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Full Length Research Paper

Abundance of mouth brooding tilapiines in the Kafue floodplains, Zambia

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The relative abundance of three mouth brooding tilapiines of the Kafue floodplains, Zambia, *Oreochromis andersonii, Oreochromis macrochir* and the introduced *Oreochromis niloticus* were studied between October 2010 and March 2011. This study was aimed at determining whether or not the alien species has dominated the floodplains in comparison to the local *Oreochromis* species. The floodplain showed a Shannon's diversity of H = 2.289 and an even distribution of J = 0.73. The relative abundance was compared so as to establish the dominance of the alien species, *O. niloticus,* over the local *Oreochromis* spp. Three stations were selected for this investigation. The stations represented the major habitats in a floodplain, lagoon (Chanyanya), swamp (Chilumba) and riverine (Kasaka) habitats. The introduced *O. niloticus* showed the highest percentage index of relative importance (IRI) of 3.2% followed by *O. andersonii* (0.4%) and *O. macrochir* (0.1%). It was further noted that *O. niloticus* contributed the most to the diversity (H = 0.063) and evenness (0.02) of the floodplain compared to the local *Oreochromis* spp. Chanyanya had the most number (10 ± 1.8085) of fish samples and was highly diverse (0.5433 ± 0.2117) and the species were evenly spread (0.5320 ± 0.1970).

Key words: Mouth brooders, index of relative importance, diversity, evenness.

INTRODUCTION

The Kafue River is one of the major fisheries of Zambia ranking fourth amongst the fisheries according to records from the Department of Fisheries, Zambia (2000). Cichlids (Breams) are an important family in the Kafue River and have two lineages, haplochromine and tilapiines. The tilapiines are considered commercially important and are also used in aquaculture. *Oreochromis andersonii* (Castelnau, 1861) and *Oreochromis macrochir* (Boulenger, 1912) are mouth brooding tilapiine species naturally found in the Kafue floodplain. Since the introduction of the alien species, *Oreochromis niloticus* (Linnaeus, 1758), it appears to have thrived, replacing the indigenous mouth brooding tilapiines.

Introduction of fish species are made for various reasons such as promotion of farming, ornamental purposes and filling ecological niches in aquatic habitats that are altered. In the Kafue floodplain, *O. niloticus*, together with *O. aureus*, were imported from the University of Stirling in The United Kingdom (U.K) in 1982, to Mazabuka in the Kafue catchment area by the Zambia Sugar Company for aquaculture purposes. The stock of *O. niloticus* was successfully established (Schwank, 1994) and latter escaped into the Kafue floodplains. The introduction of the *O. niloticus* into the Kafue River has brought about establishment of a permanent population in the Kafue floodplains and most likely comes into competition with *O. andersonii* and *O. macrochir* (Audenaerde, 1994).

Since the introduction of *O. niloticus* into the Kafue floodplain, there has not been any regular monitoring of the fish community making it difficult to assess the impact of the introduction on tilapiines that naturally exist in the area. The general objective of this study was to assess the relative dominance of the introduced *O. niloticus* in the Kafue floodplain. The hypothesis being tested was that of no significant difference in relative abundance of

