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Early Dry Season Community Structure of Fin Fishes of the Amadi Creek Port Harcourt, Rivers State, Nigeria.

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ABSTRACT
A survey was conducted to document the community structure of fin fishes of the Amadi Creek, during the early dry season. Landed fish samples collected from local fishers were assessed using standard methods. Results revealed a composition of seven families, having twelve species (Sarotherodon melanotheron, Sarotherodon galilaeus, Coptodon zilli, Coptodon guineensis, Hemichromis fasciatus, Mugil cephalus, Parachelon grandisquamis, Chrysichthys nigrodigitatus, Elops lacerta, Pomadasys perotaei Lutjanus dentatus). Monthly composition fluctuated, however, Cichlids species were dominant with S. melanotheron most dominant, while E. lacerta recorded least species. Monthly diversity was generally low, but higher for the Cichlids (with exception of the Coptodon zilli) while all other species/families recorded lower diversities. Sarotherodon melanotheron (0.26 - 0.36) recorded the highest diversity, while, Pomadasys perotaei (0.02) was least diverse. Monthly relative abundance fluctuate with some species like the Sarotherodon melanotheron having increased relative abundance from October (57.4%), to March (57.74), while others like Mugil cephalus decreased (8.0% - October to 0.78% - December). However, Cichlids were most abundant, with exception of Coptodon zilli. Generally, Sarotherodon melanotheron (37.39% to 67.27%) was most abundant, while Pomadasys perotaei, least abundant (0.38% to 0.52%). Abundance score indicated Sarotherodon melanotheron was mostly common (C); Sarotherodon galilaeus and Coptodon guineensis rare (R) to few (F); whereas all other species were rare (R). Analysis of variance for abundance and diversity indicated variation in significant difference between species, each month, throughout the study (P<0.05), especially between the least abundant and diverse species, and the highly abundant and diverse species.
Keywords: *Abundance, Amadi Creek, Composition, Community Structure, Diversity, Fishes.*

INTRODUCTION

Community structure of fishes in water bodies are of great importance for the conservation and management of various species (Pino-Del-Carpio *et al.* 2014).

According to King (1995), a survey of fish fauna composition is essential in proper management and conservation of fish resources of any water body.

Abundance was defined by Sikoki *et al.*(2003), as the total number of catch or biomass of fish species found in a given area. Abundance was also used to determine the effect of over fishing and other human activities or climatic conditions which bring about changes in the fish population. It was also reported that, knowing the species abundance of different water bodies can provide salient information on the nature of the ecosystem and give insight into less obvious properties of the aquatic ecosystem including competition and predatory behaviors of fish in the ecosystem (Thompson *et al.,*2015).

Fish diversity is the variation of species of fish in their size, shape, biology and habitat (Severn ,1992; Shabir *et al.,* 2000). Fish fauna exhibit greater species diversity than any other group of vertebrates (Froese and Pauly, 2017).

Fish community structure and species assemblages in streams, rivers, creeks or any other body of water depends upon the biotic and abiotic factors and types of ecosystem (Nanda and Tiwari, 2001). The diversity and abundance of fish species in a given habitat can be influenced by various factors such as stream size, availability of food and also difference in the physical, chemical and biological parameters which further leads to stream zonation, accounting for the changes in fish fauna diversity (Barita *et al.,* 2000). Diversity of different organisms is can be more often limited by a specific factor in the ecosystem that limits its ability to survive, grow or reproduce (Thaman, 2007).

