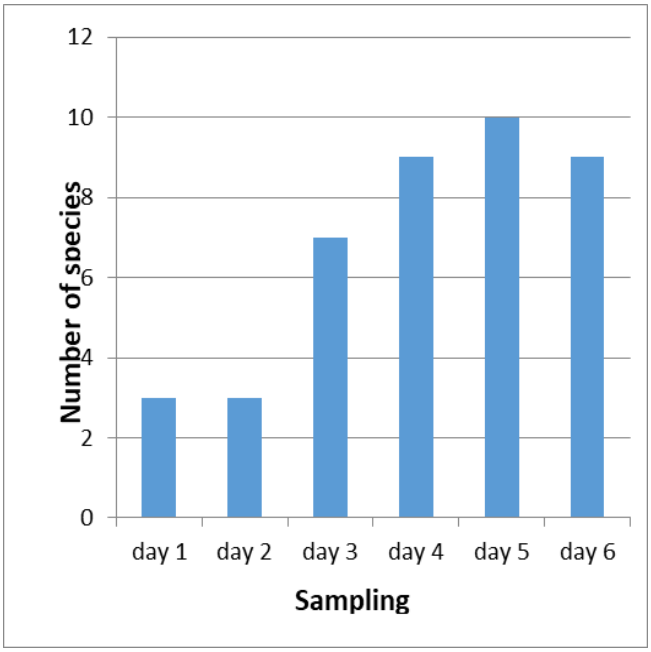

Fig 2: Species composition per sampling occasion

Percentage composition of species per sampling site and occasion

The percentage composition of species at the sampling sites and occasion is shown in Table 2. The downstream site had the highest percentage composition of species (100%) of all the total species recorded, while upstream site had the lowest percentage composition of species (75%). During the sampling occasion, day 5 recorded the highest percentage (83.3%) of the total species recorded while day 1 (25%) and day 2 (25%) recorded the least percentage composition.

Table 2: % composition of species at sampling site and sampling occasion

Sampling site/occasion	Number of species	% composition
Upstream	9	75
Downstream	12	100
Day 1	3	25
Day 2	3	25
Day 3	7	58.3
Day 4	9	75
Day 5	10	83.3
Day 6	9	75

Species abundance per sampling site

Of the 562 total catch recorded during this study, *Chrysichthys nigrodigitatus* (313), *C. longipinnis* (72) and *Oreochromis niloticus* (56) dominated the overall catch. The numbers of individuals present at upstream and downstream reaches were 265 and 297 respectively and *Chrysichthys nigrodigitatus* dominated both in the upstream (133) and downstream (180) reaches. *Synodontis omias* (5) was the least abundant upstream while *Citharichthys stamflii* (2) and *Barilius niloticus* (2) were the least abundant downstream. *Citharichthys stamflii*, *Mugil falcipinnis* and *Eleotris vittata* were absent at the upstream and were recorded only at the downstream sections of the Kwa falls as shown in Fig. 3.