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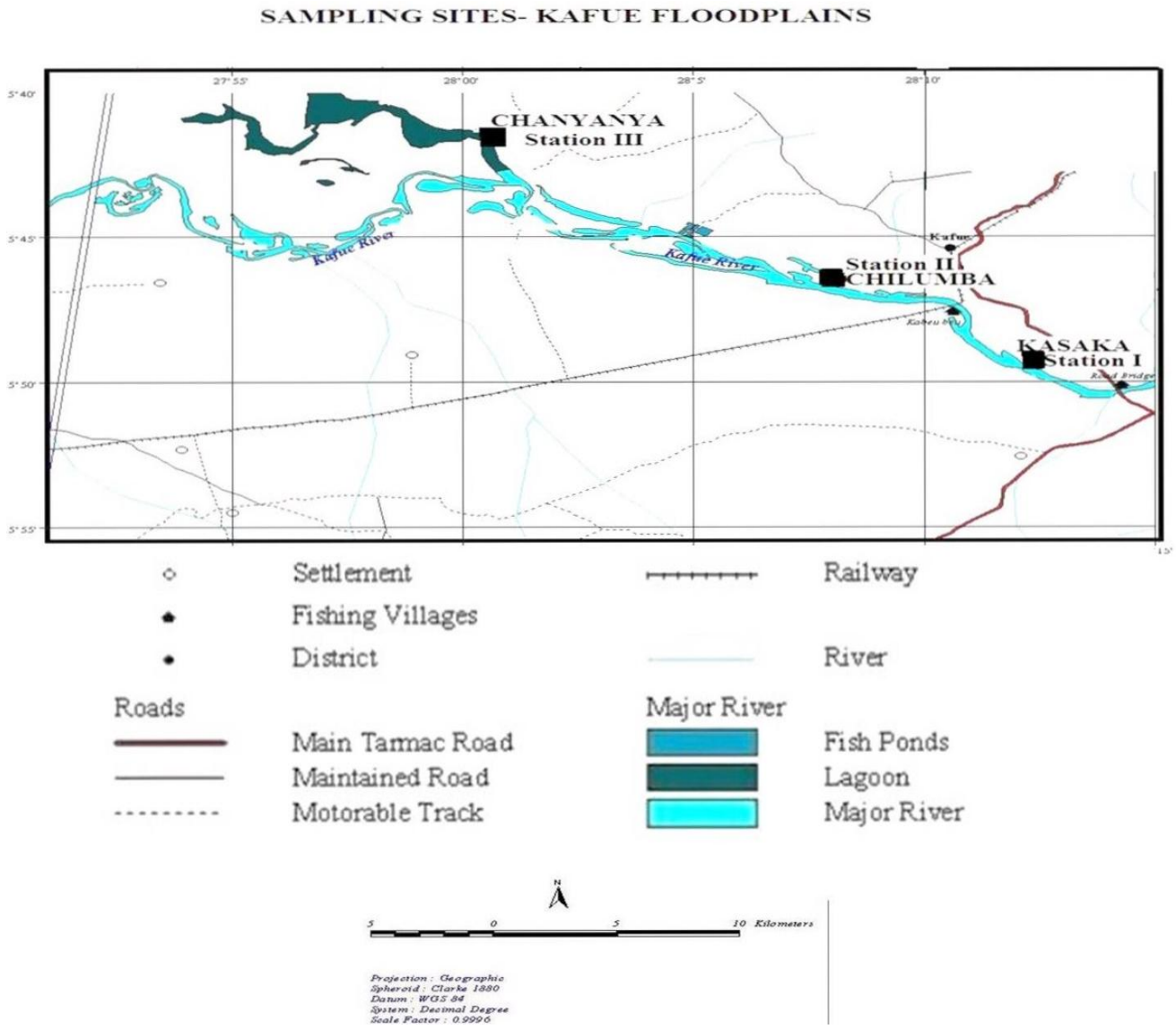

Figure 1. Map of the Lower Kafue floodplains showing sampling stations based on Shcwanck, 1992.

O. andersonii, O. macrochir and *O. niloticus* in the Kafue floodplains. It is expected that results of this study will provide the background information required for policy framework regarding fish species introduction in Zambia.

MATERIALS AND METHODS

Study area

The Kafue flats cover 6500 km^2 stretching from Itezhi-tezhi to the Kafue gorge. It is located entirely in Zambia, Central Africa. The flooding regime of this fishery has changed since 1977 when the dam construction at Itezhi-tezhi was completed. Before the Itezhi-tezhi reservoir was put up, the extent of the floods covered an area of between 22 and 60 km from the river channel but has reduced to about 10 to 15 km in a good rainy season after the construction of the dam (Mbewe, 2006).

Sampling stations

The three sampling stations that were selected, Stations I, II and III (Figure 1) represent the different habitats in a river system. Station I, Kasaka (15°47'11"S, 28°12'50"E), is near the Kafue-Mazabuka road bridge and is typical of the river habitats of the Kafue. It has fast running water as the river approaches the Kafue Gorge. The substrate consists of rock, cobbles, or gravel with occasional patches of sand. The natural dissolved oxygen concentration is normally near saturation (Cowardin et al., 1979).

Station II, Chilumba (15°47'12"S, 28°10'42"E), is along the river and is bounded on the landward side by vegetation and characterized by still water. This station is typical of the swampy areas of the flood plains. It is characterized by an unconsolidated bottom with scrubs and shrubs in the aquatic bed (Cowardin et al., 1979).

