Journal of Advances in Biology & Biotechnology
4(2): 1-16, 2015; Article no.JABB.18320
ISSN: 2394-1081

SCIENCEDOMAIN *international*
www.sciencedomain.org

Fish Association Dynamics in Three Clearwater and-Blackwater River Systems in the Eastern Delta of Nigeria

John Onwuteaka[1*]

[1]Department of Applied and Environmental Biology, Rivers State University of Science and Technology, Port Harcourt, Nigeria.

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JABB/2015/18320
Editor(s):
(1) Kuo-Kau Lee, Department of Aquaculture, National Taiwan Ocean University, Taiwan.
Reviewers:
(1) Keshav Kumar Jha, Department of Zoology, Rajiv Gandhi Central University, India.
(2) A. M. Orire, Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna, Nigeria.
(3) Kumbukani Mzengereza, Fisheries Department, Mzuzu University, Malawi.
Complete Peer review History: http://sciencedomain.org/review-history/10017

Original Research Article

Received 15th April 2015
Accepted 10th June 2015
Published 2nd July 2015

ABSTRACT

Fish species associations in three rivers, Orashi, Sombriero and New Calabar on the Eastern delta of Nigeria were studied using the presence-absence method. A total of 154 species were reported of which 135 species occurred on the Orashi River; 79 species on the Sombriero River and 63 species on the New Calabar River. A hierarchical cluster analyses identified five association types; a ubiquitous group of the Orashi-Sombriero-New Calabar River cluster making up 31.8% of total species. Other associations identified were the Orashi-Sombriero at 0.65%; the Orashi-New Calabar at 8.4% and Sombriero – New Calabar, co-occurring at 5.2%; of total species. The restricted distributions were identified with 52.6% of fish associations confined to Orashi River while 1.3% were confined to Sombriero River. A Sorenson similarity index shows a higher degree of taxonomic homogenization between Sombriero and New Calabar (0.9) than between either Sombriero and Orashi (0.54) or New Calabar and Orashi Rivers (0.5). The findings in this study are consistent with the hypothesis that fish species diversity is mainly influenced by fine-scale environmental factors such as interconnectivity of rivers and streams. In this regard, the study results agree with interpretations from previous studies of fish assemblage structure where habitat diversity either on a longitudinal or spatial gradient influence fish diversity. The remarkable

**Corresponding author: E-mail: onwuteaka.john@ust.edu.ng;*

difference in fish taxonomic richness between the Orashi River and the other two river systems (New Calabar and Sombriero) is evidence that the exclusive interconnection of the catchment areas of the Orashi River and the Niger River during the wet season promotes habitat diversity. Consequently this promotes the mixing of fishes and the sharing of species resulting in the highest species richness being recorded on the Orashi River despite the fact that the three river systems exhibit Blackwater and Clearwater characteristics during the wet season and dry season respectively.

Keywords: Fishes; clearwaters; blackwaters; Orashi River; Sombriero River; New Calabar River.

1. INTRODUCTION

In the Niger Delta, Nigeria a major challenge for river and stream fish ecologists is the identification of the mechanisms and processes responsible for fish composition in relation to biotic and abiotic factors. There is documented evidence that the structure of fish assemblages in rivers can be influenced by factors that act on the temporal and spatial dimensions [1-3]. Several studies conducted in the region have provided information on catch statistics [4-9], systematics and distribution [10,11]. Little attention has been given to the relationship between habitat diversity and fish diversity in freshwater inland rivers and streams considering the variable differences in catchment area and the Clearwater and Blackwater characteristics Rivers. The lack of this knowledge is a cause of concern as there is considerable oil and gas activity at the exploration and exploitation levels connected with each of these river systems. Any compositional changes in homogeneity or differentiation across spatial boundaries due to anthropogenic influence can have significant ecological consequences and can influence mitigation and environmental management planning. Given increasing levels of habitat alteration, natural resource exploitation and land use changes in many communities along the watershed of theses rivers, there is an urgent need to understand mechanisms that control taxonomic richness of freshwater fish fauna including the influence of watershed attributes on the diversity of fish species in relation to habitat characteristics in three rivers namely Orashi River, Sombriero River and the New Calabar River.

2. MATERIALS AND METHODS

2.1 The Study Area

The study area (Fig. 1) lies between 6º 22' 42.4''E; 5º 18' 0.95''N and 6º 57' 45.4''E; 4º 53' 40.3''N. The upper section of the Orashi River starts from 6º 34' 54.19''E; 5º 16' 0.63''N to 6º 33' 59.8''E; 4º 54' 47.2''N while the upper section of the Sombriero starts from 6º 34' 54.19''E; 5º 16' 0.63''N to 6º 33' 59.8''E; 4º 54' 47.2''N. The upper section of the New Calabar River starts from the head waters at Elele Alimini at 6º 22' 42.4''E; 5º 18' 0.95''N and terminates at 6º 57' 45.4''E; 4º 53' 40.3''N. The entire river systems are characterized by seasonal farms of various crops located along the river banks and are bordered by dense swamp forest vegetation that contributes a lot of leaf litter.

The Orashi River is documented to have an open character with a wide and weakly meandering channel. The Sombriero River and New Calabar River, in contrast, have a narrow, convoluted and sometimes braided channel [12]. The Orashi is the main feeder river on the east flank of the lower Niger [12] draining water from dry land runoff between the Onitsha (floodplain drainages such as Onosi, Omoku, Ndoni) and the south of Oguta. In the wet season, the Orashi is swollen by the Niger flood, which enters the Orashi River mainly through the Ndoni creek.

The Sombreiro River is located east of the Orashi River and originates from swamps in the Oguta-Ebocha zone. Seasonal changes on the Sombriero River depend on local rainfall, buffered by the holding capacity of marginal swamps. The headwater swamps of the New Calabar originate north of Elele-Alimini and its headwater discharge comes from ground seepage and local rainfall, which is negligible in the dry season. The three rivers are tropical water systems with conductivity values that classify them as clear and black waters depending on the season [13].

2.2 Field Collection

Three sample sites with upper, middle and lower sections of an equal length in each river were selected and sampled. Fish inventory were conducted with active and passive sampling techniques such as beach seining, cast netting, bottom trawl, fish traps, open cast netting and hand nets.