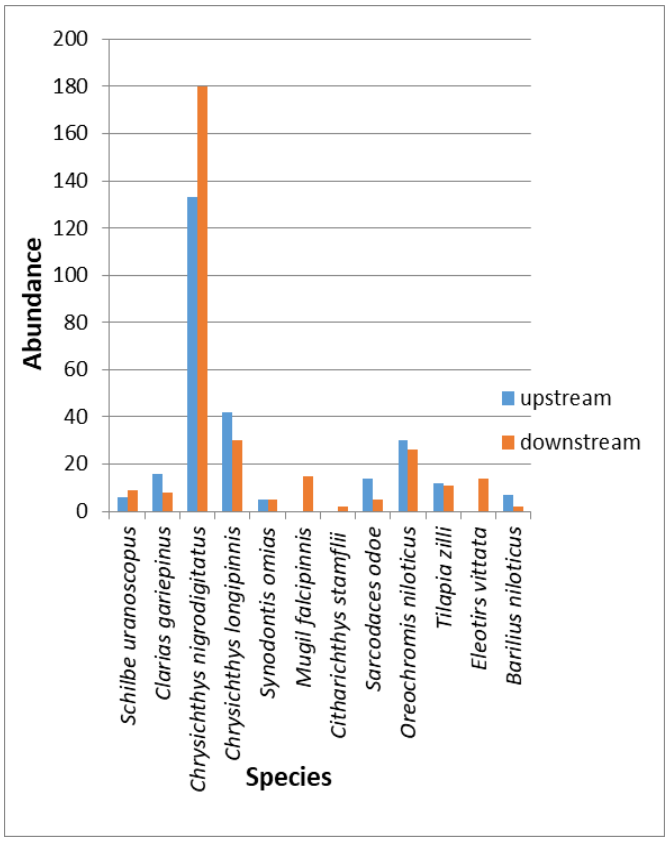

Fig 3: Species abundance per sampling site

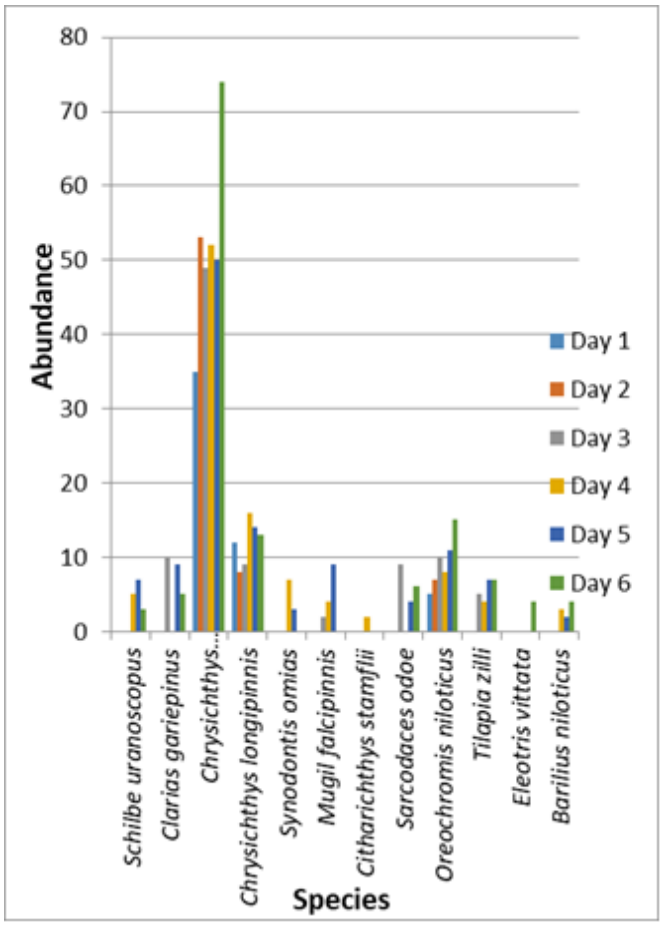

Fig 4: Species abundance per sampling occasion

Species abundance per sampling occasion

In terms of monthly species abundance, September and October recorded the highest values while August recorded the least values, 195, 247 and 120 respectively with *Chrysichthys nigrodigitatus* dominating the total number of catch in August (88), September (101) as well as October (124), while *Citharichthys stamflii* (2) and *Eleotris vittata* (4) were the least abundant in September and October respectively. *Chrysichthys nigrodigitatus, Chrysichthys longipinnis, Oreochromis niloticus* were the only fish species recorded in August. (Fig. 4)

Percentage abundance of species sampled per station and occasion

The percentage abundance of species sampled per station is shown in table 3. *Chrysichthys nigrodigitatus* had the highest percentage abundance both in the upstream (50.2%) and downstream (60.6%) reaches. *Synodontis omias* (1.9%) had the least percentage abundance upstream while *Citharichthys stamflii* (0.7%) and *Barilius niloticus* (0.7%) had the least abundance downstream. Also, the percentage abundance of species sampled per occasion is shown in table 4. Day 1 recorded the least percentage abundance of species sampled while day 6 recorded the highest percentage abundance of species sampled**.**