Station III, Chanyanya (15°42'40"S, 28°00'42"E), is a lagoon on the banks of the Kafue River characterised low water gradient and slow water velocity. The substrate consists mainly of sand and mud.

Oxygen deficits may sometimes occur (Cowardin et al., 1979). Figure 1 shows the position of the three sampling stations.

Sampling design

Three sites (Station I, II and III) were used for the collection of fish samples. At each site fish sampling by gill netting was done for three nights each month from October 2010 to March 2011. Fish samples were collected from the selected sampling sites of the Kafue River using a panel of gillnets of the following mesh sizes; 25, 37, 50, 63, 76, 89, 102, 114, 127, 140, 152, 165, 192, 204 and 216 mm according to the Gill survey Manual, Department of Fisheries, Zambia (2008) in order to sample both large and small fish.

Fish were collected for three consecutive days at each station. The nets were set between 16:00 and 18:00 h and hauled between 6:00 and 7:00 h the following day.

Data collection

The procedure included identifying the fish and measuring the length (total and standard in millimeters) and weight (in grams) of each fish specimen. Identification was done using standard keys (Skelton, 2001) for the species being studied and verification by pictures, detailed published descriptions Measurement of length was done using measuring board while the weight was measured using an electronic scale.

Data analysis

Relative abundance

Pasgear (2007) was used to calculate the relative abundance, of each species in the catch composition using an Index of Relative Importance (IRI) (Kolding, 1989):

$$IRI = \sum \left[\frac{(\%W_i + \%N_i) * \%F_i}{(\%W_j + \%N_j) * \%F_j} * 100 \right]$$

Where: $\%W_i$ and $\%N_i$ are percentage weight and number of each species of total catch respectively, $\%F_i$ is percentage frequency of occurrence of each species in total number of settings, and S is total number of species.

Shannon's Diversity Index, *H*, as a measure of the abundance and evenness of species present in a sample, was calculated at each sampling site. The index is defined by Begon et al. (1990) as:

$$H = -\sum_{i=1}^{S} P_i \ln P_i$$

Where: *P*i is the number of individuals of each species divided by the total number of individuals of all species in each sample and *S* is the total number of individuals of all species.

Shannon's evenness index (*J*) was calculated as:

$$J = H/\ln S$$

This index lies between 0 and 1, with 1 being complete evenness.

IRI was numerically compared among the *Oreochromis* spp. analysis of Variance (ANOVA- Statix 9 programme, 2009) was used to test for significant differences in Shannon's diversity, Shannon's evenness of the floodplain.

The sum of fish caught, species diversity and species evenness for Stations I, II and III were computed using PC-ORD (McCune B and Mefford MJ 2006). The distribution of *O. andersonii, O. macrochir* and *O. niloticus* were analysed at each station.

Significant variations in the variables were analysed using Analysis of Variance (ANOVA) Statix 9.

RESULTS

Relative abundance

A total of twenty three (23) fish species were sampled in the Kafue River (Appendix 1). All the species were noted as indigenous to the region and within their natural distribution range (Skelton, 2001) with the exception of *O. niloticus*.

General species distribution in the Kafue floodplains

Fifty nine (59) of the fish caught were *Oreochromis* spp. In terms of numbers, *O. niloticus* was the most numerous of the *Oreochromis* spp, contributing 1.5% to the total number of fish samples collected (2683). *O. andersonii* and *O. macrochir* contributed 0.4 and 0.3%, respectively (Appendix 2). *O. niloticus* was the most important in terms of mass (W), followed by *O. andersonii* and *O. macrochir* accounting for 10.8, 2.88 and 1.1%, respectively.

The overall fish species diversity of the Kafue floodplains was calculated as (H) and the value was 2.289. *O. niloticus* contributed the highest diversity value (H = 0.063), followed by *O. andersonii* and *O. macrochir* with, H = 0.024 and 0.016, respectively. The overall distribution of all fish species of the Kafue floodplains was estimated using Shannon's Evenness Index (J) which was equal to 0.73. *O. niloticus* was the most evenly distributed followed by *O. andersonii* and *O. macrochir* with J = 0.02, 0.01 and 0 respectively.