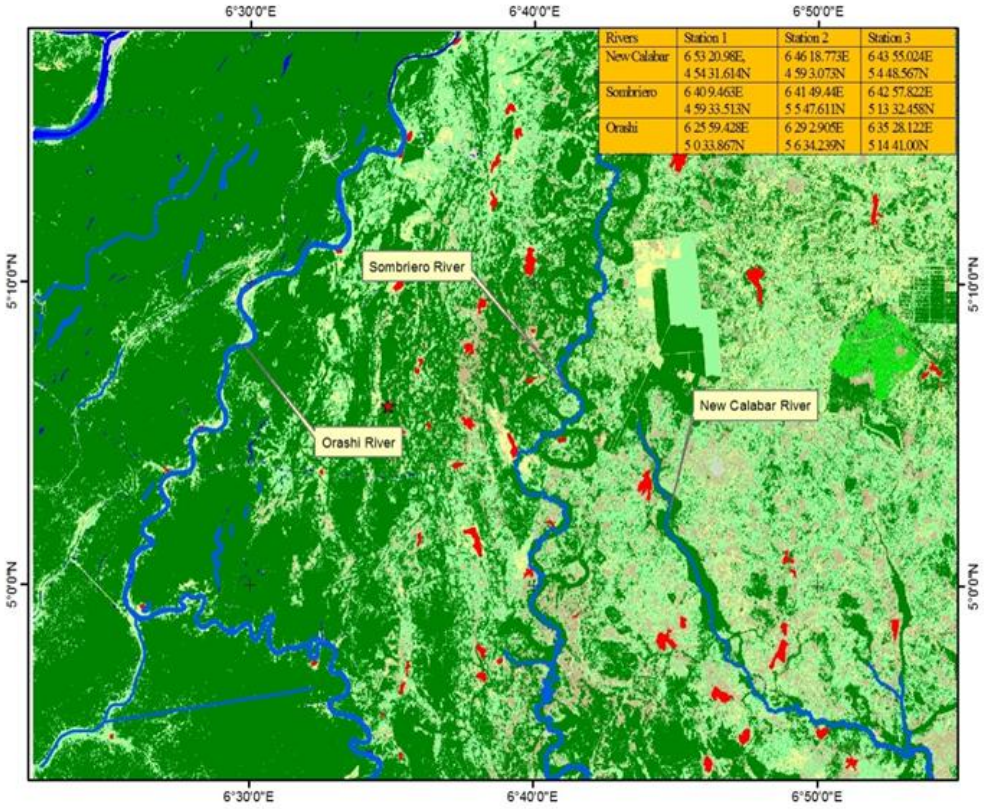

Fig. 1. Study area showing the sampled upper sections of the Orashi, Sombriero and the New Calabar Rivers. Coordinates of sampling stations are indicated
(Source: Landsat ETM 2010)

Habitat types were surveyed with the help of fishermen recruited during the survey and actual fishing effort was supplemented by the survey of fish catch from fishermen within each river system from March to December 2010. Fishes were preserved in 10% formalin in the field and subsequently in the laboratory washed in water and transferred to 50% isopropyl alcohol. A statistical software JMP SAS was used to perform cluster analysis to derive association groupings of the fishes using their presence-absence in the three river systems. A similarity index was calculated with Sørensen index [14], to compare the relative similarity or dissimilarity in the taxonomic richness among the three river systems.

The Sørensen's similarity coefficient as applied to presence/absence data is given as

$$QS = \frac{2 \cdot C}{A + B}$$

where A and B are the species numbers in sample A and B, respectively, and C is the number of species shared by the two samples. QS is the quotient of similarity and ranges from 0 – 1.

3. RESULTS

The results of the species inventory and distribution are illustrated in Table 1. The table shows that a total of one hundred and fifty-four (154) species were collected from the three river systems. This is spread through 41 families and 89 genera.

The data on presence-absence of fishes was segregated into families and genera as are shown in Figs. 2 and 3. In all, the percentage of families and genera were highest in the Orashi River (97.56%; 96.63%) while between the New Calabar River and Sombrieiro River the number of families (70.73%; 65.85%); were higher in the New Calabar River while the number of genera were higher for the Sombrieiro River (47.19%; 55.1%).

Table 1. Presence-absence of fish species in the upper Orashi, Sombriero and New Calabar Rivers

	Species	Orashi	Sombriero	New Calabar River
1	*Ctenopoma kingsleyae* Günther	x	x	x
2	*Ctenopoma nebulosum* Norris and Teugels	x	x	x
3	*Auchenoglanis biscutatus* Geoffroy Saint-Hilaire	x		
4	*Auchenoglanis occidentalis* Valenciennes in Cuvier and Valenciennes	x		
5	*Bagrus bayad* Forsskål	x		
6	*Bagrus docmac* Forsskål	x		
7	*Chrysichthys aluuensi* Risch		x	x
8	*Chrysichthys auratus* Geoffroy Saint-Hilaire	x	x	x
9	*Chrysichthys nigrodigitatus* Lacepède	x	x	x
10	*Clarotes laticeps* Rüppell	x		
11	*Parauchenoglanis akiri* Boulenger		x	x
12	*Parauchenoglanis fasciatus* Gras	x	x	x
13	*Citharichthys stampflii* Steindachner	x		
14	*Caranx hippos* Linnaeus	x		
15	*Trachinotus teraia* Cuvier in Cuvier and Valenciennes	x		
16	*Lates niloticus* Linnaeus	x		
17	*Parachanna africana* Steindachner	x	x	x
18	*Parachanna obscura* Günther	x	x	x
19	*Alestes baremoze* Joannis	x		
20	*Arnoldichthys spilopterus* Boulenger		x	x
21	*Brycinus intermedius* Boulenger	x		
22	*Brycinus leuciscus* Günther	x		
23	*Brycinus longipinnis* Günther	x	x	x
24	*Brycinus macrolepidotus* Valenciennes in Cuvier and Valenciennes	x	x	x
25	*Brycinus nurse* Rüppell	x	x	x
26	*Bryconaethiops quinquesquamae* Teugels and Thys van den Audenaerde	x		
27	*Hydrocynus vittatus* Castelnau	x		
28	*Micralestes acutidents* Peters	x		
29	*Micralestes elongates* Daget	x		
30	*Micralestes humilis* Boulenger	x		
31	*Micralestes occidenta* Günther	x		
32	*Rhabdalestes septentrionalis* Boulenger	x		
33	*Rhabdalestes brevidorsalis* Pellegrin		x	
34	*Chromidotilapia guentheri* Trewavas	x	x	x
35	*Hemichromis bimaculatus* Gill	x	x	
36	*Hemichromis elongates* Guichenot in Duméril	x	x	x
37	*Hemichromis fasciatus* Peters	x		
38	*Pelvicachromis pulcher* Boulenger	x	x	x
39	*Pelvicachromis taeniatus* Boulenger		x	x
40	*Sarotherodon galilaeus* Linnaeus	x		
41	*Thysochromis ansorgii* Boulenger	x	x	x
42	*Tilapia guineensis* Günther	x	x	x
43	*Tilapia mariae* Boulenger	x	x	x
44	*Tilapia zillii* Gervais	x		
45	*Citharinops distichodoides* Pellegrin	x		
46	*Citharinus citharus* Geoffroy Saint-Hilaire	x	x	
47	*Clarias agboyiensis* Sydenham	x	x	x