Ehrlich and Wilson (1991), reported the study of Biodiversity as essential for stabilization of ecosystems, protection of general environmental quality of a given area and also understanding the intrinsic worth of species in that area, and it is essential for the sustainability of fisheries resource so as to conserve and increase the needs for fish population for the future. According to Zainudin (2005), biodiversity also serves as a biological indicator to show the level of aquatic pollution contributing to environmental quality

The Amadi Creek is an inland water body located within the Port Harcourt metropolis of Rivers state. It is a tidal, tributary of the Bonny River (Ibim and Njoku, 2018). This creek is primarily of immense economic importance to the people of the Rivers State as a source of fish and income for the indigenes, and artisanal fishers respectively. Secondly, the creek is strategically located, and so serves as a major medium for the transportation of staff, goods and services, for several local and multinational companies located at its fringes (Ezeilo and Dune, 2012; Ibim and Njoku, 2018). Also, ship building/maintenance, domestic waste disposal, land filling and sand dredging, oil bunkering, among several other activities take place there. However, the secondary activities have advertently/inadvertently led to the release of anthropogenic materials into the water body. This will consequently affect the fish fauna in the creek (Ibim and Njoku, 2018).

Numerous studies have been carried out on the ichthyofaunal community structure of several rivers in the Niger Delta Basin such as; Elechi Creek in Rivers State (Allison *et al,* 1997); Lower Nun River, Bayelsa State (Abowei, 2000); Lower Bonny River, Rivers State (Chindah *et al.,* 2008); Nun River, Bayelsa State (Allison and Okadi, 2009); Uta Ewa Creek (Akpan, 2013), among many others. Despite all of the negative activities going on, and the anthropogenic substances released into the Amadi creek, there's paucity of information on the fish fauna community structure of this creek. The few available information recorded in the Amadi Creek during the wet season by Ibim and Njoku (2018), reported fish composition of four species from four genera and three families, while Ibim and Iwalehin (2019), reported twelve species in ten genera and seven families in the late dry season. However, there is no information on the early dry season fin fish community structure of the creek to close the gap in information between the previous studies in the creek, thereby providing a seasonal/year-round information of the fish community structure. The main objective of this study therefore, is to assess and document the composition, diversity, and abundance of the early dry season community structure of fin fishes in the Amadi Creek. This is aimed at complementing the late dry season and wet season studies, to provide a seasonal picture that will provide vital information for the management of the fishes and fisheries, and ultimately the ecosystem of Amadi Creek.

MATERIALS AND METHOD

Study Area

This study was carried out in the Amadi Creek in Port Harcourt, Nigeria (Figure1), at points located within longitude 4^0 470' N - 4^0 473'N and latitude $7^0$1'0"E - $7^0$2'0"E. The creek is a tributary of the Bonny River, flowing from Okrika town, through several communities (Borokiri, Marine Base, Amadi-Ama, among others) and finally empting into the main Bonny River, from where it connects the Atlantic Ocean. The water flows into the creek during high tide and out at low tide but stagnates briefly at the point of tidal changes as it is tidal (semi-diurnal) (Wilcox, 1980). The creek channel creek is fairly deep with muddy and sand bottom with the intertidal banks being covered mostly with chikoko mud (Ibim and Njoku, 2018)

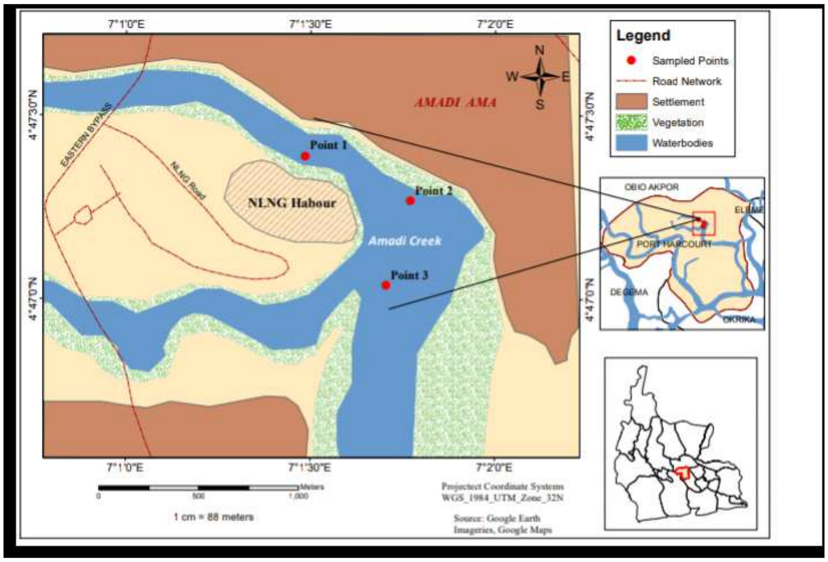

Figure 1: Study Area showing the Amadi Creek.2018).