There was a significant difference in the number of fish caught in some stations ($F_{2, 9} = 6.31$; $P = 0.0194 < 0.05$). Chanyanya (Station III) was noted to have the highest mean value of fish caught in the sampling period (10 ± 1.8085). This was significantly different from the amount of fish caught in Kasaka (Station I) which had a mean total of 1.25 ± 1.8085 fish caught through the entire sampling period. Chanyanya (Station III) therefore had the highest number of fish caught followed by Chilumba (Station II) and the lowest catch was in Kasaka (Station I).

There was no significant difference in species evenness ($F_{2, 9} = 1.14$; $P = 0.3633 > 0.05$) and diversity ($F_{2, 9} = 1.18$; $P = 0.3509 > 0.05$) among the three stations.

However, Chanyanya (Station III) had the highest values of all three indices as indicated in Table 1.

Table 1. Numbers, diversity (H) and species evenness (J) for the three sampling stations.

Station	Sum	Diversity (H)	Evenness (J)
Chanyanya	10 ± 1.8085	0.5433 ± 0.2117	0.5320 ± 0.1970
Chilumba	3.5 ± 1.8085	0.0872 ± 0.2117	0.1258 ± 0.1970
Kasaka	1.25 ± 1.8085	0.2638 ± 0.2117	0.2400 ± 0.1970

Table 2. Variation of *Oreochromis* spp. in the three sampling stations.

Station	*Oreochromis andersonii*	*Oreochromis macrochir*	*Oreochromis niloticus*
Chanyanya	2.50 ± 0.8165	0.50 ± 0.4859	7.00 ± 1.5964
Chilumba	0.00 ± 0.8165	0.75 ± 0.4859	2.00 ± 1.5964
Kasaka	0.50 ± 0.8165	0.25 ± 0.4859	0.50 ± 1.5964

Distribution of Oreochromis spp. *in stations I, II and III*

There was no significant difference in the number of *O. andersonii* caught in the three stations ($F_{2, 9}$ = 2.63; P = 0.1265 > 0.05). There was no significant difference in the number of *O. macrochir* caught in the three stations sampled ($F_{2, 9}$ = 0.26; P = 0.7732 > 0.05).

There was a significant difference in the number of *O. niloticus* caught in some stations sampled ($F_{2, 9}$ = 4.28; P = 0.0495 < 0.05). When compared amongst each other, only Chanyanya (Station III) and Kasaka (Station I) showed a significant difference in the sum of *O. niloticus* caught. Chilumba (Station II) did not show any difference from both stations. The mean values of species caught at each station are as summarized in Table 2.

DISCUSSION

The Kafue floodplains have 73% even distribution of fish species implying an even representation of each of the species.

General species distribution

Among the mouth brooding tilapiines, the *O. niloticus* contributed the most to the population sampled. The ability of *O. niloticus* to colonise new areas in a short period of time could be due to several reasons such as its ability to tolerate a large array of environments (Trewevas, 1983) and grow into adulthood quickly (Peterson et al., 2002).

It was noted to have an IRI of 3.2% which was the highest compared to the *O. andersonii* (IRI = 0.4%) and *O. macrochir* (IRI = 0.1%). The success of *O. niloticus* as an invasive species indicates that there are few, if any, successful competitors in the ecological systems where the species has been introduced. Similar results were noted in a gill net survey program by the Department of Fisheries Zambia, carried out in 2008 in the Kafue floodplains, it was also noted that the *O. niloticus* was the most abundant among the mouth brooding tilapiines with 6% IRI while *O. andersonii, O. macrochir* contributed 3% giving an indication that *O. niloticus* has become an important fish in the fishery Njobvu, 2008.

Species distribution according to habitats

Chanyanya, a lagoon, had the highest number of fish sampled (10 ± 1.8085). The lagoon characterized by slow waters with high vegetation is a suitable habitat for the *Oreochromis* species as described by Skelton (2001). Kasaka was the lowest as it is characterised by fast running water which is an unsuitable habitat for the species.

It was observed, in this study, that Chilumba, though well vegetated and also characterized by low water velocity, had the least diversity (0.0872 ± 0.2117) and even distribution (0.1258 ± 0.1970). This is due to the over fishing that has been noted in the area by Mbewe (2006).

The *O. niloticus* has not only established its population in the Kafue but has dominated the numbers among the mouth brooding tilapiines. The indigenous species possibly differ from *O. niloticus* which have higher performance growth and better reproduction strategies such as bigger egg sizes thereby increasing its abundance and giving it higher survival chances compared to the indigenous mouth brooding tilapiines within the Kafue floodplains.