48	*Clarias buthupogon* Sauvage	x	x	x
49	*Clarias camerunensis* Lönnberg	x	x	x
50	*Clarias ebriensis* Pellegrin	x	x	
51	*Clarias gariepinus* Burchell	x		
52	*Gymnallabes typus* Günther	x	x	x
53	*Heterobranchus bidorsalis* Geoffroy Saint-Hilaire	x		
54	*Odaxothrissa ansorgii* Boulenger	x		
55	*Odaxothrissa mento* Regan	x		
56	*Pellonula leonensis* Boulenger	x	x	
57	*Pellonula vorax* Günther	x		
58	*Sierrathrissa leonens* Thys van den Audenaerde	x		
59	*Cynoglossus senegalensis* Kaup	x		
60	*Barboides gracilis* Brüning	x		
61	*Barbus callipterus* Boulenger	x	x	x
62	*Barbus hypsolepis* Daget	x		
63	*Barbus leonensis* Boulenger	x		
64	*Barbus macrops* Boulenger	x		
65	*Barbus nigeriensis* Boulenger	x		
66	*Barbus sylvaticus* Loiselle and Welcomme		x	x
67	*Labeo coubie* Rüppell	x		
68	*Labeo senegalensis* Valenciennes in Cuvier and Valenciennes	x		
69	*Leptocypris niloticus*	x		
70	*Raiamas senegalensis* Joannis	x		
71	*Aphyosemion arnoldi* Boulenger		x	x
72	*Aphyosemion bitaeniatum* Ahl	x	x	x
73	*Aphyosemion calliurum* Boulenger		x	x
74	*Aphyosemion deltaense* Radda		x	
75	*Aphyosemion gulare* Boulenger	x		
76	*Aphyosemion sjoestedti* Lönnberg	x		
77	*Aplocheilichthys macrurus* Boulenger	x	x	x
78	*Epiplatys biafranus* Radda		x	
79	*Epiplatys bifasciatus* Steindachner	x		
80	*Epiplatys graham* Boulenger		x	x
81	*Epiplatys longiventralis* Boulenger	x	x	x
82	*Epiplatys sexfasciatus* Gill		x	x
83	*Foerschichthys flavipinnis* Meinken	x	x	x
84	*Procatopus similis* Ahl		x	
85	*Dasyatis margarita* Günther	x		
86	*Denticeps clupeoides* Clausen		x	
87	*Distichodus brevipinnis* Günther	x		
88	*Distichodus engycephalus* Günther	x		
89	*Distichodus rostratus* Günther	x		
90	*Ichthyoborus monodi* Pellegrin	x		
91	*Nannocharax fasciatus* Nichols and Boulton	x	x	x
92	*Nannocharax latifasciatus* Coenen and Teugels		x	x
93	*Nannocharax occidentalis* Daget	x		
94	*Neolebias ansorgii* Boulenger	x	x	x
95	*Neolebias powelli* Teugels and Roberts		x	x
96	*Neolebias unifasciatus* Steindachner	x	x	
97	*Paradistichodus dimidiatus* Pellegrin	x		
98	*Phago loricatus* Günther	x	x	x
99	*Eleotris daganensis* Steindachner		x	x
100	*Eleotris senegalensis* Steindachner	x	x	x
101	*Kribia kribensis* Boulenger	x	x	x

102	*Elops lacerta* Valenciennes in Cuvier and Valenciennes	x		
103	*Chonophorus lateristi* Poey	x	x	x
104	*Gymnarchus niloticus* Cuvier	x		
105	*Hepsetus odoe* Bloch	x	x	x
106	*Lutjanus endecacanthus* Bleeker	x	x	
107	*Malapterurus beninensis* Murray	x	x	x
108	*Caecomastacembelus sp.* Poll	x	x	x
109	*Hemisynodontis membranaceus* Geoffroy St. Hilaire	x		
110	*Synodontis budgetti* Boulenger	x		
111	*Synodontis nigrita* Valenciennes in Cuvier and Valenciennes	x		
112	*Synodontis obesus* Boulenger	x	x	x
113	*Synodontis schall* Bloch and Schneider	x		
114	*Synodontis sorex* Günther	x		
115	*Psettias sebae* Cuvier	x		
116	*Brienomyrus longianalis* Boulenger	x	x	x
117	*Campylomormyrus tamandua* Günther	x		
118	*Gnathonemus petersii* Günther	x	x	x
119	*Hyperopisus bebe* Lacepède	x		
120	*Isichthys henryi* Gill	x	x	x
121	*Marcusenius cyprinoides* Linnaeus	x		
122	*Mormyrops anguilloides* Linnaeus	x		
123	*Mormyrus hasselquistii* Valenciennes in Cuvier and Valenciennes	x		
124	*Mormyrus macrophthalmus* Günther	x		
125	*Mormyrus rume* Valenciennes in Cuvier and Valenciennes	x		
126	*Petrocephalus bane* Lacepède	x		
127	*Petrocephalus bovei* Valenciennes in Cuvier and Valenciennes	x		
128	*Petrocephalus sauvagii* Boulenger		x	
129	*Petrocephalus soudanensis* Bigorne and Paugy in Lévêque, Paugy and Teugels		x	x
130	*Pollimyrus adspersus* Günther	x	x	x
131	*Pollimyrus isidori* Valenciennes in Cuvier and Valenciennes	x	x	x
132	*Liza falcipinnis* Valenciennes in Cuvier and Valenciennes	x	x	
133	*Polycentropsis abbreviate* Boulenger	x	x	x
134	*Papyrocranus afer* Günther	x	x	x
135	*Xenomystus nigri* Günther	x	x	x
136	*Caecula cephalopeltis* Bleeker	x		
137	*Heterotis niloticus* Cuvier	x	x	
138	*Pantodon buchholzi* Peters	x	x	x
139	*Phractolaemus ansorgii* Boulenger	x	x	x
140	*Polynemus quadrifilis* Cuvier	x		
141	*Erpetoichthys Calabar* Smith	x	x	x
142	*Polypterus ansorgii* Boulenger	x		
143	*Polypterus senegalus* Cuvier	x		
144	*Pomadasys jubelini* Cuvier in Cuvier and Valenciennes	x		x
145	*Protopterus annectens* Owen	x		
146	*Eutropiellus buffei* Nichols and La Monte	x	x	x
147	*Parailia pellucida* Boulenger	x	x	x

148	*Schilbe intermedius* Rüppell	x		
149	*Schilbe niloticus* Rüppell	x		
150	*Dagetichthys lakdoens* Stauch and Blanc	x		
151	*Sphyraena afra* Peters	x		
152	*Enneacampus ansorgii* Boulenger	x	x	x
153	*Microphis brachyurus* Bleeker	x		
154	*Tetraodon lineatus* Linnaeus	x		

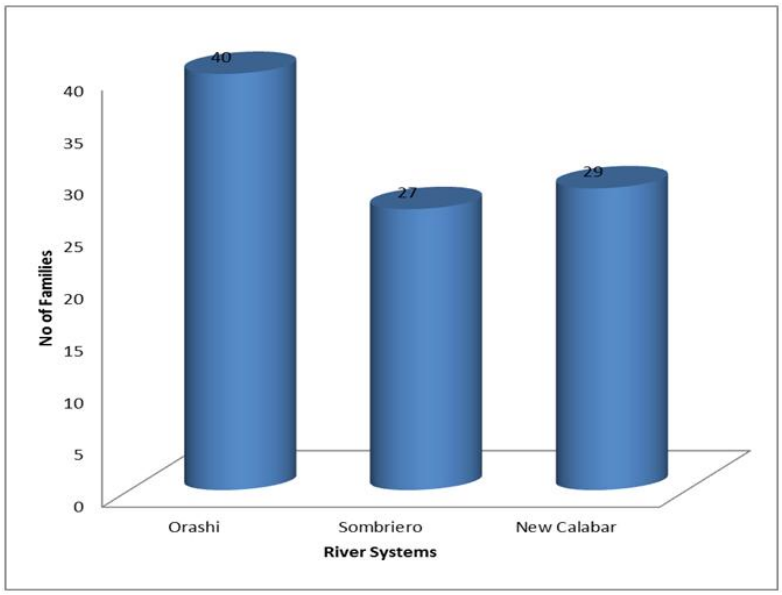

Fig. 2. Total families of freshwater fish in the upper sections of Orashi River Sombriero River and New Calabar River

