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Freshwater Fish Diversity of a Tropical Rainforest River in Southeast Nigeria

Adaka, G. S.[1*], Udoh, J. P.[2] and Onyeukwu, D. C.[1]
1. Department of Fisheries and Aquaculture, School of Agriculture and Agricultural Technology, Federal University of Technology, P.M.B.1526, Owerri, Imo State, NIGERIA; revadaka@gmail.com
2. Department of Fisheries and Aquatic Environmental Management, University of Uyo, P.M.B. 1017, Uyo - 520001, NIGERIA; jjamesphilip@gmail.com
*Corresponding Author: revadaka@gmail.com, +2348037838049

Abstract
Fish samples were collected at three stations twice per month from January to December 2013 with the help of local fishers using hook and line, gill net, cast net, bagnet and local traps for ecological studies of important fish species and resource management issues of Oramiri-Ukwa River, southeast Nigeria. An estimate of 25 fish species, 15 genera, 21 families and six orders were obtained. Ecological indices indicate a polydiverse community and no single species exhibited true dominance (≥ 50%). Paired group cluster analysis establishes *Tilapia zilli* and *Hemichromis fasciatus* as the focal species and identifies the associated species combinations that characterize spatial variability and account for the biodiversity resources and structure of the artisanal fishery. Other important species include *Tilapia mariae>Synodontis nigrita* while *Polypterus senegalus>Parachanna africana* and *Shilbe mystus* were the least in number. Monospecific and rare fish species of ecological and conservation significance identified include *Ctenopoma kingsleyae*, *Clarias gariepinus* as well as *Erpetoichthys calabaricus* and *Pantodon buchholzi* derived from interconnections with other African rivers. This study presents lower fish diversity compared to earlier reports. This difference may be linked to increased human activities and fluctuating biotic and abiotic factors of the ecosystem, among others.

Keywords: Abundance, biodiversity, conservation, rare species

1. Introduction

Ichthyodiversity refers to variety of fish species depending on the context and scale; it could refer to alleles or genotypes within piscian population, to species or life forms across aqua regimes (Burton *et al.*, 1992). Fishes are the important elements in the economy of many nations as they have been a stable item in the diet of many people. According to Ehrlich & Willson, (1991) biodiversity is essential for stabilization of ecosystem, protection of overall environmental quality for understanding intrinsic worth of all species on the earth. Freshwater biodiversity has declined faster than either terrestrial or marine biodiversity over the past 30 years (Jenkins, 2003). Biodiversity is often ambiguously misused or overused to describe population dynamics of a location or community (Lawson & Moduke, 2010). Declining river flow rates (discharge) have been a major cause of species loss and are likely to be further reduced by warming temperatures, reduced precipitation and increased water withdrawal for agriculture and other human uses (Plafkin *et al*., 1989). Future declines can therefore negatively affect freshwater biodiversity. Inland waters and freshwater biodiversity constitute a valuable natural resource, in economic, cultural, aesthetic, scientific and educational terms. The streams and rivers are facing number of environmental problems throughout the world largely associated with anthropogenic activities in their catchment areas (Young *et al.*, 2004). The adverse effects of human activities have resulted in degradation of stream and reverine ecosystem which ultimately alters the structure and function of stream biota. Their conservation and management are critical to the interests of all human, nations and governments. According to Nwafili & Tianxiang (2007), artisanal fishery continues to dominate fisheries, contributing over 85% of total fish production. The inland water and coastal seas are fully exploited and the increase in fishery production is not likely. Nigerian inland water bodies are primarily utilized for fishing by fisher folks. The greater part of inland fisheries is artisanal in nature supplying families with food and income. Artisanal fishing usually is usually not a full-time activity but rather integrated with farming and other activities.

The main aim of this study is to provide multi-gear and multi-species ichthyofaunal composition and spatial distribution of the Oramiri-Ukwa River in comparison with others in order to share, update information, and provide data for future analysis. This study also seeks to identify species of ecological significance in the study area and to promote discussions for the management of the fishery to avoid risk of fish stock collapse and loss of invaluable ecosystem goods.

2. Materials and Methods

The Study Area was Orammiri-Ukwa River (Fig. 1) located at Azaraegbulu, Emekuku in Owerri North Local Government Area of Imo State, southeast Nigeria at approximately latitude $5^{0}30'$N and longitude $7^{0}19'$E. Oramiri-Ukwa is a typical rain forest River. On both sides of the main River channel are large fringes of heavily forested swamps dominated by the raffia palm. The river flows from a highland in Okigwe and joins the Mbaa River to flow through Okahia Ezihe in Isiala Mbano Local Government Area, through Opara-nadim in Mbaise to

Onu-ngara Avuvu in Ikeduru Local Government Area of Imo-State, Nigeria. Oramiri-Ukwa flows southwards for about 5.8km before discharging into Otamiri River and Nworie River which are tributaries of the larger Imo River which drain into the Atlantic Ocean, southeast Nigeria. The climate of the area is characterized by two distinct seasons: the dry (November – March) and rainy seasons (April to October). The River is the main source of water supply especially during the dry season to the towns and villages through which it flows.

Three sampling stations (S_1- Emekuku, S_2- Avuvu and S_3 – Amakohia) were established along the main course of the River. Fish species were collected bi-monthly for 12 consecutive months (January to December, 2013) from the three sampling stations, with the assistance of local artisanal fishers using different types of nets namely gill nets, cast nets, hook and line, local traps and bagnets. The sampling sites were also generally accessible throughout the year and shallow in depth with surface to bottom transparency along sandy areas. Water lilly (*Nymphaea spp.*) and floating filamentous plants were common**.**

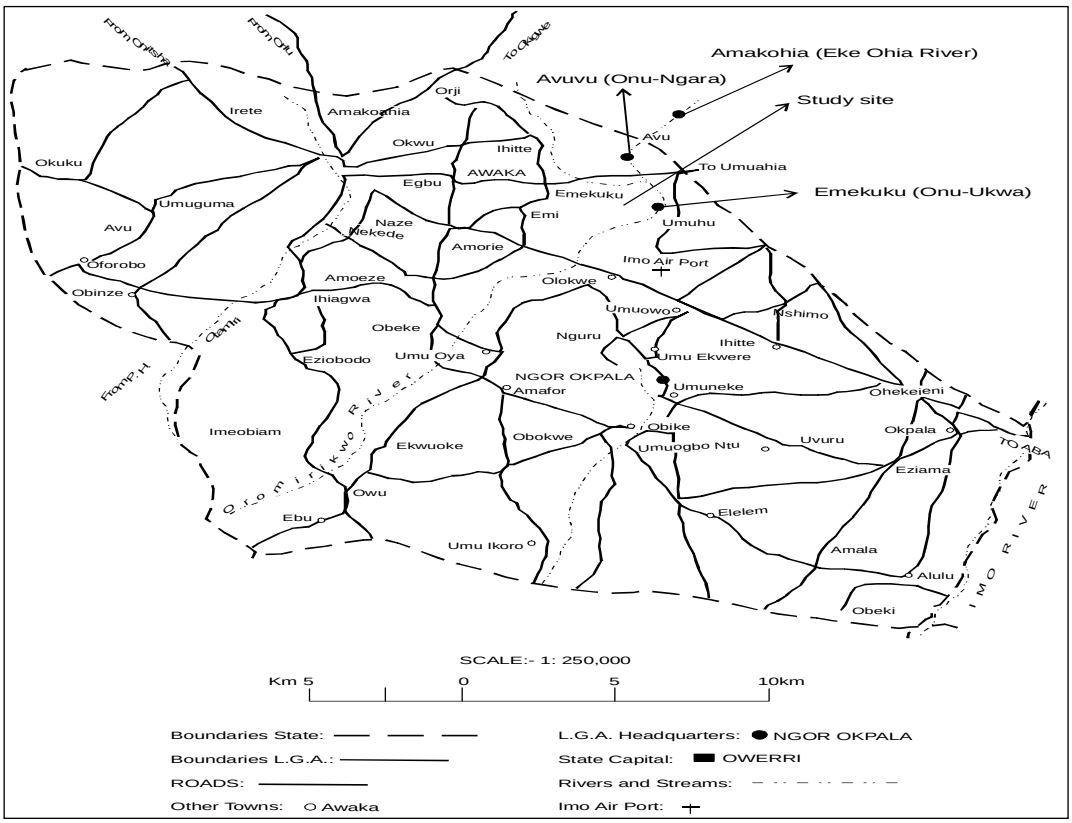

Fig. 1: Map of Owerri Capital territory, Nigeria, showing towns and sampling stations

Immediately after collection, photographs were taken prior to preservation since formalin decolorizes the fish color on long preservation. Fishes were fixed in 4% formalin solution in separate bottles and brought to the laboratory. Fish identifications were carried out with the aid of Boulenger (1916), Talwar & Jhingran (1991) and Fishbase database (Froese & Pauly, 2010).

Ecological biotic indices of Shannon-Weiner Diversity, *H'* (Shannon &Weaver, 1963), Simpson Dominance, *D*; Diversity, *1-D*; Evenness, e^H/S, and Equitability, *J*, indices (Odum, 1971) and Margalef index, *d* **(**Margalef, 1968**)** were used to describe the structure of the community and compare the sampling stations**.** The relative floodplain diversity, *RFD* (Mandal & Naskar, 2008; and Udoh, 2013) of each of the habitats was calculated as: $RFD = 100 \times [(Fn + Gn + Sn). N^{-1}]$, where *Fn*, *Gn* and *Sn* are respectively, numbers of families, genera and species, and $N = 61$ (sum of numbers of families, genera and species of all the three habitats investigated in the river).

3. Results

Table 1 provides a broad overview of the ecological indices and ichthyofaunal composition of the Oramiri-Ukwa River system of Imo State southeast Nigeria. Diversity indices calculated reveal a polydiverse ecosystem accommodating about 25 fish species, 15 genera, 21 families and six orders of freshwater species. The different genera accommodate one to four species, each represented by an average of 18 individual fish. The Simpson's dominance index (*D*) range from 0.060 in station three to 0.075 in station two. Simpson's index of diversity range from 0 (= no diversity) to 1 (= maximal diversity), i.e., the closer the index to one, the greater the sample diversity. The Shannon-Weiner (2.789 – 2.970), Simpson's Diversity (0.925 - 0.940) and Margalef

values indicate a polydiverse community with high species variety while the Evenness and Equitability indices indicate the species were equally common and well represented in all sampling stations. In this study, station three (S_3) is the best representation of the ichthyofaunal assemblage in the study area having a relative diversity of 100% with all 25 species, 21 genera and 15 families contributing individuals equally to its habitat. Pair wise comparison of sampling stations (Table 2) also buttresses this fact.

Table 1: Summary of species taxa and diversity of the Oramiri-Ukwa River, Nigeria

Number of Taxa/Diversity Indices	Sampling stations			Total
	S_1	S_2	S_3	
No. of Orders	5	6	6	6
No. of Families	13	15	15	15
No. of Genera	16	19	21	21
No. of Species	19	22	25	25
Species diversity, *H′*	2.789	2.795	2.970	2.965
Simpson's index of dominance, *D*	0.070	0.075	0.060	0.060
Simpson's index of diversity, *1- D*	0.930	0.925	0.940	0.940
Evenness, e^H/S	0.856	0.744	0.779	0.776
Equitability, J	0.947	0.904	0.923	0.921
Margalef index, *d*	9.011	9.785	10.045	9.007
Relative Diversity, *RFD*	77.05	91.80	100.00	100.00
No. of fish sampled, *n*	77	140	245	462

Table 2. Pair wise comparison of sampling stations

Sampling Stations	S_1	S_2	S_3
S_1	0.00	0.23	0.00
S_2	2.35	0.00	0.02
S_3	6.27	3.92	0.00

The Perciformes (43.71%) comprising three families (Cichlidae>Channidae>Anabantidae; in that order of magnitude) and seven species occurred most in number; followed by the Siluriformes (18.83%) comprising four families (Mochokidae>Clariidae>Scheilbeidae>Malapteruridae) and six species. The Osteoglossiformes (Mormyridae>Notopteridae) and Cyprinodontiformes (Aplocheilidae>Pantodontidae) follow next, each comprising two families and four species and each making 8.87% of the population. The least occurring order was the Characiformes - 5.41% represented by two families (Hepsetidae>Alestidae; in that order) each represented by a species (Table 3). Cichlidae (32.68%) was the fish taxa of high biodiversity significance and richness contributing four species, *Tilapia zilli>Tilapia mariae>Oreochromis niloticus>Hemichromis fasciatus* in that order, to all sampling stations; followed by Mormyridae - three species (6.28%). In terms of families Cichlidae, 32.68% was the most abundant in all the stations followed by Mochokidae, 10.17%; Polypteridae, 8.44% and Mastacembelidae, 6.49%; with Malapteruridae, 0.86% and Alestidae, 0.64% being the least abundant in all the stations (Fig. 2).

In the hierarchy of association and importance of species (Fig. 3), the most abundant species was (1) *Tilapia zilli*, 12.6%, followed by (2) *Erpetoichthys calabaricus*, (3) *Tilapia mariae*, *Synodontis nigrita*, *Oreochromis niloticus*, *Hemichromis fasciatus* and *Mastacemblus loennebergi* (7.4 – 6.5% in that order of magnitude) and *Ctenopoma kingsleyae*, *Clarias gariepinus* and *Hepsetus odoe* (5.4 – 4.8%). The least abundant species were *Petrocephalus bovei*, *Parachanna africana* and *Scheilbe mystus* (2.2 – 1.7%) and *Polypterus senegalus*, *Malapterurus electricus*, *Physialla pellucida*, *Aphyosemion gardneri*, *Petrocephalus bane* and *Brycinus leuciscus* (1.1 – 0.6%).

Fish families/species that exhibited restricted spatial distribution and/or were completely absent in some sampling stations include *Fundulopanchax gardneri* (Boulenger, 1911) in the family Mormyridae and *Petrocephalus bane* (Lacepade, 1803) in Aplocheilidae (= Cyprinodontidae) found only in one sampling location, S_3, and not elsewhere.

The rare endemic species of ecological and conservation importance in the study area also include eight monospecific fish families namely: the Anabantidae - *Ctenopoma kingsleyae*; Clariidae - *Clarias gariepinus;* Malapterurıdae - *Malapterurus electricus;* Pantodontidae - *Pantodon buchholzi;* Notopteridae - *Papyrocranus afer;* Alestidae (=Characidae) - *Brycinus leuciscus;* Hepsetidae - *Hepsetus odoe*; and Mastacembelidae - *Mastacembelus loennbergi*. Also of ecological importance is the occurrence of the euryhaline *Erpetoichthys*

*calabaricus (*Polypteridae) as well as species contributions from other African rivers to the Oramiri-Ukwa River viz-a-viz *Oreochromis niloticus* (Nilo-Sudanian river basin), and *Pantodon buchholzi* (Zairean fauna).

4. Discussion

Biodiversity, the life sustaining systems of the biosphere has intrinsic value and its components have ecological, social, economic, scientific, educational, cultural and aesthetic value (Rajaregar and Sendhikumar, 2009). According to Shinde *et al*. (2009), River conserves a rich variety of fish species which support artisanal and commercial fisheries. Fish diversity of Rivers essentially represents the fish faunal diversity and their abundance. The present study indicates lower fish diversity and distribution in the study area compared to the results of other studies. Adaka *et al*. (2010) earlier reported 30 species in 16 families in the same water body. Okereke (1990) recorded 46 species in 20 families in Otamiri River in the same ecozone/river basin. Other comparable results include Sydenham (1977), 85 species in Ogun River southwest Nigeria; Udoidiong (1988) recorded 27 species in Abak River southeast Nigeria while Ekpo and Udoh (2013) estimated 77 species distributed into 52 genera, 29 families and 9 orders, with averagely one to three species per genus in the Lower Cross River floodplain, southeast Nigeria. Though the Oramiri - Ukwa River lacks the attributes of an Outstanding Universal biodiversity Value (OUV) under UNESCO classification (Hillary *et al.,* 2003), it however enhances the biodiversity value of the larger Imo River into which it drains and in relation to Nigeria's fish biodiversity of 648 fish species (FMOE, 2010). Paired group cluster analysis (Fig. 3) illustrates patterns of species distribution and establishes *Tilapia zilli* and *Hemichromis fasciatus* as the foci or major species; and identifies the associated species combinations that characterize spatial variability and account for the biodiversity resources and structure of the artisanal fishery.

The observed differences between the fish diversity in this study compared to others in the same ecozone may be attributed to extended investigation periods (Teugels *et al.*, 1992), the number of researchers, museum (preserved) specimens used and the length of the River system/floodplain sampled (Teugels *et al.*, 1992). The distribution of the fish species could also depend upon the biotic and abiotic factors of the ecosystem including rainfall (Moses,1987, 2001), volume of river discharge and surface area of river basin (Hugueny, 1989; Livingstone *et al.*, 1982), hydrographic heterogeneity - mean depth, water level fluctuations, morphometric features and nature of the river bottom, etc (Hugueny, 1989), gradual and abrupt changes in physical parameters (Ramirez and Pringle, 2001), river zonation (Covich, 1988) and river continuum (Vannote *et al.,* 1980) with increased human activities.

Table 1 also indicates that of the three sampling stations, S_3 recorded the maximum *RFD* (100 %) in fish species biodiversity. The higher the *RFD*, the greater the resemblance of the habitat to overall taxa composition of the River. The preference of S_3 may be due to higher plankton richness, fairly stable and favourable hydrographic conditions for fish survival and growth and the effort and dexterity of the local fishers employed in the survey.

The distribution and species abundance observed in this study is similar to the observations made by Ekpo and Udoh (2013) with Perciformes, Siluriformes and Osteoglossiformes being among the three most dominant fish orders as well as Cichlidae being the most abundant fish family. The most abundant species was *Tilapia zilli*, 12.6%. Generally, the individual species exhibited low abundances, 0.6 – 12.6% (< 30.0%) since no species was truly dominant (≥ 50%), further buttressing the polydiverse nature of the fishery.

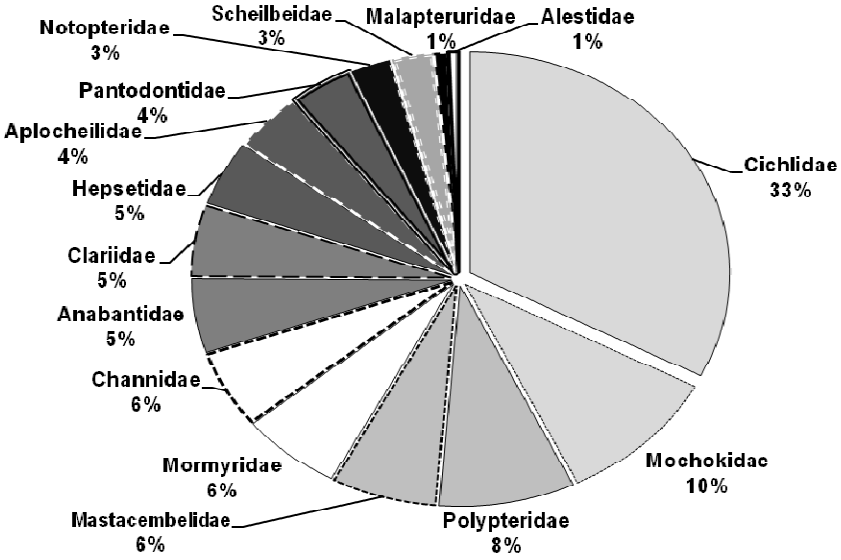

Fig 2: Percentage Occurrence of fish families of Oramiri-Ukwa River, Southeast Nigeria

The link of Oramiri-Ukwa River to the Atlantic Ocean via Imo River, affords it the presence of one marine intrusive (euryhaline) species, *Erpetoichthys calabaricus (*Polypteridae) as well as species contributions from other African rivers such as *Oreochromis niloticus* (Nilo-Sudanian river basin), and *Pantodon buchholzi* (Zairean fauna). These introductions probably result from ancient hydrographic linkages and inter-connections (Teugels *et al.*, 1992). The absence/presence of some fish species in some sampling locations in this study may also be due to differences in sampling techniques, gear and dexterity of the local fishers employed in the survey. The current information also adds to the baseline information needed in measuring future changes in species biomass and number, particularly, it identifies species of ecological significance with reference to the study area. The reduced fish diversity could decrease the fish production of native species thereby limiting the socio-economic livelihood and exploitable fish species by artisanal fishery communities. These may eventually cause instability and increasing poverty among the local fishers.

Table 3: Fish species abundance, richness and distribution in Oramiri-Ukwa River, southeast Nigeria

S/N	Taxa/Species	No. of species in sampling stations			Spatial Distribution	Abundance, *n*	Remark
		Station 1	Station 2	Station 3			
	Perciformes						
	Anabantidae						
1	*Ctenopoma kingsleyae* Günther, 1896	6	10	9	3	25	Rare Species; Equally distributed
	Channidae						
2	*Parachanna obscura* (Günther, 1861)	4	6	8	3	18	Equally distributed
3	*Parachanna africana* (Steindachner, 1879)	2	3	3	3	8	Equally distributed
	Cichlidae						
4	*Tilapia zilli* Gervais, 1848	11	20	27	3	58	Equally distributed
5	*Tilapia mariae* Boulenger, 1899	7	15	10	3	32	Equally distributed
6	*Hemichromis fasciatus* Peters, 1857	4	16	10	3	30	Equally distributed
7	*Oreochromis niloticus* (Linnaeus, 1758)	4	7	20	3	31	Nilo-Sudanian Species
	Siluriformes						
	Clariidae						
8	*Clarias gariepinus* Burchell, 1822	5	7	12	3	24	Rare Species; Equally distributed
	Malapterururidae						
9	*Malapterurus electricus* (Gmelin, 1789)	2	1	1	3	4	Rare Species; Equally distributed
	Mochokidae						
10	*Synodontis nigrita* Valenciennes, 1840	2	6	24	3	32	Equally distributed
11	*Synodontis courteti* Pellegrin, 1906	-	2	13	2	15	Equally distributed
	Scheilbeidae						
12	*Parailia pellucida* Boulenger, 1901	1	1	2	3	4	Equally distributed
13	*Schilbe mystus* (Linnaeus, 1758)	2	2	4	3	8	Equally distributed
	Polypteriformes						
	Polypteridae						
14	*Polypterus senegalus* Cuvier, 1829	1	-	4	2	5	Partiually distributed
15	*Erpetoichthys calabaricus* (Smith, 1865)	4	10	20	3	34	Estuarine Species
	Cyprinodontiformes						

	Aplocheilidae (= Cyprinodontidae)						
16	*Epiplatys bifasciatus* (Steindachner, 1881)	5	2	10	3	18	Equally distributed
17	*Fundulopanchax gardneri* (Boulenger, 1911)	-	-	3	1	3	Partially distributed
	Pantodontidae						
18	*Pantodon buchholzi* Peters, 1876	-	6	12	2	17	Rare Species; Zairean Species
	Osteoglossiformes						
	Mormyridae						
19	*Mormyrus rume* Valenciennes, 1847	4	3	9	3	16	Equally distributed
20	*Petrocephalus bovei* (Valenciennes, 1847)	-	3	7	2	10	Partially distributed
21	*Petrocephalus bane* (Lacepade, 1803)	-	-	3	1	3	Partially distributed
	Notopteridae						
22	*Papyrocranus afer* Günther, 1868	4	4	4	3	12	Rare Species; Equally distributed
	Characiformes						
	Alestidae (=Characidae)						
23	*Brycinus leuciscus* Günther, 1867	-	1	2	2	3	Rare Species; Partially distributed
	Hepsetidae						
24	*Hepsetus odoe* (Bloch, 1794)	3	6	13	3	22	Rare Species; Equally distributed
	Synbranchiformes						
	Mastacembelidae						
25	*Mastacembelus loennbergi* Boulenger, 1898	6	9	15	3		Rare Species; Equally distributed

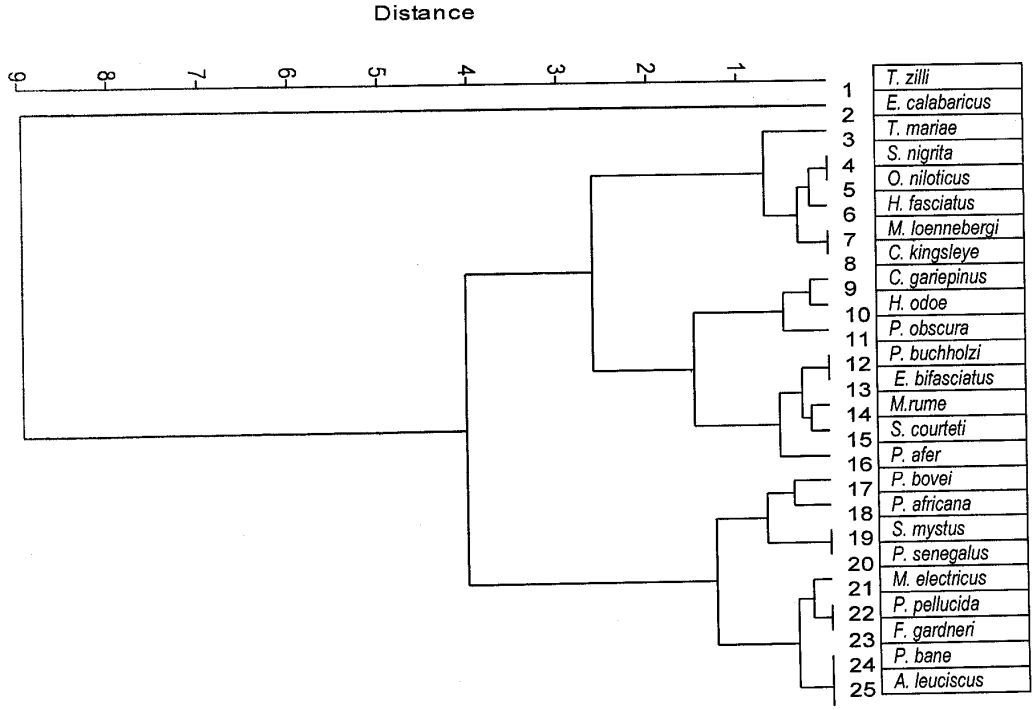

Fig. 3. Paired group cluster analysis showing hierarchy of association and importance of species

5. Conclusion

The Oramiri-Ukwa River accommodates diverse species, including monospecific and rare fish species of ecological significance hence gear that exclude juveniles and fingerlings should be encouraged; environmental awareness to educate the fishers and other stakeholders on the danger of extinction of the species and the need for its conservation is necessary. Also future developments, autogenic and anthropogenic threats, and activities and harmful practices which predispose fish species extinction along the floodplain and catchment area of the river should be subjected to environmental scrutiny to maintain the environmental health and integrity of the ecosystem. Species diversity studies should be a continuous work to determine the health of the fishery and enhance conservation measures. Once extinction occurs, it could not be easily reserved or recalled (Shukla and Singh 2013).

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Adaka, G. S. is a lecturer at Department of Fisheries and Aquaculture, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri, Nigeria and member America Fisheries Society (AFS). His research interests are in fisheries biology, rural sociology and environmental management.

Dr. Udoh, James P. is a senior lecturer at Department of Fisheries and Aquatic Environmental Management, University of Uyo, Uyo, Nigeria and member of the Fisheries Society of Nigeria (FISON). He holds a Ph. D. in Fisheries and Hydrobiology from Michael Okpara University of Agriculture, Umudike, Nigeria. His research interests are in fisheries biology, aquaculture, aquatic environmental management and fish population dynamics.

Onyeukwu, D. C. is a graduate student at Department of Fisheries and Aquaculture, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri, Nigeria. Her research interests are in fisheries biology and conservation.

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