Table 3: Percentage abundance of species sampled per station

Species	Upstream	Downstream
	%	%
Schilbe uranoscopus	2.3	3
Clarias gariepinus	6	2.7
Chrysichthys nigrodigitatus	50.2	60.6
Chrysichthys longipinnis	15.9	10.1
Synodontis omias	1.9	1.7
Mugil falcipinnis	-	5.0
Citharichthys stamflii	-	0.7
Sarcodaces odoe	5.3	1.7
Oreochromis niloticus	11.3	8.8
Tilapia zilli	4.5	3.7
Eleotris vittata	-	1.3
Barilius niloticus	2.6	0.7
	100	100

Table 4: Percentage abundance of species sampled per occasion

Sampling occasion	No of individuals	%
Day 1	52	9.3
Day 2	68	12.1
Day 3	94	16.7
Day 4	101	18.0
Day 5	116	20.6
Day 6	131	23.3
Total	562	100

Species Richness and Diversity Indices

Monthly species richness and diversity indices estimated include Margalef's Index (*d*); August (0.418), September (1.896) and October (1.815), Shannon-Weiner Index (H'); August (0.756), September (1.699) and October (1.741) and Simpson's index (*D*); August (0.572), September (0.297) and October (0.284). Evenness index (E) was highest in October (1.59) and least in August (0.69). In the two stations, Margalef's Index (*d*) shows higher richness in downstream section (1.932) than the upstream section (1.434) while Shannon-Weiner Index (H') shows higher diversity in the upstream section (1.606) than the downstream (1.555) and Simpson's diversity index (*D*) showed higher values in downstream than the upstream section (0.366) and (0.297) respectively. Species Evenness (E) was higher in the upstream section than the downstream section, (0.73) and (0.63) respectively.

Discussion

The 6 orders consisting of 11 families, 10 genera and 12 species observed during this study, within the period of 3 months, shows that Kwa falls is rich in ichthyofauna and as a small riverine ecosystem, it compares favorably with the Agbokim waterfall which has 9 fish families consisting of 22 species[13]. In terms of species richness, the Claroteids and Cichlids were more dominant, agreeing with their high preponderance reported from other Nigerian Rivers. Four families of catfish (Schilbeidae, Clariidae, Claroteidae and Mackokidae) made up of 4 genera (*Chrysichthys, Synodontis*, *Clarias* and *Schilbe*) were encountered of which *Chrysichthys nigrodigitatus* was the dominant species which agrees with the findings on the fish fauna of Agbokum waterfall [13].

However, the dominance of *Chrysichthys* and the low population of species like *Sarcodaces odoe* and *Clarias gariepinus* in this study may be due to the fact that in fisheries, aggressive and competitively dominant fish are often the first to be over fished and are often in the habit of preventing subordinate fishes from taking baits [14].

Monthly differentiation in the diversity indices in this study revealed higher values for the month of October than the month of August and September. The Shannon-wiener index (H') obtained were within the range of 0.75 to 1.74 and showed significant difference between reaches, with downstream reaches having higher diversity throughout the sampling period. Although, Lawson & Olusanya [15] reported values of H' ranging from 1.869 to 2.015 in three tributaries of River Ore which are higher than those reported in this study. The difference can be attributed to disparity in ecological zones, hence the values for H' obtained for both monthly and by station in this study indicates a good spread of species diversity in Kwa falls. Also, the species richness index (*d*) of Kwa falls is lower than those reported from some other related work. This may be attributable to the difference in number of species encountered. Nevertheless, Equitability values (E) were generally low in all the reaches sampled indicating high dominance by a few species (E.g. *Chrysichthys nigrodigitatus, C. longipinnis* and *Oreochromis niloticus*) in the overall catch and relatively high Shanon-Wienner diversity indices for the two sampling stations.

Conclusion

A total of 12 species belonging to 9 families were recorded in Kwa falls. The most numerically abundant fish families in descending order are the Claroteidae > Characinidae > Clariidae and the > Cichlidae. Although, the results in this study revealed that most families were represented by only single species while others were represented by two species, their relative abundance significantly varied between species and families but did not significantly vary between stations. The monthly variation of the catch during the study revealed that there were comparatively higher catches of fish in October than in August probably due to reduced water volume which concentrated the fish for easier catchability. Likewise, downstream reaches recorded highest diversity throughout the period of sampling with higher values for the October than the month of August, hence, months typical of little rainfall like the downstream section of the Kwa falls is critical in monitoring fish stock of the water falls.

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