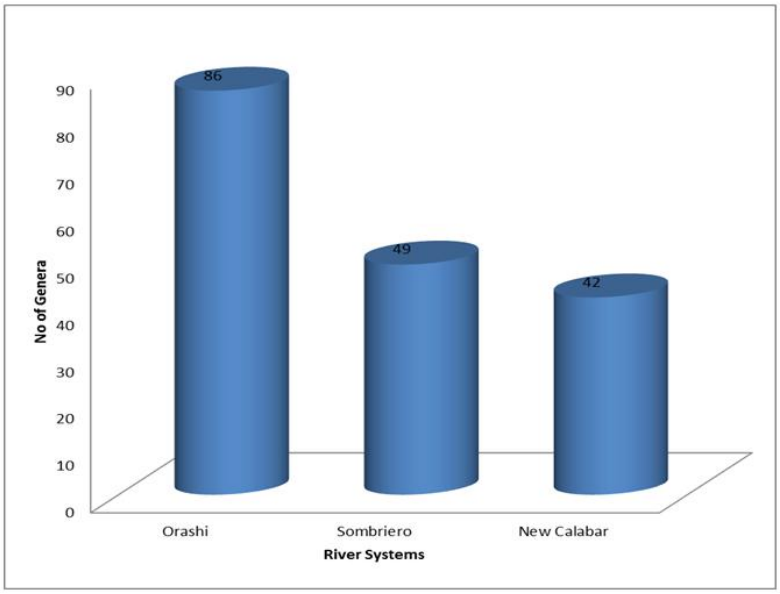

Fig. 3. Total Genera of freshwater fishes in the upper sections of Orashi River Sombriero River and New Calabar River

Figs. 4a – 4c shows the families with the number of occurring species. In Fig. 4a, the Orashi River shows evidence of the dominance of the Mormyridae which has 16 species contained in 10 genera. Following the dominant family is the Family Alestidae which has 15 species contained in 7 genera while the Citharinidae comprises of 14 species spread through 8 genera. The Notobranchidae occurred with 12 species spread through 5 genera followed by the Cichlidae with 11 species spread through 6 genera. Other important families with less than ten species are Claroteidae with 8 species and 4 genera; Clariidae with 7 species and 3 genera; Mokochidae with 6 species and 2 genera; Clupeidae with 5 species and 3 genera and Schilbeidae with 4 species and 3 genera.

In Fig. 4d the relative distribution of the dominant families in the river systems under comparison shows that over 50% of the species belonging to the families of Clariidae, Clupeidae, Cichlidae, Momyridae, Schilbeidae and Claroteidae are found on the Orashi. The other four (4) families namely Notobranchidae, Citharinidae, Cypriniidae, and Alestidae occur within a range of 38% and 45% on the Orashi River. For the Sombriero and New Calabar Rivers, similarity in relative percentage occurrence was observed for Claroteidae, Schilbeidae and Clupeidae and Alestidae while relatively higher occurrences were observed in Notobranchidae, Momyridae, Cyrinidae, Citharinidae and Cichlidae.

3.1 Species Associations

The dendrogram of average linkage cluster of the presence-absence results is shown in Fig. 5. The dendrogram recovered five clusters of fish associations which were the Orashi-Sombriero-New Calabar cluster; the Orashi-Sombriero cluster; Sombriero-New Calabar cluster; the Orashi cluster and the Sombriero cluster.

3.1.1 Orashi-sombriero-new Calabar Rivers association

The cluster analyses recovered 50 species that are distributed through 20 families and 39 Genera. The species which represents 31% of the total number are*, Aphyosemion bitaeniatum, Aplocheilichthys macrurus, Barbus callipterus, Brienomyrus longianalis, Brycinus longipinnis, Brycinus macrolepidotus, Brycinus nurse, Caecomastacembelus sp., Chonophorus lateristi, Chromidotilapia guentheri, Chrysichthys auratus, Chrysichthys nigrodigitatus, Clarias agboyiensis, Clarias buthupogon, Clarias camerunensis, Ctenopoma kingsleyae, Ctenopoma nebulosum, Eleotris senegalensis, Enneacampus ansorgii, Epiplatys longiventralis, Erpetoichthys calabar, Eutropiellus buffei, Foerschichthys flavipinnis, Gnathonemus petersii, Gymnallabes typus, Hemichromis elongates, Hepsetus odoe, Isichthys henryi, Kribia kribensis, Malapterurus beninensis, Nannocharax fasciatus, Neolebias ansorgii, Pantodon buchholzi, Papyrocranus afer, Parachanna africana, Parachanna obscura, Parailia pellucida, Parauchenoglanis fasciatus, Pelvicachromis pulcher, Phago loricatus, Phractolaemus ansorgii, Pollimyrus adspersus, Pollimyrus isidori, Polycentropsis abbreviate, Synodontis obesus, Thysochromis ansorgii, Tilapia guineensis, Tilapia mariae, and Xenomystus nigri.*

The association (Fig. 6) is dominated by three families namely: Citharinidae with 8 genera and 7 species, Mormyridae with 6 genera and 6 species and Alestidae with 4 genera and 5 species.

3.1.2 The Orashi-Sombriero River association

The Orashi-Sombriero Association comprises of eight (8) species from 7 families. The numbers of species represent 5.2% of the total number of species. *Citharinus citharus, Clarias ebriensis, Liza falcipinnis, Lutjanus endecacanthus, Neolebias unfasciatus, Pellonula leonensis, Hemichromis bimaculatus* and *Heterotis niloticus.*

3.1.3 The Sombriero-new Calabar River association

The association is made up of thirteen (13) species distributed within nine (9) families and making up 8.4% of the total number of species collected. The species strongly associated between this sub drainage unit are *Aphyosemion calliurum, Aphyosemion arnoldis, Arnoldichthys spilopterus, Barbus sylvaticus Chrysichthys aluuensi, Eleotris daganensis, Epiplatys graham, Epiplatys sexfasciatus, Nannocharax latifasciatus, Neolebias powelli, Parauchenoglanis akiri, Pelvicachromis taeniatus* and *Petrocephalus soudanensis.*

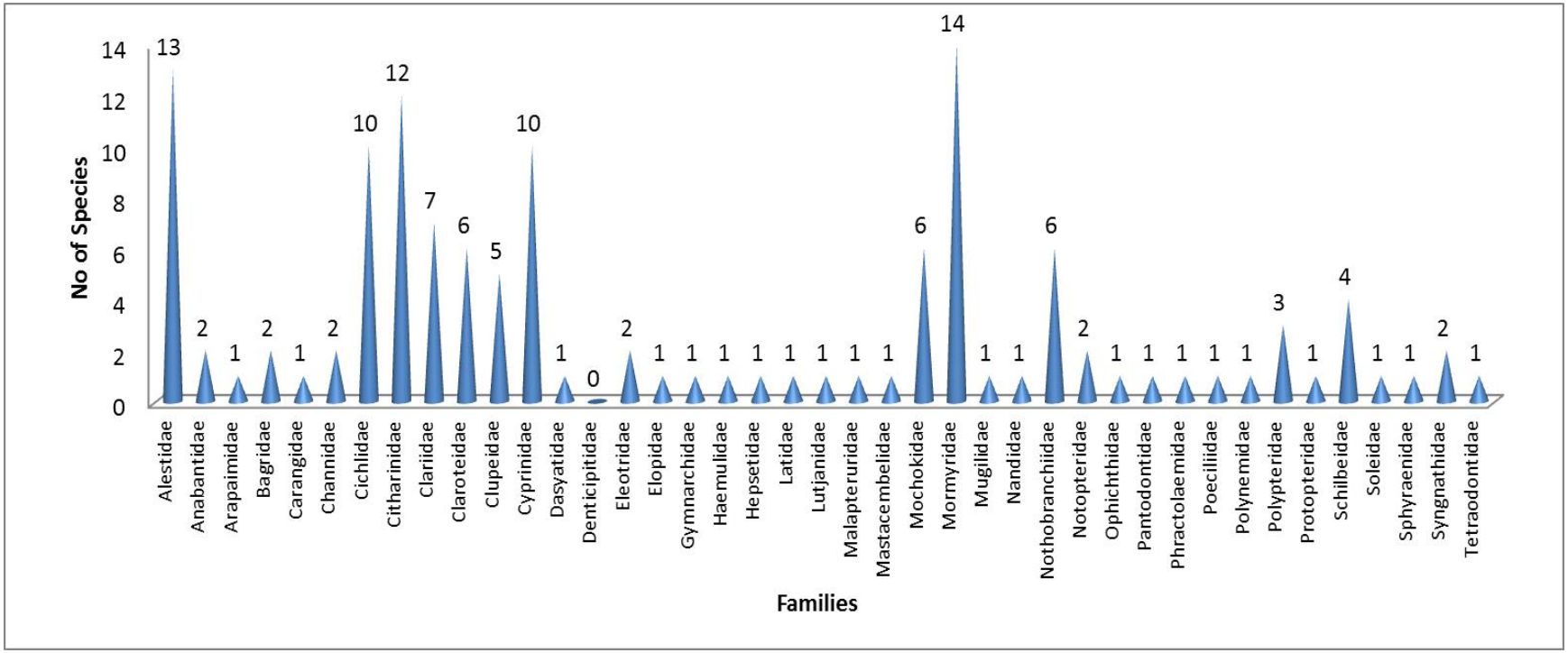

Fig. 4a. Number of fish families with corresponding number of species in Orashi River

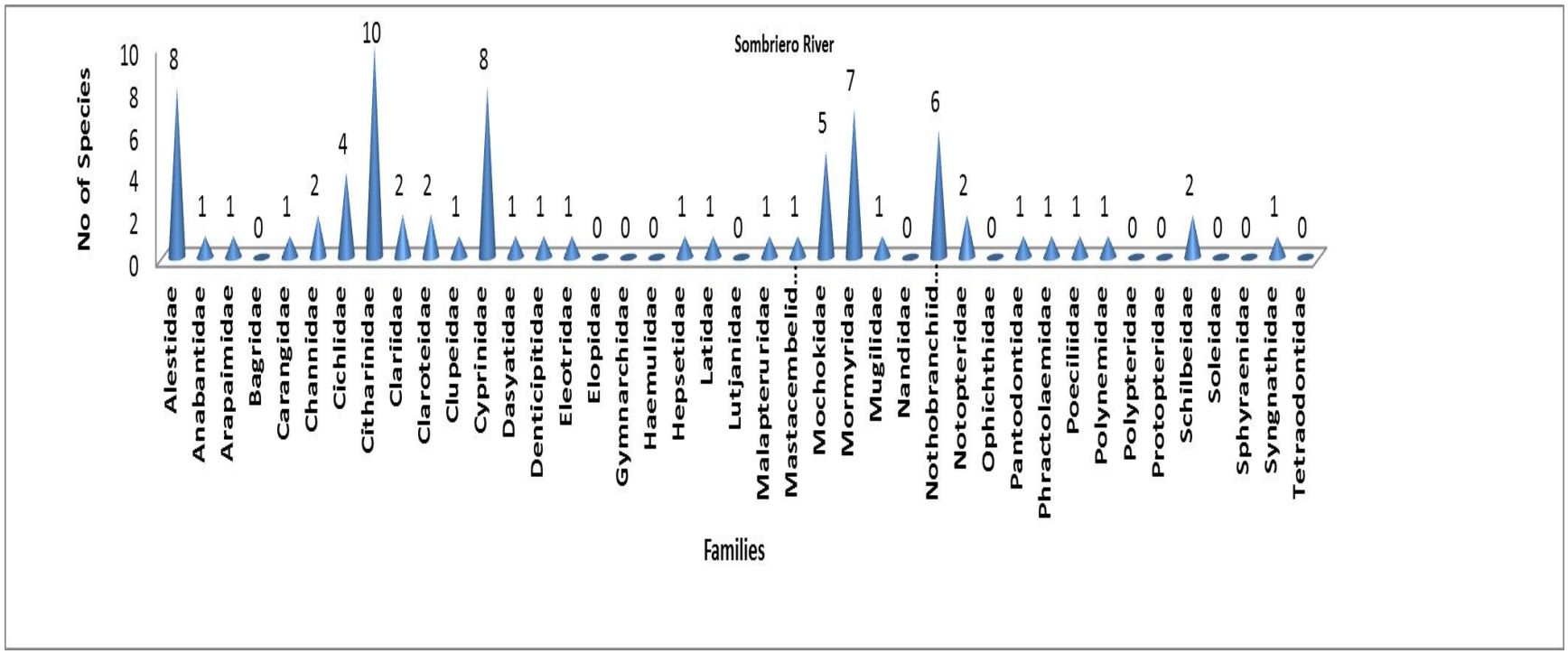

Fig. 4b. Number of fish families with corresponding number of species in Sombriero River