The dominance of *O. niloticus* over the local *Oreochromis* spp. poses a threat on the ecosystem of the Kafue floodplain and to the floodplains fish diversity. *O. niloticus* is highly competitive and has the potential to be successful in terms of survival and may displace the

mouth brooding tilapiines in the area. When the three species were separately compared among the stations, *O. niloticus* showed a higher sum in all three stations compared to the other *Oreochromis* species and Chanyanya had the most of each species.

It has been noted that fisheries that exploit a wide range of species or a range of populations may have a more sustainable catch than fisheries that exploit a single species (Dulvy et al., 2000; Hilborn et al., 1992).

Therefore the replacement of the local tilapiines by *O. niloticus* in the Kafue flats threatens the sustainability of the Kafue Floodplain Fishery. In this situation, fishery management authorities in Zambia should review policies relating to fish species introduction and endeavour to prevent the spread of *O. niloticus* to other fishery areas.

REFERENCES

Analytical Software (2009). Statix 9 User's manual. Analytical Software. Tallahassee, USA.

Audenaerde Dirk FE Thys-Van-Den (1994). Introduction of aquatic species into Zambian waters, and their importance for aquaculture and fisheries. Food and Agriculture Organisation of the United States.

Begon M, Harper JL, Townsend CR (1990). Ecology, Individuals, Population and Communities. 2nd Edition. Blackwell, Oxford, p. 954.

Cowardin LM, Carter V, Golet FC, LaRoe ET (1979). Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/resource/1998/classwet/classwet.htm (Version 04 DEC 98).

Dulvy NK, Metcalfe JD, Glanville J, Pawson MG, Reynolds JD (2000). Fishery stability, local extinctions and shifts in community structure in skates. Conserv. Biol., 14: 283-293.

Hilborn R, Waters CJ (1992). Quantitative fishers Stock Assessment; Choice, Dynamics and uncertainty. New York; Chapman and Hall.

Kolding J (1989). Changes in species composition and abundance of fish populations in Lake Turkana, Kenya. In: Pitcher, T. J & P.J.B. Hart. (eds) The impact of species changes in African Lakes: Chapman & Hall, London, pp. 335-365.

Kolding J, Skaalevik A (2007). Pasgear software; version 2.2. Norway.

Mbewe M (2006). Frame Report for Kafue Floodplain Fisheries. Zambia Department of Fisheries.

McCune B, Mefford MJ (2006). PC-ORD. Multivariate Analysis of Ecological Data.Version 5.10 MjM Software, Gleneden Beach, Oregon, U.S.A.

Njombvu L (2008). GNS Determination of abundance of Nile tilapia, natural *Oreochromis* species and hybrids of the Kafue fishery. Zambia Department of Fisheries.

Peterson MS, Slack WT, Woodley CM (2002). Influence of tilapiine fishes on freshwater fishes in south Mississippi. Final Report to Mississippi Wildlife Fisheries and Parks.

Schwank EJ (1994). The introduction of *O. niloticus* is spreading on the Kafue floodplains, Zambia. Hydrobiol. J., pp. 143-147.

Skelton P (2001). Diversity and distribution of freshwater fishes in East and Southern Africa. Ann. Mus. Cent. Af., Zool., 275: 95-131.

Trewevas E (1983). Tilapiine Fishes of the Genera *Sarotherodon, Oreochromis* and *Danakilia*. British Museum of Natural History, Publ. Num. 878. Comstock Publishing Associates. Ithaca, New York, p. 583.

Zambia Department of Fisheries and Research Gillnet survey Manual and Guide (2000). Zambia, 1: 18.

APPENDIX

Appendix 1. Fish species caught in gill nets at the Kafue floodplains caught between October 2010 and March 2011.

Species	Common name
Characidae	
Brycinus lateralis (Boulenger, 1900)	Striped robber
Cichlidae	
Callochromis stappersii (Boulenger, 1914)	Redspot callochromis
Oreochromis andersonii (Castelnau, 1861)	3-spotted bream
Oreochromis macrochir (Boulenger, 1912)	Green head tilapia
Oreochromis niloticus (Linnaeus, 1758)	Nile tilapia
Pharyngochromis acuticeps (Steindachner, 1866)	Zambesi kurper
Pseudocrenilabrus philander (Weber, 1897)	Southern mouth brooder
Sargochromis carlottae (Boulenger, 1905)	Rainbow bream
Sargochromis codringtonii (Boulenger, 1908)	Green bream
Serranochromis angusticeps (Boulenger, 1907)	Thin face largemouth
Tilapia rendalli (Boulenger, 1896)	Red breasted bream
Tilapia sparrmanii (Smith 1840)	Banded tilapia
Claridae	
Clarias ngamensis (Castelnau, 1861)	Blunt tooth catfish
Cyprinidae	
Labeo cylindricus (Peters, 1852)	Red eye labeo
Barbus sp.	
Hepsetidae	
Hepsetus odoe (Bloch, 1794)	Kafue pike
Mochokidae	
Synodontis macrostigma (Boulenger, 1911)	Large spot squeaker
Synodontis macrostoma (Skelton and White, 1990)	Large mouth squeaker
Synodontis sp.	
Mormyridae	
Marcusenius macrolepidotus (Peters,1852)	Bulldog
Petrocephalus catostoma (Günther, 1866)	Northern Churchill
Petrocephalus wesselsi (Kramer & van der Bank, 2000)	Southern Churchill
Schilbeidae	
Schilbe intermedius (Rüppell, 1832)	Butter barbell, Silver catfish

Appendix 2. Overall percentage, age contribution by numbers for the mouth the species of the Kafue floodplains from October 2010 to March 2011.

Species	NO*	% NO*	W* (kg)	% W*	FRQ*	% FRQ*	IRI*	% IRI*	H*	J*
Barbus sp.	259	9.7	3.411	3.1	29	67.4	860	7	0.226	0.07
Brycinus lateralis	573	21.4	7.142	6.5	33	76.7	2136	17.4	0.33	0.11
Clarias gariepinus	36	1.3	19.043	17.3	16	37.2	692	5.6	0.058	0.02
Clarias ngamesis	57	2.1	27.812	25.2	21	48.8	1335	10.9	0.082	0.03
Clarias stappersii	1	0	0.202	0.2	1	2.3	1	0	0.003	0

Appendix 2. Contd.

Hepsetus odoe	39	1.5	4.852	4.4	17	39.5	231	1.9	0.062	0.02
Labeo cylindricus	4	0.1	0.067	0.1	3	7	1	0	0.01	0
Marcusenius macrolepidotus	188	7	3.346	3	32	74.4	747	6.1	0.186	0.06
Oreochromis andersonii	12	0.4	3.119	2.8	6	14	46	0.4	0.024	0.01
Oreochromis macrochir	7	0.3	1.233	1.1	5	11.6	16	0.1	0.016	0
Oreochromis niloticus	40	1.5	11.899	10.8	14	32.6	400	3.2	0.063	0.02
Petrocephalus catostoma	76	2.8	0.54	0.5	16	37.2	124	1	0.101	0.03
Petrocephalus wesselsi	151	5.6	1.106	1	19	44.2	293	2.4	0.162	0.05
Pharyngochromis acuticeps	1	0	0.048	0	1	2.3	0	0	0.003	0
Pseudocrenilabrus philander	68	2.5	0.437	0.4	16	37.2	109	0.9	0.093	0.03
Sargochromis carlottae	1	0	0.055	0	1	2.3	0	0	0.003	0
Sargochromis codringtonii	7	0.3	0.871	0.8	7	16.3	17	0.1	0.016	0
Schilbe intermedius	572	21.3	12.417	11.3	40	93	3030	24.6	0.33	0.11
Serranochromis angusticeps	40	1.5	4.302	3.9	23	53.5	288	2.3	0.063	0.02
Serranochromis macrocephalus	5	0.2	0.417	0.4	4	9.3	5	0	0.012	0
Synodontis sp.	426	15.9	4.803	4.4	33	76.7	1553	12.6	0.292	0.09
Tilapia rendalli	17	0.6	1.167	1.1	9	20.9	35	0.3	0.032	0.01
Tilapia sparrmanii	103	3.8	2.039	1.8	29	67.4	384	3.1	0.125	0.04
Total	2683	100	110.328	100	-	-	12303	100	2.289	0.73

*NO: Number, NO%: percentage number, W (kg): weight in kilogram, W%: percentage weight, FRQ: frequency, FRQ%: percentage frequency, IRI: index of relative Importance, IRI%: index of relative importance, H: Shannon's diversity index, J: Shannon's evenness index.