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Species Richness and Diversity of Ichthyofaunal communities of the Lower Cross River floodplain, Nigeria

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Abstract

The ichthyofaunal composition of the floodplains of the Lower Cross River was investigated and compared in order to promote its management. A total of 5211 fish were sampled for 12 consecutive months from commercial landings of artisanal fishers from three sampling stations. We estimate 77 species distributed into 52 genera, 29 families and 9 orders, both of freshwater (88.66%) and euryhaline (marine intrusive) fishes (11.34%), with averagely 1-3 species per genus. The fishes composed mainly Perciformes, the least being Polypteriformes and Clupeiformes.. The five most abundant fish families are the Bagridae > Cichlidae > Mormyridae > Mugilidae and Cyprinidae. Study suggests growth and recruitment overfishing with populations generally bigger upstream than their counterparts downstream and elucidates contributions of floodplains as nursing and spawning grounds in river fisheries and productivity.

Keywords: Bagridae, classification, conservation, fish sizes, rare species

Introduction

One characteristic feature of most tropical rivers, like the Cross River, is the high endemic multi-species diversity of the fish fauna. The Niger Delta with Cross River Barrier lagoon system (Nigeria) was classified in the "A List" as areas unanimously recognized to be of Outstanding Universal biodiversity Value (OUV) by a UNESCO biodiversity study team. Similarly the Cross River Estuary (Nigeria, Cameroon) was classified in the "B List" as areas identified to have significant components of OUV. The "C List" comprises areas that may be of OUV but lack adequate information for assessment[1]. These wetland systems comprise part of the West African Flyway, a major migratory bird route that provides year round habitat for many bird species. The Cross river is a major hydrographic feature in the Gulf of Guinea and possesses attributes of OUV in relation to Nigeria's fish biodiversity (updated from 239 fish species in 46 families[2] and 511 species in 121 families[3] to 648 fish species in the fourth National Biodiversity Report[4]).

This paper provides multi-gear and multi-species ichthyofaunal composition of the floodplains of the Lower Cross River in comparison with others in order to share, update information, and provides data for further analysis and to promote discussions for the management of the fishery to avoid risk of fish stock collapse and loss of invaluable ecosystem goods.

Material and Methods

The main channel of the Cross river has a total surface area of 70,000 km^2 of which 50,000 km^2 is at the lower reaches. At bankful, the Lower Cross River (LCR) is approximately 7m deep and inundates an area (floodplain) of approximately 8000 km^2. The floodplain contains numerous swamps, pools and lagoons that are often isolated from the main river, sometimes in the dry season[5]. The river channels, floodplain pools, lakes and marginal swamps provide a range of habitats for different fish species.

Three sampling stations (S_{1-3}) were established along the extensive floodplains in the freshwater zone of the inshore waters of the LCR (379437.913mE and 558778.199mN), Southeastern Nigeria at Esuk Nnyanyaha, S_1 (along a meander of the CR tributary), Ikot Offiong, S_2 (along the main channel) and Nwaniba, S_3 (around the river mouth), (figure-1). The river is subject to seasonal flooding between July and October. The area experiences, the wet season in April – October and the dry in November-March. Most of the flood areas dry up as the water recedes[5,6].

The commercial landings of artisanal and subsistence fishers along the floodplains from the three sampling stations were randomly sampled bimonthly, over a period of 12 calendar months. Fish samples were identified and measured to the nearest 0.1cm total length (TL) and 0.1g total weight (TW); some samples were preserved in 10% diluted formaldehyde. Keys were used in fish identification[6-8]. Fish condition factor was calculated as: $K = 100\,TW.TL^{-3}$.

The pooled data of catches by all gear types in each sampling station was used in assessing abundance by calculating the index of preponderance (IP)[9-10]. $IP = [(\%N\%W).100].[\sum(\%N\%W)]^{-1}$. Fishes with IP values less than (<) 0.50 were regarded as being of relatively insignificant contribution while those with IP values greater than (>) 0.50 were regarded as being significant contribution[5]. Ecological indices[11-13] were used to classify the environment, describe the structure of the community and compare the

sampling stations. The relative floodplain diversity (RFD)[14] of each of the 3 habitats was calculated as $RFD = 100 \text{ x } [Fn + Gn + Sn).N^{-1}]$,where F_n, G_n and S_n are respectively, numbers of families, genera and species, and N = 348 (sum of numbers of families, genera and species in floodplain of all the three habitats investigated. Comparative analysis of fish diversity, with similar African rivers, in relation to basin area was established using overall biological diversity indices, B_A[15] and species richness, N[16]: $N = 5\,x\,S0^{0.25}$

$B_A = \sum(Dfamily, Dgenera, Dspecies)$; where,

B_A= Biological diversity, A = Surface area of river basin, km^2;

$Dfamily = (Ln\,F, family\ richness).(Ln\,A)^{-1}$

$Dgenera = (Ln\,G, generic\ richness).(Ln\,A)^{-1}$

$Dspecies = (Ln\,S, species\ richness).(Ln\,A)^{-1}$;

N = Number of species and S = Surface area of river basin, km^2.

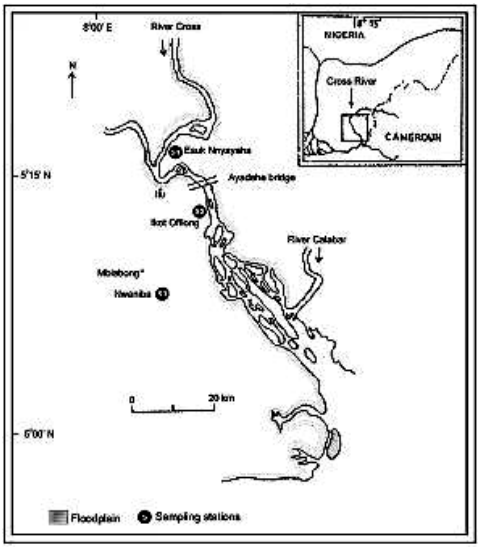

Figure-1
Map of the lower reaches of the Cross River showing sampling stations and flood plains

Results and Discussion

Species composition, diversity and ecological significance: Table-1 provides a broad overview of the ecological indices and ichthyofaunal composition of the lower Cross River system which reveal a polydiverse ecosystem accommodating about 77 fish species, 52 genera, 29 families and 9 orders of both fresh and euryhaline (marine intrusive) species. Earlier investigations estimated 37, 45, 45 and 166 species[6,17,15,18], respectively, and 23 species in 18 families[19]. The observed differences may be attributed to the investigation periods (1857 and 1992)[18], the number of researchers, museum (preserved) specimens used and the length of the Cross River system/floodplain sampled. Other reasons include influenced of rainfall[5,6,20-23], volume of river discharge and surface area of river basin[15,24], hydrographic heterogeneity[15], gradual and abrupt changes in physical parameters[25], river zonation[26] and river continuum[27]. Current information adds to the baseline information needed in measuring future changes in species biomass and number.

Table-1 also indicates that of the three sampling stations, S_1 recorded the maximum RFD (38.51 %) in fish species biodiversity and condition factor (K = 9.24). The higher the RFD, the greater the resemblance of the habitat to overall taxa composition of LCR. The preference of S_1 may be due to i. higher plankton richness; ii. fairly stable and favourable hydrographic conditions for fish survival and growth; iii. its location around a meander of the LCR: Meanders are known to produce a succession of habitats of varying depths and bottom types encouraging the development of distinct groups adapted to such conditions; and iv. more fishes from the marine environment navigate upstream up to S_1 than the other stations. Some characteristic species found only in S_1 and not elsewhere include *Micralestes humilus, Citharinus lates, Petrocephalus bovei, Heterotis niloticus, Chromidotilapia batesii, Synodontis nigrita, Bothygobius soporator, Mugil cephalus* and *Cynoglosus senegalensis*. The lower species mix at S_3, may be due to the slow tidal influence coupled with salt ingression, which poses a challenge to the survival of purely freshwater species.

The species composition in table-2 indicates a total of 5211 fish specimens were sampled - 4620 (88.66%) being freshwater species and 591 (11.34%) - euryhaline fishes. In terms of number the Siluriformes (Bagridae, Bothidae, Clariidae, Malapteruridae, Mochokidae and Schilbeidae) occurred most in number, 59.52%; followed by the Perciformes (Anabantidae, Channidae, Cichlidae and Nandidae), 19.62% and then the Osteoglossiformes (Mormyridae, Notopteridae, Osteoglossidae and Pantodontidae), 5.58%. The least occurring species was of the Polypteriformes (Polypteridae), 1.46%. Of the three euryhaline fish orders, the Perciformes, 95.76%> Pleuronectiformes (Cynoglossidae), 2.55%; while the Clupeiformes (Clupeidae), 1.70%, were the least occurring order. Cichlidae was the fish taxa of high biodiversity significance and richness contributing 13 species (18.0%) with 11, 9 and 7 species spread across sampling stations 1 to 3, respectively; followed by Mormyridae - 9 species (11.7%) and Bagridae - 6 species (7.8%). The Cross River/floodplains also show richer fish diversity when compared to other rivers as in table-3. The main river channel and floodplains accommodate about twice the number of fish species expected using Daget and Ilits'[22]formula. The high species richness and heterogeneity observed in this study area confirms the contributions of floodplains to river fisheries and productivity[28]. It's link to the Atlantic Ocean, affords it the presence of some marine intrusive (euryhaline) species. Other African rivers also contributed species to the CR viz-a-viz *Marcusenius mento* (Guinean river basin), *Heterotis niloticus, Brycinus nurse, Citharinus latus* and *Oreochromis niloticus* (Nilo-Sudanian river basin), and *Pantodon bucholzi* and *Clarias buthupogon* (Zairean faunae). These introductions probably result from ancient hydrographic linkages and inter-connections. The absence of *Heterotis niloticus* in the main channel of the LCR had earlier been reported[11] but its occurrence in this study may be due to improved sampling technique, suitability of floodplain habitat or one of ecological significance - as a monospecific fish.

Table-1
Summary of species taxa and diversity in the Lower Cross River floodplain, Nigeria

Number of Taxa/ Diversity Indices	Sampling stations			Total
	Esuk Nnyanyaha, S_1	Ikot Offiong, S_2	Nwaniba, S_3	
No. of Orders	8	7	8	9
No. of Families	26	21	22	29
No. of Genera	44	36	35	52
No. of Species	64	51	49	77
Species diversity, H	0.3199	4.6393	2.2960	1.0095
Species evenness, J	0.0769	1.1799	0.5840	0.4595
Species similarity, D	0.8796	0.9250	0.7940	0.6756
Margalef index, d	18.5616	15.807	15.4515	20.59
Relative Diversity, RFD	38.51	31.03	30.46	100
No. of fish sampled	2478	1456	1278	5212

Table-2
Occurrence, mean total length, weight and condition factor of fish communities in sampling stations in the Lower Cross River, Nigeria

	Order/Family/Species	Sampling Stations											
		Esuk Nnyanyaha (S = 64)				Ikot Offiong (S = 51)				Nwaniba (S = 49)			
		N	MTL,cm	MTW, g	K	N	MTL, cm	MTW, g	K	N	MTL, cm	MTW, g	K
Fresh Water Species													
	Characiformes	-	-	-	-	-	-	-	-	-	-	-	-
	Characidae	-	-	-	-	-	-	-	-	-	-	-	-
1	*Brycinus nurse* Ruppell	23	9.40	8.40	1.01	28	9.45	13.35	1.58	24	10.00	8.45	0.85
2	*Brycinus Longipinnis* Gunther	31	9.10	8.40	1.01	43	8.10	9.90	1.86	18	9.25	6.90	0.87
3	*Brycinus macrolepidotus* Valenciennes	8	6.20	3.50	1.47	-	-	-	-	5	11.55	13.50	0.88
4	*Micralestes Humilis* Boulenger	23	9.80	16.85	1.79	-	-	-	-	-	-	-	-
	Citharinidae	-	-	-	-	-	-	-	-	-	-	-	-
5	*Citharinus latus* Muller & Troschel	1	24.60	42.50	0.29	-	-	-	-	-	-	-	-
	Dischodontidae	-	-	-	-	-	-	-	-	-	-	-	-
6	*Ichthyborus monodi* Pellegrin	2	17.60	23.50	0.43	8	18.80	27.70	0.42	1	18.10	15.00	0.25
	Hepsetidae	-	-	-	-	-	-	-	-	-	-	-	-
7	*Hepsetus odoe* Bloch	6	22.25	86.45	0.78	3	18.70	53.90	0.82	4	18.45	47.00	0.75
	Cypriniformes	-	-	-	-	-	-	-	-	-	-	-	-
	Cyprinidae	-	-	-	-	-	-	-	-	-	-	-	-
8	*Barbus callipterus* Boulenger	98	6.30	3.70	2.68	70	7.70	6.85	1.5	20	5.00	2.40	1.92
9	*Labeo batesi* Boulenger	2	11.85	22.25	1.33	10	11.15	21.95	1.58	-	-	-	-
10	*Labeo coubie* Ruppell	5	7.25	6.25	1.64	3	8.85	13.65	1.97	-	-	-	-
	Cyprinodontiformes	-	-	-	-	-	-	-	-	-	-	-	-
	Aplocheilidae	-	-	-	-	-	-	-	-	-	-	-	-
11	*Aphyosemion bivittatum* Lonnberg	-	-	-	-	-	-	-	-	9	4.75	2.45	2.29

12	*Epiplatys sexfasciatus* Gill	21	4.45	0.85	0.96	38	5.05	2.45	1.90	25	5.10	2.20	1.66
13	*Epiplatys bifasciatus* Steindachner	11	2.80	0.55	2.51	11	2.25	1.15	10.10	44	3.45	1.30	3.17
14	*Epiplatys grahami* Boulenger	-	-	-	-	-	-	-	-	2	6.15	2.65	1.10
	Osteoglossiformes	-	-	-	-	-	-	-	-	-	-	-	-
	Mormyridae	-	-	-	-	-	-	-	-	-	-	-	-
15	*Brienomyrus brachyistius* Gill	90	8.75	6.20	0.93	41	9.65	9.75	1.08	26	10.58	10.18	0.80
16	*Gnathonemus petersii* Gunther	4	22.00	65.15	0.61	10	20.70	54.55	0.62	6	21.25	61.65	0.64
17	*Isichthys henryi* Gill	11	7.85	1.90	0.39	15	8.00	2.75	0.54	6	12.10	6.90	0.39
18	*Mormyrops deliciosus* Leach	11	16.60	39.90	0.87	12	9.05	7.75	1.05	-	-	-	-
19	*Mormyrus rume* Valenciennes	12	2795	168.65	0.77	8	21.70	50.50	0.49	-	-	-	-
20	*Petrocephalus bovei* Valenciennes	64	9.65	6.50	0.72	-	-	-	-	-	-	-	-
21	*Petrocephalus ansorgii* Boulenger	11	17.30	11.10	0.21	18	14.45	10.00	0.33	1	10.4	9.80	0.87
22	*Pollimyrus adspersus* Gunther	-	-	-	-	-	-	-	-	2	5.20	4.90	3.48
	Notopteridae	-	-	-	-	-	-	-	-	-	-	-	-
23	*Papyrocranus afer* Gunther	1	34.70	28.80	0.07	3	21.00	37.65	0.41	14	23.35	41.25	0.32
24	*Xenomystus nigri* Gunther	1	16.20	25.60	0.60	1	8.10	17.00	3.20	5	12.10	20.40	1.5
	Osteoglossidae	-	-	-	-	-	-	-	-	-	-	-	-
25	*Heterotis niloticus* Cuvier	59	50.65	3510.0	2.70	-	-	-	-	-	-	-	-
	Pantodontidae	-	-	-	-	-	-	-	-	-	-	-	-
26	*Pantodon buchholzi* Peters	-	-	-	-	-	-	-	-	4	9.85	11.75	1.23
	Perciformes	-	-	-	-	-	-	-	-	-	-	-	-
	Anabantidae	-	-	-	-	-	-	-	-	-	-	-	-
27	*Ctenopoma kingsleyae* Gunther	13	10.20	7.50	0.71	15	10.10	22.55	2.19	4	9.45	12.75	1.46
28	*Ctenopoma nebulosum* Norris & Teugels	7	10.45	28.10	0.25	5	12.50	32.10	1.64	5	10.85	19.55	1.33
	Channidae												
29	*Parachanna africana* Steindachner	7	14.04	27.30	0.98	5	17.30	29.15	0.56	44	14.40	27.30	0.91
30	*Parachanna obscura* Gunther	-	-	-	-	3	10.80	11.35	0.90	11	15.65	20.00	0.52
	Cichlidae												
31	*Chromidotilapia batesii* Boulenger	51	14.75	36.30	1.13	-	-	-	-	-	-	-	-
32	*Chromidotilapia guntheri* Sauvage	43	64.75	62.15	0.02	46	15.80	37.90	0.96	40	13.25	34.90	1.50
33	*Hemichromis bimaculatus* Gill	6	5.80	2.00	1.03	-	-	-	-	-	-	-	-
34	*Hemichromis fasciatus* Peters	40	10.00	62.15	6.22	30	7.70	15.15	3.32	22	8.90	19.50	2.77
35	*Hemichromis guttatus* Gunther	11	6.70	3.00	0.00	7	6.70	805	2.68	-	-	-	-

36	*Oreochromis niloticus* L.	-	-	-	-	-	-	-	-	3	9.5	7.0	0.82
37	*Pelvicachromis pulcher* Boulenger	27	9.60	19.25	1.00	40	8.80	17.90	2.63	19	9.45	14.90	1.77
38	*Sarotherodon galilaeus* L.	58	17.10	203.70	4.03	30	12.00	55.00	3.18	-	-	-	-
39	*S. melanotheron* Ruppell	15	12.40	61.55	3.22	26	13.35	44.60	1.87	-	-	-	-
40	*Thysochromis ansorgii* Boulenger	18	7.85	7.00	1.45	10	7.80	10.35	2.18	28	9.00	12.45	1.71
41	*Tilapia. mariae* Boulenger	37	52.50	80.90	0.06	33	12.90	16.40	0.76	20	12.10	59.00	0.05
42	*Tilapia zilli* Gervais	49	9.70	30.70	3.36	62	9.80	12.70	1.35	4	8.65	9.45	1.46
	Nandidae	-	-	-	-	-	-	-	-	-	-	-	-
43	*Polycentropsis abbreviata* Boulenger	-	-	-	-	-	-	-	-	4	5.95	5.25	2.49
	Siluriformes	-	-	-	-	-	-	-	-	-	-	-	-
	Bagridae	-	-	-	-	-	-	-	-	-	-	-	-
44	*Chrysichthys aluuensis* Risch	35	23.00	251.50	2.07	18	27.55	89.20	0.43	-	-	-	-
45	*Chrysichthys auratus* Geoffroy-Saint-Hilaire	782	15.75	65.30	1.67	231	14.00	33.80	1.23	564	14.00	51.95	1.89
46	*C. nigrodigitatus* Lacepede	241	53.15	4124.0	2.75	190	51.90	2770.0	1.98	65	50.00	6450.0	5.16
47	*Parauchenoglanis akiri* Risch	19	8.30	9.30	1.63	-	-	-	-	26	10.35	10.65	0.95
48	*Parauchenoglanis fasciatus* Gras	-	-	-	-	20	10.10	11.00	1.07	18	9.90	9.25	0.95
49	*Parauchenoglanis guttatus* Lonnberg	-	-	-	-	-	-	-	-	11	10.95	10.85	0.83
	Clariidae	-	-	-	-	-	-	-	-	-	-	-	-
50	*Clarias buthupogon* Sauvage	3	15.05	23.80	0.09	7	14.55	19.0	0.62	-	-	-	-
51	*Clarias gariepinus* Burchell	36	34.35	589.70	1.45	18	18.50	47.0	0.74	6	19.65	44.90	0.59
52	*Clarias macromystax* Gunther	5	20.45	78.50	0.92	-	-	-	-	4	21.40	67.85	0.69
53	*Heterobranchus longifilis* Val.	-	-	-	-	-	-	-	-	1	26.00	152.0	0.86
	Bothidae	-	-	-	-	-	-	-	-	-	-	-	-
54	*Citharichthys stampfilis* Steindachner	15	12.85	0.70	7	14.5	19.0	0.62	-	-	-	-	-
	Malapteruridae	-	-	-	-	-	-	-	-	-	-	-	-
55	*Malapterurus electricus* Gmelin	32	13.70	53.10	2.07	40	13.90	32.50	1.21	60	14.40	77.75	2.60
	Mochokidae	-	-	-	-	-	-	-	-	-	-	-	-
56	*Synodontis nigrita* Cuvier &Val.	20	14.95	60.75	1.82	-	-	-	-	-	-	-	-
57	*Synodontis schall* Bloch & Schneider	11	20.25	157.60	1.92	15	21.65	105.15	1.04	-	-	-	-
	Schilbeidae	-	-	-	-	-	-	-	-	-	-	-	-
58	*Schilbe intermedius* Ruppell	-		-	-	10	15.35	36.45	1.01	3	14.7	26.50	0.83
59	*Schilbe mystus* L.	32	12.90	10.80	0.50	-	-	-	-	1	8.80	10.50	1.54
	Polypteriformes	-	-	-	-	-	-	-	-	-	-	-	-
	Polypteridae	-	-	-	-	-	-	-	-	-	-	-	-
60	*Erpetoichthys calabaricus* Smith	-	-	-	-	5	28.15	44.90	0.20	58	28.35	37.50	0.16

Marine Intrusive (Estuarine) Species													
	Clupeiformes	-	-	-	-	-	-	-	-	-	-	-	-
	Clupeidae	-	-	-	-	-	-	-	-	-	-	-	-
61	*Odaxothrissa mento* Regan	3	11.80	14.00	0.85	-	-	-	-	-	-	-	
62	*Pellonula leonensis* Boulenger	3	5.25	1.90	1.31	-	-	-	-	4	5.75	1.85	0.97
	Perciformes	-	-	-	-	-	-	-	-	-	-	-	-
	Carangidae	-	-	-	-	-	-	-	-	-	-	-	-
63	*Caranx hippos* L.	30	9.85	24.50	2.50	22	7.75	13.00	2.79	10	7.30	12.30	3.94
64	*Trachinotus goreensis* Cuvier	26	9.90	16.60	1.72	21	9.40	12.50	1.51	-	-	-	-
65	*Trachinotus teraia* Cuvier	38	8.05	6.70	1.28	40	8.05	6.90	1.32	-	-	-	-
	Eleotridae	-	-	-	-	-	-	-	-	-	-	-	-
66	*Bostrychus africanus* Steindachner	-	-	-	-	-	-	-	-	2	11.35	13.80	2.94
67	*Eleotris senegalensis* Steindachner	17	12.75	34.65	0.19	9	11.50	28.40	1.87				
68	*Eleotris vittata* Dumeril	1	8.50	4.00	0.00	2	8.90	10.75	1.52	7	9.60	17.70	2.00
	Gobiidae												
69	*Bothygobius soporator* Cuvier &Val.	11	26.10	32.30	5.26	-	-	-	-	-	-	-	-
	Lutjanidae												
70	*Lutjanus endecacanthus* Bleeker	4	11.80	35.40	2.16	-	-	-	-	-	-	-	-
	Mugilidae												
71	*Liza falcipinnis* Valenciennes	72	25.95	51.00	0.29	53	18.4	40.95	0.66	6	11.75	15.65	0.01
72	*Liza grandisquamis* Valenciennes	87	25.95	52.82	0.30	60	12.4	32.15	1.69	5	11.45	8.50	0.57
73	*Mugil cephalus* L.	22	17.40	66.35	1.26	-	-	-	-	-	-	-	-
	Pomadasidae (=Haemulidae)	-	-	-	-	-	-	-	-	-	-	-	-
74	*Pomadasys jubelini* Cuvier	13	11.90	33.25	1.97	8	12.9	32.2	1.50	-	-	-	-
	Pleuronectiformes	-	-	-	-	-	-	-	-	-	-	-	-
	Cynoglossidae	-	-	-	-	-	-	-	-	-	-	-	-
75	*Cynoglossus senegalensis* Kaup	15	27.65	105.10	0.50	-	-	-		-	-	-	-
	Mean ± Std. Dev.		16.80 ± 12.33	167.25 ±668.22	3.53		13.56 ± 7.68	80.34 ± 84.72	3.22		12.79 ± 7.74	193.29 ±932.32	9.24

N = Number of fish specimen caught, S = Number of fish species caught, MTL = Mean total length, MTW = Mean weight of fish caught K = Mean condition factor

Table-3
Diversity and taxa – richness in relation to river basin area in some West African rivers

River	Surface Area, Km^2	Taxa Number			Taxa Diversity			Overall Diversity Index	
		Families	Genera	Species	$D_{families}$	D_{genera}	$D_{species}$	B_A	N
Mono	22,000	18	35	59	0.289	0.356	0.408	1.053	61
Oueme	50,000	30	64	106	0.314	0.384	0.431	1.129	75
Ogun	22,370	28	60	91	0.333	0.409	0.450	1.192	61
Cross	70,000	41	97	166	0.333	0.410	0.458	1.201	81
LCRF	8,000	29	52	77	0.375	0.440	0.483	1.298	47

B_A= Biological diversity of river basin[15] , N = Expected number of species[16,] LCRF = Lower Cross River Floodplains/this study

Table-4
Species composition of catches from the lower Cross River floodplain, Nigeria: Pooled data from three sampling stations

S/N	Fish Species	N	Wt (g)	% N	% Wt	Ave. Wt (g)	No. of fish Kg^{-1}	IP
	Fresh water species							
1.	*Aphyosemion bivittatum*	9	22.05	0.17	0.00	2.45	408.2	0.00
2.	*Barbus callipterus*	188	882.70	3.61	0.04	4.70	213.0	0.02
3.	*Brienomyrus brachyistus*	157	1222.43	3.01	0.06	7.79	128.4	0.02
4.	*Brycinus macrolepidotus*	13	95.50	0.25	0.00	7.35	136.1	0.00
5.	*Brycinus nurse*	75	769.80	1.44	0.04	10.26	97.4	0.01
6.	*Brycinus longipinnis*	92	810.40	1.82	0.04	8.81	113.5	0.01
7.	*Chromidotilapia batesii*	51	185.13	0.98	0.01	3.63	275.5	0.00
8.	*Chromidotilapia guntheri*	129	5811.85	2.48	0.27	45.05	22.2	0.07
9.	*Chrysichthys nigrodigitatus*	496	1939434.00	9.52	90.39	3910.15	0.3	86.68
10.	*Chrysichthys aluuensis*	53	10408.10	1.02	0.49	196.48	5.1	0.05
11.	*Chrysichthys auratus*	1577	88172.20	30.26	4.11	55.91	17.9	12.53
12.	*Citharichthys stampfilis*	46	720.00	0.88	0.03	15.65	63.9	0.00
13.	*Citharinus latus*	1	42.50	0.02	0.00	42.50	23.5	0.00
14.	*Clarias gariepinus*	60	22344.60	1.15	1.04	372.41	2.7	0.12
15.	*Clarias buthupogon*	10	204.40	0.19	0.01	20.44	48.9	0.00
16.	*Clarias macromystax*	9	663.90	0.17	0.03	73.77	13.6	0.00
17.	*Ctenopoma kingsleyae*	32	486.75	0.61	0.02	15.21	65.7	0.00
18.	*Ctenopoma nebolusum*	17	454.95	0.33	0.02	26.76	37.4	0.00
19.	*Epiplatys bifasciatus*	66	75.90	1.27	0.00	1.15	869.6	0.00
20.	*Epiplatys grahami*	2	5.30	0.04	0.00	2.65	377.4	0.00
21.	*Epiplatys sexfasciatus*	84	165.95	1.16	0.01	1.98	506.2	0.00
22.	*Erpetoichthys calabaricus*	63	2399.50	1.21	0.11	38.09	26.3	0.01
23.	*Gnathonemus petersii*	20	611.46	0.38	0.03	30.57	32.7	0.00
24.	*Hemichromis bimaculatus*	6	12.00	0.12	0.00	2.00	500.0	0.00
25.	*Hemichromis fasciatus*	92	1529.50	1.77	0.07	16.63	60.2	0.01
26.	*Hemichromis guttatus*	18	87.35	0.35	0.00	4.96	201.5	0.00
27.	*Hepsetus odoe*	13	868.40	0.25	0.04	66.80	15.0	0.00
28.	*Heterobranchus longifilis*	1	152.00	0.02	0.01	152.0	6.6	0.00
29.	*Heterotis niloticus*	59	3510.00	1.13	0.16	59.49	16.8	0.02
30.	*Ichythyborus monodi*	11	283.60	0.21	0.01	25.78	38.8	0.00
31.	*Isichthys henryi*	42	103.55	0.81	0.00	2.47	405.6	0.00
32.	*Labeo coubie*	8	72.20	0.15	0.00	9.03	110.8	0.00
33.	*Labeo batesi*	12	263.60	0.23	0.01	21.97	45.5	0.00
34.	*Malapterurus electricus*	132	3465.70	2.53	0.16	26.26	38.1	0.04
35.	*Marcusenius mento*	14	455.35	0.27	0.02	32.53	30.7	0.00
36.	*Micralestes humilus*	23	387.55	0.44	0.02	16.85	59.4	0.00
37.	*Mormyrops deliciosus*	23	531.90	0.44	0.03	23.13	43.2	0.00
38.	*Mormyrus rume*	20	2427.80	0.38	0.11	121.39	8.2	0.00
39.	*Oreochromis niloticus*	3	21.00	0.06	0.00	7.0	142.9	0.00
40.	*Pantodon bulcholzi*	4	11.75	0.08	0.00	2.94	340.4	0.00
41.	*Papyrocranus afer*	18	719.25	0.35	0.03	39.96	25.0	0.00
42.	*Parachanna obscura*	14	254.05	0.27	0.01	18.15	55.1	0.00
43.	*Parachanna africana*	56	1538.05	1.07	0.07	27.45	36.4	0.01
44.	*Parachenoglanis akiri*	45	453.60	0.86	0.02	10.08	99.2	0.00
45.	*Parachenoglanis fasciatus*	38	386.50	0.73	0.02	10.17	98.3	0.00
46.	*Parachenoglanis guttatus*	11	119.35	0.21	0.01	10.85	92.2	0.00
47.	*Pelvicachromis pulcher*	86	1518.85	1.65	0.07	17.66	56.6	0.01
48.	*Petrocephalus ansorgii*	30	311.90	0.58	0.01	10.40	96.2	0.00
49.	*Petrocephalus bovei*	64	416.00	1.23	0.02	6.50	153.9	0.00
50.	*Pollimyrus adspersus*	2	9.80	0.04	0.00	4.90	204.1	0.00
51.	*Polycentropsis abbreviata*	4	21.00	0.08	0.00	5.25	190.5	0.00
52.	*Sarotherodon galilaeus*	88	13464.60	1.69	0.63	153.01	6.5	0.11
53.	*Sarotherodon melanotheron*	41	2081.85	0.77	0.10	50.78	19.7	0.01

54.	*Schilbe intermedius*	13	444.00	0.25	0.02	34.15	29.3	0.00
55.	*Schilbe mystus*	33	356.10	0.63	0.02	10.79	92.7	0.00
56.	*Synodontis nigrita*	20	1215.00	0.38	0.06	60.75	16.5	0.00
57.	*Synodontis schall*	26	3310.85	0.50	0.15	127.34	7.9	0.01
58.	*Thysochromis ansorgii*	50	578.10	1.07	0.03	10.32	96.9	0.00
59.	*Tilapia mariae*	90	4614.50	1.73	0.22	51.27	19.5	0.04
60.	*Tilapia guineensis*	32	949.50	0.61	0.04	29.67	33.7	0.00
61.	*Tilapia zilli*	115	2329.50	2.21	0.11	20.26	49.4	0.03
62.	*Xenomystus nigri*	7	149.60	0.13	0.01	21.37	46.8	0.00
	Marine Intrusive (Estuarine) Species							
63.	*Bathygobius soporator*	11	355.30	0.21	0.02	32.30	31.0	0.00
64.	*Bostrychus africanus*	2	27.60	0.90	0.00	13.8	72.5	0.00
65.	*Caranx hippos*	62	144.00	0.06	0.05	18.45	54.2	0.01
66.	*Cynoglossus senegalensis*	15	1576.50	0.29	0.07	105.10	9.5	0.00
67.	*Eleotris senegalensis*	26	844.65	0.50	0.04	32.49	30.8	0.00
68.	*Eleotris vittata*	10	149.40	0.19	0.01	14.94	66.9	0.00
69.	*Liza gradisquamis*	152	6566.84	2.92	0.31	43.20	23.2	0.09
70.	*Liza falcipinnis*	131	5936.25	2.51	0.28	45.31	22.1	0.07
71.	*Lutjanus endecacanthus*	4	141.60	0.08	0.01	35.40	28.2	0.00
72.	*Mugil cephalus*	22	1459.70	0.42	0.07	66.35	15.1	0.00
73.	*Odaxothrissa mento*	3	42.00	0.06	0.00	14.00	71.4	0.00
74.	*Pellonula leonensis*	7	13.10	0.13	0.00	1.87	534.8	0.00
75.	*Pomadasys jubelini*	21	689. 85	0.40	0.03	32.85	30.4	0.00
76.	*Trichinotus teraia*	78	530.60	1.19	0.03	6.80	147.0	0.01
77.	*Trichinotus goreensis*	47	694.10	0.13	0.03	14.77	67.7	0.00
	∑	**5211**	**2145588.06**	**100**	**100**	**411.74**	**2.43**	**100**

N = number of fish caught Wt = weight of fish caught IP = index of preponderance

Figure-2
Length frequency of fish catches along the Lower Cross River Floodplain, Nigeria

Earlier reports[5,18,22] indicate that at least 33 marine species (from 28 genera, 16 families and 8 orders) penetrate the fresh waters of the Lower Cross River system. In this study, the marine intrusive species constitute about 20% of species, eight families-28% (Clupeidae, Carangidae, Eleotridae, Gobiidae, Lutjanidae, Mugilidae, Haemulidae and Cynoglossidae) and three orders-33% (Clupeiformes, Perciformes and Pleuronectiformes). Brackishwater species like *Mugil cephalus, Pomadasys jubelini* and *Caranx hippos* co-occurring in the freshwater zone (like their marine counterparts), probably entered with the tidal waves, which are still observable as far as S_1. Some of these fishes were probably searching for food, spawning sites to lay eggs and/or nursery grounds for growth, and have become adapted. The longitudinal distribution of *C. nigrodigitatus* stretching from the mouth of the river inwards to the upper reaches suggests its ability to tolerate wider range of salinity. Therefore, it is a good candidate for brackish water culture along with *Mugil cephalus, Pomadasys jubelini* and *Caranx hippos*.

The indices of preponderance in table-4 indicate the most important fish family is Bagridae (IP=99.26; Siluriformes) occurring in all the sampling stations: S_1 (IP=54.88), S_2 (IP=98.52) and S_3 (IP=98.15). The top five families in terms of numbers are the Bagridae, 42.6% (IP=99.26), especially *Chysichthys auratus* contributing 30.26% and *C. nigrodigitatus* - 9.52%; Cichlidae, 15.49% (IP=0.28) *Chromidotilapia guntheri* - 2.48% and *Tilapia zilli* - 2.21%; Mormyridae, 7.14% especially *Brienomyrus brachyistus* - 3.01%); Mugilidae, 5.85% especially *Liza falcipinnis* - 2.51% and Cyprinidae, 3.99%, especially *Barbus callipterus* - 3.61%. In terms of gross weight of fish caught, the order is Bagridae, 95% > Cichlidae, 1.55% > Clariidae, 1.09%. In terms of size (i.e., number of individuals per kg), the bagrid catfish, *Chysichthys nigrodigitatus* (0.3) surpassed all other species (> *Clarias gariepinus*-2.7 > *C. aluuensis*-5.1).

At the species level in table-4, *C. nigrodigitatus* and *C. auratus* are the most significant. Other important species include *Heterotis niloticus* and *Clarias gariepinus. Chrysichthys* remains the main fishery in the lower Cross River as observed in this study and others[5,23,28] though we obtained a higher average number of 0.3 fish (*C. nigrodigitatus*) per kg compared to an earlier value of 0.4[5]. Populations were generally bigger upstream than their counterparts downstream. The mean sizes of individual species increase with increase in number of species upstream, from the transitional zone at the river mouth, S_3 to S_1 (S_3 = 49, S_2 = 54 and S_1 = 64 species, with mean TL = 12.79, 13.56 and 16.08cm, respectively). Specimens of the dominant species such as *Chrysichthys auratus* showed mean total lengths of 15.75, 14.00 and 14.00cm; *C. nigrodigitatus* - 53.15, 51.90 and 50.00cm and *Chromidotilapia guntheri* - 64.75, 15.80 and 13.25cm in S_1 to S_3, respectively. The survey indicates that the smaller-sized *C. auratus* with average weight of 55.91kg were caught in higher number (30.26%) than the larger-sized *C. nigrodigitatus* (3910.15g; 9.52%). The size range in figure-2 suggests that fishing gears with narrow selectivity were employed hence most fish sampled fall within 5-20cm, the juvenile class range. The species of fish inhabiting floodplain rivers usually cover a wide range of sizes which normally span three orders (i.e., 1.5cm to 1500cm). It also suggests that the floodplain is highly utilized by juvenile of commercially important fishes from the sea possibly as nursery and feeding grounds. However, the fishery is still vulnerable to (growth and recruitment) over-fishing (particularly during the spawning season) due to the persisting indiscriminate interception, massive capture in very large numbers and complete removal of young and gravid *C. nigrodigitatus* catfish during their upstream migration with the rise in river level and the inundation of the floodplains, particularly in May – June[22]. Such over-fishing decreases the resilience of the fish fauna making it more susceptible to environmental fluctuations, climate change and anthropogenic perturbations. Gears that exclude juveniles and fingerlings should therefore be encouraged.

Conclusion

The Cross River floodplain has been shown to be a nursery and feeding ground for diverse species, including monospecific and rare species of fish hence gears that exclude juveniles and fingerlings should therefore be encouraged and future development along the floodplain 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.

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