The economic importance of the creek is based on the fact that, a number of human and economic activities depend and take place, within and at the fringes of the Creek. Also, it hosts several industries, factories, boat harbors, and most importantly, artisanal fishing activities that supply fish to the major markets in Port Harcourt metropolis (Ibim and Njoku, 2018).

The vegetation of the creek is scanty and consists of a few red and white mangrove (*Rhizophora mangle* and *Avicenia africana* respectively) mixed with a vast array of invasive Nypa palm (*Nypa fruticans),* that is almost dominating the creek's flora (Wilcox, 1980).

The predominant seasons in this area are wet and dry season and a brief spell of very dry season called the harmattan season. Due to the inland location of the creek, it is fresh during the rainy/flood season and salty during the dry season (Ezeilo and Agunwamba, 2014).

Experimental Design, Sample Collection and Treatment

The study involved a 24 weeks (six months) survey of the fin fish fauna during the early dry season period of the year, from October to March, 2019, with three sampling points randomly selected in the creek, separated 1kilometre away from each. The sampling points were titled, Point A: Latitude 04^{0}47.270'N and Longitude 007^{0}01.777'E (Amadi-Ama), Point B: Latitude 04^{0}47.389'N and Longitude 007^{0}01.587'E (Dredging site) and Point C: Latitude 04^{0}47.112'N and Longitude 007^{0}01.696 'E (Marine Base).

These sampling points were surveyed and sampled for fish bi-weekly, by collection of landed fish from fisher folks that fished with gill and cast net of 9m length, 9 m width and mesh size 15 and 25mm, and valve and basket traps.

The fish samples were preserved in buckets containing 4% formalin, and taken to the laboratory, after snap shots had been taken to prevent loss of information that may be needed for the identification of the fish.
Water samples were also collected from the sampling points to determine the physicochemical parameters of the water body.

Data Collection

Fish Composition Determination

The fish composition was determined by counting all landed fin fishes from the fisher. The fishes were sorted into various kinds and a few selected representative fish samples were taken to laboratory for detailed identification. The fish species identification was done to the lowest, species level using standard identification keys such as Wheeler (1994), Atlas of fin fishes in the Andoni River in Niger Delta (Sikoki and Francis, 2007), Album of food and fin fishes in Niger Delta (Ibim and Francis, 2012), and Fish Base (Froese and Pauly, 2017)

Fish Species Abundance Determination

The fish species abundance was determined by the relative abundance method which involves counting the total number of fish species caught per sampling point and calculating the percentage of the total population. Also, the abundance score of the fishes was estimated following the criteria of Allison *et al.,*(2003) where; if the number of fishes is 1-50= Rare (R); 51-100= Few (F); 101-200= Common (C); 201-400= Abundance (A) and above 400= Dominant (D).

Fish Species Diversity Determination

The diversity of fish species was determined using the Shannon-Wiener index (Krebs, 1999) as follows;

$$H^{i} = -\sum_{i}^{s} \text{Pi In Pi}$$

Where; Pi= proportion of individuals found in the i^{th} species (i.e Pi= ni/N)
In= natural Logarithm N= total abundance Ni= number of individual species

RESULTS

Fish composition

The composition of the fin fishes in the Amadi Creek throughout the sampling period as shown in the Checklist of species (Table 1), revealed a total of twelve species from ten genera and seven families, from a total catch of 3,890 individuals, over the study period. The seven families and twelve species presented in descending order are as follows; Cichlidae (five species -*Sarotherodon melanotheron, Sarotherodon galilaeus, Coptodon zilli, