Diversity and Distribution of Freshwater Fishes in Oguta Lake, Southeast Nigeria

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Abstract
The ichthyofaunal composition of the largest natural lake in Nigeria - the Oguta Lake, was investigated from January, 2012 to December, 2013. Bi-monthly random samples of fish catches of artisanal fishers employing hook and line, gill net, cast net, bagnet and local traps were analysed. A total of 1,989 fishes were sampled comprising 6 orders, 22 genera, and 32 species spread into 18 families. The Perciformes, Cichlidae and *Tilapia zill* were the most abundant fish order, family and species, respectively. The study reveals that species diversity was highest at station 4 (Osemotor) though no significant spatial differences were detected. The lake is of ecological significance in accommodating some threatened species like *Erpetoichthys calabaricus* and serving as a source of broodstock of *Clarias gariepinus* for aquaculture. A seriation analysis of species presence/absence matrix in the lake reveals *Tilapia mariae, Synodotis schall, Mormyrus rume, Synodontis nigrita* and *Petrocephalus banebane* are important fish species to ecosystem health of the lake. The fish abundance and diversity values in present study are lower than the findings of previous studies in the same water body, suggesting need for proper and articulated management.
Keywords: Biodiversity, blue Lake, conservation, food security, sustainable management

1. Introduction

Fisheries resources are on the decline in Nigeria due to over exploitation and inadequate management of inland waters. For sustainability of these resources, an adequate knowledge of species composition, diversity and relative abundance of the fisheries resources of the water bodies must be understood. Increased fishing pressure exerted by artisanal fishermen that are operating in this water body coupled with the downstream migration of fish in search for food, shelter and spawning, industrialization, urbanization and farming activities around the river are factors that contribute variation in fish composition and diversity in Nigeria. External factors affecting populations of freshwater species include; simple habitat loss resulting from withdrawal of water for human use such as irrigation, domestic and industrial use; impact of anthropogenic factors; impoundment, wetland drainage and flood control which cause the load of inorganic and organic pollutants in flowing waters to increase. Available evidence strongly suggests that fish abundance and diversity are in decline at the same time that human population's destructive activities are increasing. The fish supply gap in Nigeria as indicated by Adekoya and Olunuga (1999) is at least 1.0 million metric tons. As a measure to bridge the fish demand gap with its supply, Nigeria resorted to importation of fish thereby causing a considerable drain in the foreign reserve. Despite expenses on fish importation, the gap between supply and fish demand widens the more with population increase. In his contribution, Tobor (1973) advanced effective domestic production rather than fish importation in covering this gap. The contribution of artisanal fisheries is poor due to low output, poor processing mechanism, ineffective distribution and marketing of fishing products, pollution and post-harvest loss. Although freshwater ecosystems such as rivers, lakes and wetlands occupy less than 2% of the earth's total land surface, they provide a wide range of habitats for a significant proportion of the world's plant and animal species. Many are yet to be discovered, but the number of freshwater species worldwide is estimated at between 9,000 and 25,000 (Cosgrove and Rijsberman, 2000). The fish yield of most inland waters in Nigeria are generally on the decline for causes that may range from inadequate management of the fisheries to degradation of water bodies (Odo *et al*., 2009). Due to a general lack of data, it is difficult to access the status of the inland water biodiversity. Indeed monitoring the status and trends of freshwater biodiversity is essential to quantify impacts of human activities on freshwater systems and to improve freshwater biodiversity conservation. According to Adaka *et al.* (2014) environmental awareness to educate the fishers and other stakeholders on the danger of extinction of the species and the need for its conservation was necessary. Also future developments on autogenic and anthropogenic threats, and activities and harmful practices which predispose fish species extinction along the floodplain and catchment area of rivers should be subjected to environmental scrutiny to maintain the environmental health and integrity of the ecosystem. Similarly, Ude *et al*., (2011) stated that detailed knowledge of the function of the river system and the responses of fish species are needed for effective fisheries management planning. The aim of this study therefore is to provide ichthyofaunal composition of Oguta Lake along a spatial gradient to promote discussions for its ecological significance and management of the fishery to avoid risk of fish stock collapse and loss of invaluable ecosystem goods.

2. Materials and Methods

The study was conducted at Oguta Lake (latitudes 5°41′ and 5°44′ north and longitude 6°45′ and 6°50′ East) within the equatorial rainforests belt in Imo state, Nigeria. The Oguta blue Lake is the largest natural lake in Nigeria and originates from a natural depression. It is the largest hydrological feature in Imo state and services several adjoining communities along its boundaries. Four rivers are associated with the Lake; two of which flow into the Lake (Njaba and Awbana) while the third (Orashi) flows through the Lake at its south eastern end and the fourth (Utu) flows into the Lake only during the rainy season (Nwadiaro, 1989). The surface areas of the lake during the dry and wet seasons are 1.8 and 2.5km^2, respectively, while the maximum depth is about 8.0m (Nwadiaro, 1989).

Five sites along the main course of the lake were chosen as the sampling stations. The description of the stations is as follows; station 1 represent Onu Utu which cover up to Ossai Uhamiri very close to Njeba River, station 2 represent Onu Okposha where Awbana River flow into the Lake, Ogbe Hause is station 3

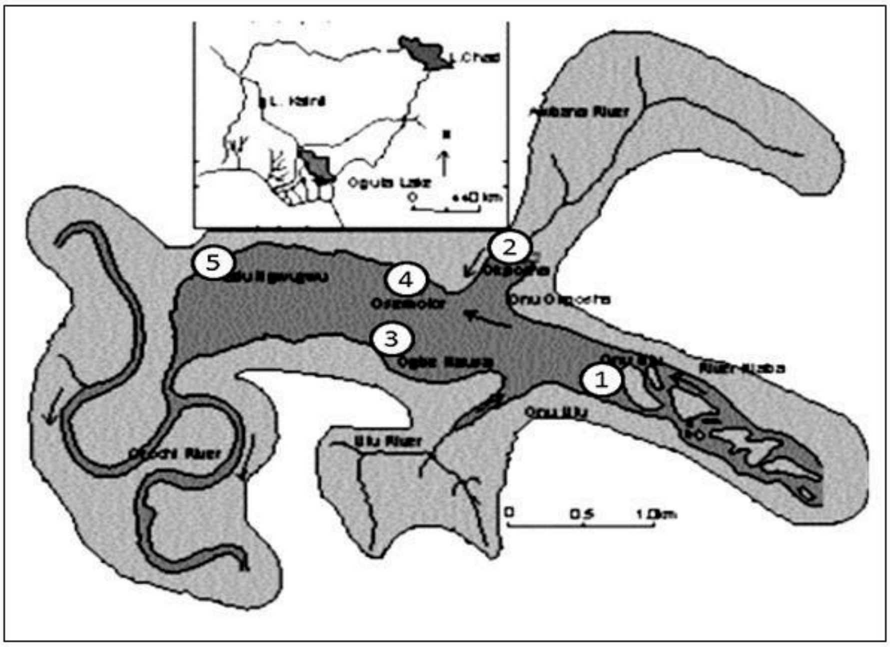

Fig. 1: Sketch map of Oguta Lake, Nigeria (numbers represent sampling stations)

which extend to Eze Ogwe, this site is near the Utu River, station 4 is Osemotor, while station 5 is the Ede Ngwugwu, it extend to Agbata Uhamiri near Urashi at the confluence, where the two water bodies show distinct colour differentiating Oguta Lake from Urashi River. These sites are accessible throughout the year. The sites are presented in Figure 1.

Fishes were collected from the different sample stations fortnightly during the study period of January 2012 to December 2013 with the help of local fishers using different types of gears namely gill nets, cast nets (>3.8cm mesh sizes), hook and line and local traps. Immediately photographs were taken prior to preservation since formalin decolorizes the fish color on long preservation. Fish identifications were carried out with the aid of the keys of Olaosebikan and Raji (1998), Idodo-Umeh (2003) and Fishbase database (Froese and Pauly, 2010). Rare specimens with some difficult to identify on the spot were preserved in 5% formalin for laboratory observation. Both morphometric measurements and meristic counts were used in the identification. All members of a species were physically counted in order to establish relative abundance and recorded monthly. The Simpson's Dominance index, *C*, Shannon-Weiner Diversity index, *H'*, and Margalef's species richness, *d*, as in Odum (1971) were used to evaluate the trend in fish community structure as calculated below:

$$C = 1 - \Sigma \left(\frac{ni}{N}\right)^2 \qquad (1)$$

$$H' = -\Sigma P_i \, log_e \, P_i \qquad (2)$$

$$d = S - 1/log_e \, \mathrm{N} \qquad (3)$$

S = total species number, P_i = proportion of each species in each sample (n_i/N)
N = Total number of individuals of all species, n_i = Number of individuals per samples

All diversity indices were calculated with the aid of MS Excel and PAST® softwares. The fish species presence/absence data matrix was fed into PAST® (Hammer, 2011) for generating and seriating random matrices within each species for 'optimal' re-ordering of the species encountered to achieve best range plot concentrating the presences along the diagonal matrices across spatial gradient.

3. Results and Discussion

The distribution of the fish species mainly depends on the biotic and abiotic factors. The type of ecosystem, mean depth, water level fluctuations, morphometric features and bottom of the river may also have great implications. During the study period, a total of 1,989 fishes were sampled comprising 32 species from 18 families and six orders (Table 1). The families included Cichlidae which was the most abundant in all the stations followed by Mormyridae, Polypteridae and Alestidae with Characidae and Ciprinidontidae having lesser numbers in all the stations while Pantodontidae was least in abundance. The number of species per order varied from two to eight: Characiformes-8, Cyprinodontiformes-3, Osteoglossiformes-6, Perciformes-7, Polypteriformes-2, and Siluriformes-6.

The distribution and species abundance in Table 1 shows the three most dominant fish orders were Perciformes (25.64%), Characiformes (21.62%) and Siluriformes (21.42%). This is at variance with the observations of Ekpo and Udoh (2013) and Adaka *et al.* (2014) in which Perciformes, Siluriformes and Osteoglossiformes were the three most dominant fish orders in inland lotic freshwater bodies. However like the latter, Cichlidae (16%) was the most abundant fish family while *Tilapia zill* (8.20%) was the most abundant species. Generally, the individual species exhibited low abundances, 0.65 – 8.20% (< 10.0%). No single species was truly dominant (n = 50%), indicating the polydiverse nature of Oguta Lake fishery. The second most dominant species in this Lake was *Erpetoichthys calabaricus* (6.38%), a species of ecological interest because of its threatened status by human population density, habitat degradation and collection in aquarium trade (Olaosebikan and Bankole, 2005). The popular farmed fish, *Clarias gariepinus* (5.63%) was the third most dominant species. Consequently, the Oguta Lake fishery is of great significance in terms of food security (with its abundant cichlid species), conservation of threatened species like *E. calabaricus* and as a source of broodstock of *Clarias gariepinus* for aquaculture.

Figure 2 presents the percentage occurrence of fish families in Oguta Lake showing that Cichlidae is followed by Mormyridae (11%) > Polypteridae (10%) > Alestidae (9%) while Characidae, Ciprinidontidae, Distichodontidae and Arapaimidae had 2% each while Pantodontidae recorded the lowest occurrence (1%).

Table 1: Fish species abundance, richness and distribution in Oguta Lake, Nigeria

S/N	Orders/Families/Species	S_1	S_2	S_3	S_4	S_5	Distribution	Abundance, n
	Characiformes							
	Alestidae (= Characidae)							
1	*Hydrocynus forskali* (Cuvier, 1819)	14	14	12	16	12	5 (Evenly distributed)	68^{ne}
2	*Hydrocynus vittatus* (Castelhau, 1861)	-	15	-	15	25	3 (Partially distributed)	55^{ne}
3	*Brycinus nurse* (Rüppell, 1832)	12	-	-	17	20	3 (Partially distributed)	49^{ne}
4	*Brycinus leuciscus* Günther, 1867	-	23	-	14	-	2 (Partially distributed)	37^{ne}
	Citharinidae							
5	*Citharinus citharus* (Geoffroy Saint-Hilaire, 1809)	26	19	16	10	5	5 (Evenly distributed)	76^{r}
6	*Citharinus latus* Müller & Troschel, 1844	14	10	5	14	5	5 (Evenly distributed)	48^{r}
	Distichodontidae							
7	*Distichodus rostratus* (Günther, 1864)	6	14	15	-	10	4 (Evenly distributed)	45^{r}
	Hepsetidae							
8	*Hepsetus odoe* (Bloch, 1794)	10	24	-	18	-	3 (Partially distributed)	52^{r}
	Cyprinodontiformes							
	Aplocheilidae (= Cyprinodontidae)							
9	*Epiplatys bifasciatus* (Steindachner, 1881)	15	12	-	10	-	3 (Partially distributed)	37^{r}
10	*Fundulopanchax gardner* (Boulenger, 1911)	10	-	-	-	26	2 (Partially distributed)	36^{ne}
	Pantodontidae							
11	*Pantodon buchholzi* Peters, 1876	-	16	-	12	-	2 (Partially distributed)	28^{ne}
	Osteoglossiformes							

	Arapaimidae (=Osteoglossidae)							
12	*Heterotis niloticus* (Cuvier, 1829)	-	7	14	10	10	4 (Evenly distributed)	41[ne]
	Mormyridae							
13	*Mormyrus rume* Valenciennes, 1847	24	33	-	29	-	3 (Partially distributed)	86[r]
14	*Petrocephalus bovei* (Valenciennes, 1847)	-	13	-	17	-	2 (Partially distributed)	30[ne]
15	*Petrocephalus bane* (Lacepede, 1803)	-	-	-	13	-	1 (Partially distributed)	13[ne]
16	*Mormyrops anguilloides* Linnaeus, 1758	13	22	15	13	22	5 (Evenly distributed)	85[ne]
	Notopteridae							
17	*Papyrocranus afer* Günther, 1868	16	4	23	7	14	5 (Evenly distributed)	64[r]
	Perciformes							
	Anabantidae							
18	*Ctenopoma kingsleyae* Günther, 1896	17	10	14	6	18	5 (Evenly distributed)	65[ne]
	Channidae							
19	*Parachanna obscura* (Günther, 1861)	34	10	-	28	18	4 (Evenly distributed)	90[r]
20	*Parachanna africana* (Steindachner, 1879)	19	-	-	20	-	2 (Partially distributed)	39[ne]
	Cichlidae							
21	*Tilapia zilli* Gervais, 1848	31	50	13	47	22	5 (Evenly distributed)	163[r]
22	*Tilapia mariae* Boulenger, 1899	17	15	-	20	-	3 (Partially distributed)	52[r]
23	*Sarotherodon galilaeus* (Linnaeus, 1758)	14	-	26	10	-	3 (Partially distributed)	50[r]
24	*Oreochromis niloticus* (Linnaeus, 1758)	15	17	-	14	5	4 (Evenly distributed)	51[r]
	Polypteriformes							
	Polypteridae							
25	*Polypterus senegalus* Cuvier, 1829	13	-	24	13	26	4 (Evenly distributed)	76[ne]
26	*Erpetoichthys* (Smith, 1865)	14	10	20	55	28	5 (Evenly distributed)	127[ne]
	Siluriformes							
	Clariidae							
27	*Clarias gariepinus* Burchell, 1822	30	17	-	42	23	3 (Partially distributed)	112[r]
	Claroteidae (=Bagridae)							
28	*Chrysichthys nigrodigitatu* (Lacepede, 1803)	15	25	10	27	-	4 (Evenly distributed)	77[r]
	Malapteruridae							
29	*Malapterurus electricus* (Gmelin, 1789)	9	11	11	12	14	5 (Evenly distributed)	57[r]
	Mochokidae							
30	*Synodontis nigrita* Valenciennes, 1840	12	26	-	24	-	3 (Partially distributed)	62[r]
31	*Synodotis schall* Valenciennes, 1840	14	16	-	10	-	3 (Partially distributed)	40[r]
	Schilebeidae							
32	*Schilbe mystus* (Linnaeus, 1758) = *Eutropius niloticus*	18	22	15	-	23	4 (Evenly distributed)	78[r]
	TOTAL	**432**	**455**	**233**	**543**	**326**		**1989**

S_1 = Onu Utu, S_2 = Onu Okposha, S_3 = Ogbe Hasue, S_4 = Osemotor, S_5 = Ede Ngwugwu
[r] = reported by Ita and Balogun (1983) and Ita (1993)
[ne] = new entrant, not reported by Ita and Balogun (1983) and Ita (1993)

Table 2: Fish species abundance, richness and biodiversity indices of Oguta Lake, Nigeria

Biodiversity Indices	Sampling sites				
	S_1	S_2	S_3	S_4	S_5
Abundance (*N*)	432	455	233	543	326
Order	6	6	6	6	6
Family	16	18	12	16	13
Genus	22	22	14	22	17
Species Richness	26	26	15	29	19
Shannon-Weiner index (*H'*)	0.0142	0.0156	0.0041	0.0224	0.0080
Simpson's index of dominance (*C*)	0.0471	0.0522	0.0136	0.0744	0.0267
Simpson's index of diversity (*1-D*)	0.9529	0.9477	0.9864	0.9256	0.9733

Table 3: Fish species earlier reported upon but not found in current study in Fishes in Oguta Lake, Nigeria

S/N	Families	Species
1	Carangidae -1	*Trachinotus goreensis* Cuvier, 1832
2	Cichlidae- 5	*Haplochromis wingatii* (Boulenger, 1902)
3		*Tilapia melanopleura* (= Tilapia zillii (Gervais, 1848)
4		*Tilapia monodi* = *Oreochromis aureus* (Steindachner, 1864)
5		*Tylochromis sp.*
6	Citharinidae-1	*Citharinops distichodoides* (Pellegrin, 1919)
7	Cyprinidae-2	*Labeo brachypoma* Günther, 1868
8		*Labeo senegalensis* Valenciennes, 1842
9	Distichodontidae-2	*Distichodus brevipinnis* Günther, 1864
10		*Distichodus engycephalus* Günther, 1864
11	Gymnarchidae -1	*Gymnarchus niloticus* Cuvier, 1829
12	Latidae-1	*Lates niloticus* Linnaeus, 1758
13	Mochokidae-4	*Synodontis clarias* (Linnaeus, 1758)
14		*Synodontis eupterus* Boulenger, 1901
15		*Synodontis ocellifer* Boulenger, 1900
16		*Synodontis resupinatus* Boulenger, 1904
17	Mormyridae-2	*Gnathonemus abadii* = *Marcusenius abadii* (Boulenger, 1901)
18		*Gnathonemus senegalensis* = *Marcusenius senegalensis* (Steindachner, 1870)
19	Mugilidae-1	*Mugil cephalus* Linnaeus, 1758
20	Notopteridae-1	*Xenomystus nigri* (Günther, 1868)
21	Tetraodontidae-1	*Tetraodon fahaka* (=*Tetraodon lineatus* Linnaeus, 1758)

The dominance of cichlid fishes agrees with what is obtained in many other lakes and reservoirs in Africa (Ita, 1993). The preponderance of this family in terms of species diversity, number and weight could be attributed to the presence of high food resource such as plankton (Nwadiaro, 1989), their prolific breeding capabilities and their strong adaptation to lacustrine conditions of the Lake. The high number of *Tilapia zillii* could also be attributed to the absence of large numbers of effective predators (like *Lates niloticus*) to check their prolific breeding which contributes to its high species index and abundance.

The spatial distribution (Tables 1 and 2) of the fish assemblage of the Lake exhibit high preference for station 4 (Osemotor) accommodating 29 species (69%) and 16 fish families (89%). This might be due to high plankton productivity and favourable hydrographic conditions for fish survival and growth as well human error, such as the effort and dexterity of the local fishers employed in the survey. However, the biotic indices presented in Table 2 do not indicate significant spatial variations. Shannon-Weiner index (*H'*) was highest in station 4 (0.0224) and least in station 5 (0.0080). The Simpson's dominance index (*D*) and index of Diversity (*1-D*) follow the same pattern. The Simpson's dominance index (*d*) range between 0 and 1; 0 represents infinite diversity and 1 indicating no diversity, the higher the value the smaller the diversity. The Simpson's index of diversity (*1-D*) represents the probability that two individual fish randomly selected from a sample will belong to different species. This value also ranges between 0 and 1, the greater the value, the greater the sample diversity.

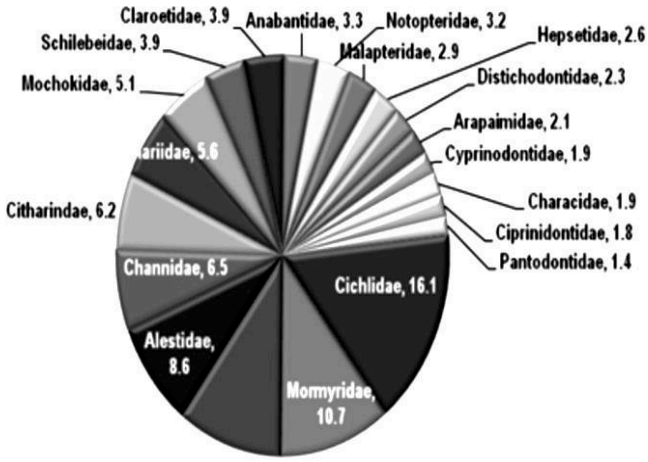

Fig. 2. Percentage occurrence of fish families in Oguta Lake, Nigeria

Fish diversity of rivers essentially represents the fish faunal diversity and their abundance. The study affirms earlier fears that fish diversity and distribution of the study area is reducing with increased human activities (Tables 1, 3). Okereke (1990) in a study of Otamiri River within same ecozone recorded 46 species in 20 families while an earlier survey of the lake (Ita and Balogun, 1983; Ita, 1993) recorded 40 species compared to 32 species recorded in the present study. Eighteen (18) of the 32 species encountered in this study were present (*r*) in the Lakes' species lists of 1983 and 1993 while 14 are probably new entrants, *ne*, since they were not encountered then (Table 1). With its interconnection with several rivers some of which connect to the Atlantic Ocean through the Imo Rivers, Oguta Lake fishery has actually been enriched with the inclusion of some new species that have adapted to the Lake environment. Also conspicuously absent from the present survey are 21 species from 12 families (Table 3); notably 5 cichlid species, 4 mochokid *Synodontis* species and large species like *Lates niloticus.* This could be related to high fishing effort and human population explosion as earlier observed by Ita and Balogun (1983) and Ita (1993). Other noted factors include destruction of breeding ground, habitat destruction, eutrophication, human activities, undesirable fishing methods (Adite *et al.,* 2006); reduced availability of food, competition between species for food and space, loss of vegetation and alterations in food webs and river morphology, ultimately leading to decrease in biodiversity and induced changes in fish yield and species composition (Hanson and Buttler, 1994),

The 32 species of fish encountered in this study was however higher than the 30 species in 16 families in Oramiri-Ukwa River reported by Adaka *et al.* (2010), and 27 species in Abak River and 23 fish species in Udum and Nung-oku stream reported by Udoidong (1988), among others.

The fish species seriation plot (Figure 3) identified the important species whose presence/absence could affect ecosystem health of the lake to include *Tilapia mariae, Synodotis schall, Mormyrus rume, Synodontis nigrita* and *Petrocephalus banebane*. Hence, fishery management plans for the Lake should include management of these species.

Presently, the Oguta Lake contains major fisheries upon which the livelihoods of hundreds of thousands of people depend. The increasing population pressure and the high demand for livelihood opportunities is a threat to the health of the fishery and ecosystem. A management plan must be initiated, enforced and properly funded to prevent the collapse of the fisheries and the social and economic disruption which will inevitably follow. More especially since the fisheries operate under conditions of free and open-access. The best approach to the conservation of the species is to disseminate conservation information, educate the fishers and other stakeholders about the danger of extinction of the species and the need for its conservation. This will go a long way towards protecting and preserving the species. Prevention now is not only better, but also cheaper than looking for ways of recalling lost species. Once extinction occurs, it may not be easily reserved or recalled. Presently, the fish yields are not very encouraging compared to similarly-sized inland rivers or lakes. This study recorded low species abundance probably owing to over exploitation and other factors earlier mentioned or to human error in sampling procedure such as the engagement of part time fishers, mostly young persons who fished either for sport or to enrich family meals. The results recorded in this study have only brought to light the need for further research on this Lake and many others in the country. Such research work should cover at least five years. It is also important to locate and enroll all the fishers operating in the river/lake basin into pro-active and efficient development of a catch statistics database for biological assessment and sustainable management of the fish stock. In the meantime, it is advisable to reverse the trend in fish decline and biodiversity loss by undertaking a re-stocking of the lake with fingerlings of some commercially important fresh water fish species to boost its productivity.

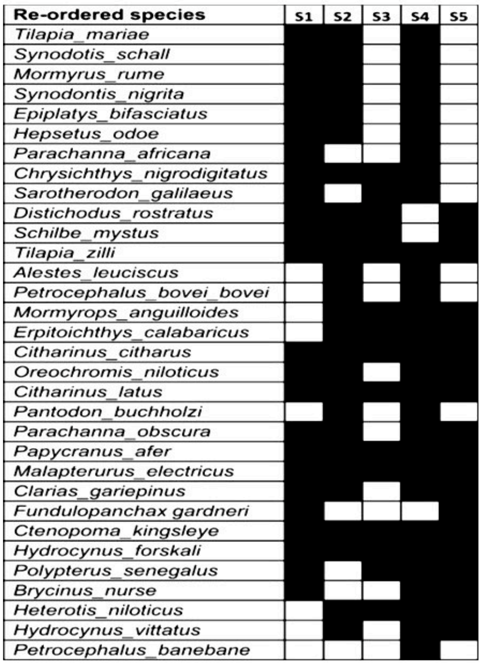

Fig. 3. Seriation and re-ordering of fish species data matrix along a spatial gradient using *PAST*®

Acknowledgement
The authors acknowledge the financial assistance extended to the corresponding author, Dr. G. S. Adaka, by the authorities of the Federal University of Technology, Owerri, Imo State, Nigeria, in the course of this research.

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