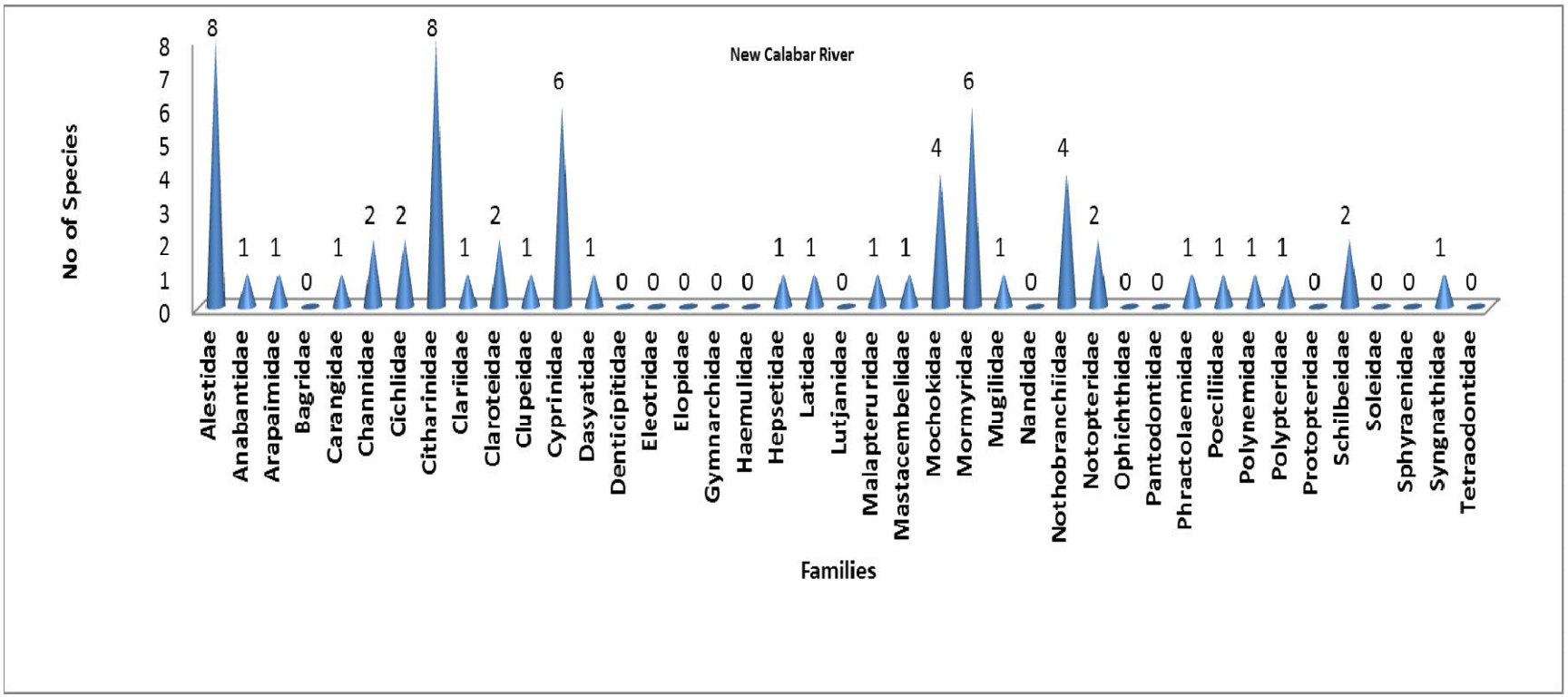

Fig. 4c. Number of fish families with corresponding number of species, on New Calabar River

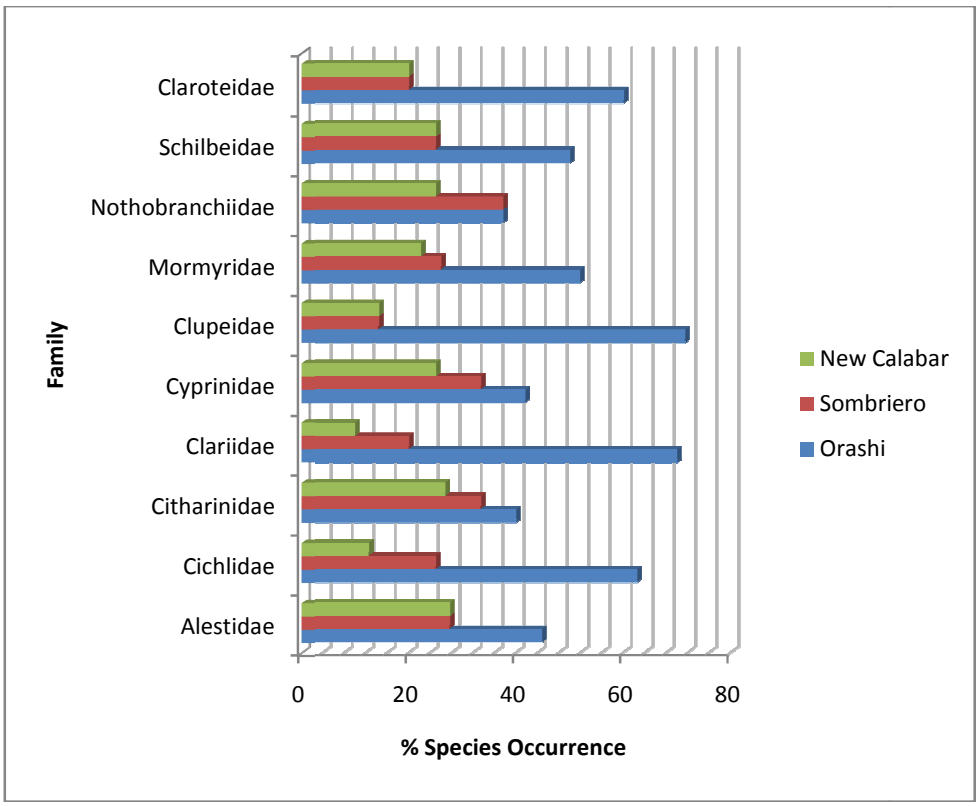

Fig. 4d. Dominant families with percentage occurrence of species in the three river systems

3.1.4 The Orashi River association

The Orashi association is made up of seventy-seven (77) species that occur exclusively on the Orashi River and represent 50% of the total species. The seventy-seven species which are distributed through twenty-seven (27) families and fifty-three (53) genera include: *Alestes baremoze, Auchenoglanis biscutatus, Auchenoglanis occidentalis, Aphyosemion gulare, Barboides gracilis. Bagrus docmac, Barbus hypsolepis, Barbus leonensis, Barbus macrops, Barbus nigeriensis, Brycinus intermedius, Brycinus leuciscus, Bryconaethiops quinquesquame, Caecula cephalopeltis, Campylomormyrus tamandua, Caranx hippos, Citharichthys stampflii, Citharinops distichodoides, Clarias gariepinus, Clarotes laticeps, Cynoglossus senegalensis, Dagetichthys lakdoens, Dasyatis margarita, Distichodus brevipinnis, Distichodus engycephalus, Distichodus rostratus, Elops lacerta, Aphyosemion sjoestedti, Epiplatys bifasciatus, Gymnarchus niloticus, Hemichromis fasciatus, Hemisynodontis membranaceus, Heterobranchus bidorsalis, Hydrocynus vittatus, Hyperopisus bebe, Ichthyoborus monodi, Labeo coubie, Labeo senegalensis, Lates niloticus, Leptocypris niloticus, Marcusenius cyprinoides, Micralestes acutidents, Micralestes elongates, Micralestes humilis, Micralestes occidenta, Microphis brachyurus, Mormyrops anguilloides, Mormyrus hasselquisti, Mormyrus macrophthalmus, Mormyrus rume, Nannocharax occidentalis, Odaxothrissa ansorgii, Odaxothrissa mento, Paradistichodus dimid, Pellonula vorax, Petrocephalus bane, Petrocephalus bovei, Polynemus quadrifilis, Bagrus bayad, Polypterus ansorgii, Polypterus sensgalus, Protopterus annectens, Psettias sebae, Raiamas senegalensis, Rhabdalestes septentrionalis, Sarotherodon galilaeus, Schilbe intermedius, Schilbe niloticus, Sierrathrissa leonens, Sphyraena afra, Synodontis budgetti, Synodontis nigrita, Synodontis schall, Synodontis sorex, Tetraodon lineatus, Tilapia zillii, and Trachinotus teraia.*

The Orashi River association (Fig. 7) is dominated by six families namely Alestidae, Cithariiidae, Clupeidae, Cyprinidae, Mokochidae and Momyridae, with species number ranging from 4 to10.

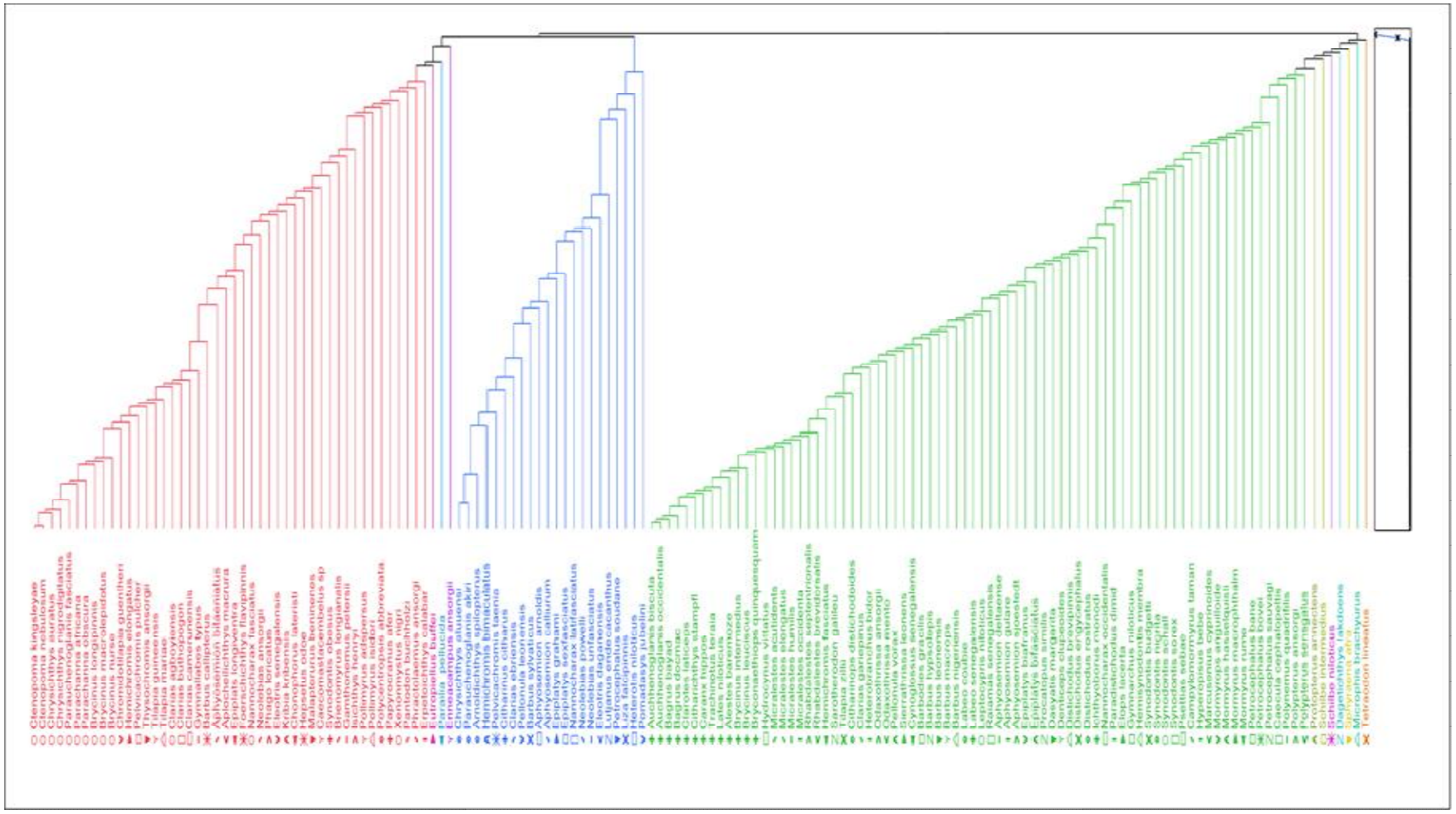

Fig. 5. Average linkage dendrogram of fish species associations

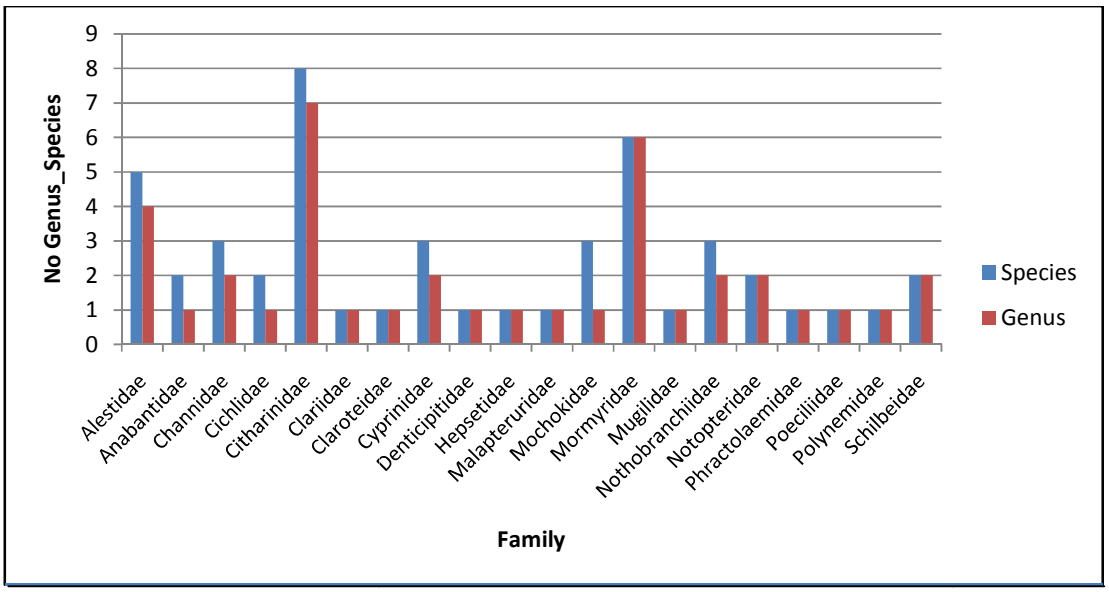

Fig. 6. Dominant fish families within the Orashi-Sombriero-New Calabar River Association

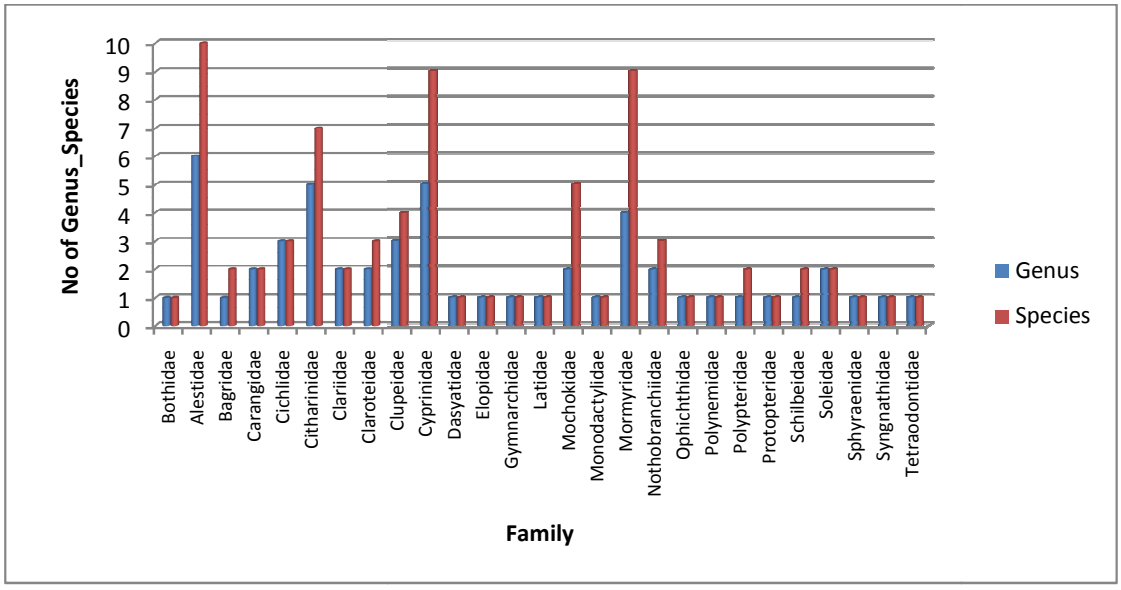

Fig 7. Genus-species occurrence among the Orashi association

3.1.5 The Sombriero River association

The Sombriero association comprises of six (6) species namely *Aphyosemion deltaense*, *Denticeps clupeoides, Epiplatys biafranus, Petrocephalus sauvagii, Procatopus similis* and *Rhabdalestes brevidorsalis*. These species make up 3.9% of the total species and are distributed through five (5) families.

4. DISCUSSION

The study has shown fish species richness from the three river systems to be relatively high when compared with the reported statistics for freshwater systems of Anambra, Kaduna, Sokoto-Rima, Cross River, Ogun, Oshun [15,16]. Ita [15] reported species richness for the Anambra, Kaduna, Sokoto-Rima as 22, 28, 22 and Cross River, Ogun and Oshun as 39, 23, and 23 respectively. In addition, Odo et al. [16] provided new statistics for Anambra River where 52 species were collected. The species richness of 135, 76 and 63 found in Orashi, Sombriero and New Calabar Rivers adds to the growing evidence of the species assemblages of the inland waters of Nigeria.

The study has also shown an ordering of the fish species by the dendrogram into a ubiquitous and a restricted group across the spatial divide of the three river systems. The ubiquitous group is represented by 31% of the total species and distributed in 51% of the fish families. Overall, the similarity was greater among stretches of the same river according to fish species abundance, as showed by cluster analysis results of Orashi River where 50% of the species were of restricted distribution. The similarity was also greater between streams of same drainages such as the Sombriero and New Calabar which had a Sorenson similarity value of 0.9 in contrast to the Sorenson value of 0.54 between Orashi and Sombriero and 0.25 values between Orashi and New Calabar River.

The taxonomic richness of fish in each river system seems to be consistent with the physical and chemical water variables as documented in NEDECO [12] and NNPC/RPI [13]. The three river systems at wet season have typical blackwater pH and conductivity and at dry season are clear water systems. The difference between the Orashi taxonomic fish assemblage and the New Calabar and Sombriero River is plausibly due to the reported evidence [12] of drastic physical and chemical changes as a result of the large contribution of the River Niger water during the wet season. Reported evidence [12] shows that during most of the year the Orashi River is an independent river drawing most of its waters from its own catchment area. However during the wet season when the River Niger runs high a larger part of the land between the two rivers is flooded and some of the white water characteristics of the Niger waters discharge into the Orashi giving it a mixed river classification. This factor is likely to promote the mixing of the fish species and the sharing of fish species. Thereby the highest fish species was recorded at the Orashi River.

5. CONCLUSION

Our findings are consistent with the hypothesis that fish species diversity is mainly influenced by fine-scale environmental factors such as interconnectivity of rivers and streams. In this regard, the conclusions agree with interpretations from previous studies of fish assemblage structure where habitat diversity either on a longitudinal or spatial gradient influence fish diversity [17-19]. The remarkable difference between the Orashi River and the other two river systems (New Calabar and Sombriero) show that the expansion of habitats between the catchment areas of the Orashi and the River Niger during the wet season contribute to spatial variability that increase species richness. The results highlights the need to consider watershed characteristics, geochemical setting and catchment connectivity differences in comparative ecology of fishes in rivers with similar chemical characteristics.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Matthews WJ, editor. Patterns in freshwater fish ecology. Boston: Kluwer Academic Publishers. 1998;756.
2. Winemiller KO, Agostinho AA, Caramaschi EP. Fish ecology in tropical streams. In: Dudgeon D, editor. Tropical stream ecology. London: Academic Press. 2008; 107-46.
3. Gido KB, Jackson DA. Community ecology of stream fishes: Concepts, approaches, and techniques. Bethesda: American Fisheries Society, Symposium. 2010;73: 684.
4. Scott JS. Report on the Fisheries of the Niger Delta Special area. NDDB Port Harcourt. 1966;109.
5. Sikoki FD, Hart AI, Abowei JF. Gill net selectively and fish abundance in the lower Nun River, Nigeria. J Appl Sci Environ Manage. 1998;1:13-9.
6. Sikoki FD, Hart SA. Studies on the fish and fisheries of the Brass river system and adjoining coastal waters in Bayelsa State Nigeria. J. Appl Sci Environ Manage. 1999; 2:63-7.
7. Abowei JFN. Aspects of the fisheries of the lower Nun River. Ph. D. Dissertation, University of Port Harcourt, Port Harcourt. 2000;248.
8. Abowei JFN. Morphometric parameters of *Parailia pellucida* (Boulenger, 1901) from the fresh water reaches of lower Nun River, Niger Delta, Nigeria. Adv J Food Sci Technol. 2009;1(1):43-50.
9. Abowei JFN, Hart AI. Size, composition, age, growth, mortality and exploitation rate of *Chysichthys nigrodigitatus* from Nun River, Niger Delta, Nigeria. Afr J Appl Zool Environ Biol. 2007;9:44-50.

10. Akari EJ. Identification of common fresh water fishes of a stretch of Orashi River. HND Project, Rivers State University of Science and Technology, Port Harcourt. 1982;45 .
11. Dokubo IAK. Longitudinal distribution of fishes in Sombrero River. Rivers State BSc. Project, University of Port Harcourt, Choba. 1982;140.
12. NEDECO (Netherlands Engineering Company). The Waters of the Niger Delta. The Hague. 1961;210-228.
13. NNPC/RPI. Environmental baseline studies for the establishment of control criteria and standards against petroleum related pollution in Nigeria; 1985. RPI/R/84/4/15-7.
14. Sorensen T. A method of establishing groups of equal amplitude in plant sociology based on similarity of species and its application to analyses of the vegetation on Danish commons. Kongelige Danske Videnskabernes Selskab. 1948; 5(4):1–34.
15. Ita EO. Inland Fishery Resources of Nigeria. FAO, CIFA Occasional Paper No. 20. Rome: Italy, FAO. 1993;120.
16. Odo GE, Nwani CD, Joseph EE. The fish fauna of Anambra River basin, Nigeria: Species abundance and morphometry. Rev Biol Trop. (Int J Trop Biol.). 2009; 57(1-2):177-86. ISSN-0034-7744.
17. Southwood TR. Tactis, strategies and templets. Oikos. 1988;52:2–18.
18. Angermeier PL, Winston R. Local vs. regional influences on local diversity in stream fish communities of Virginia. Ecology. 1998;79:911–27.
19. Peres-Neto PR. Patterns in the occurrence of fish species in streams: the role of site suitability, morphology and phylogeny versus species interactions. Oecologia. 2004;140:352–60.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/10017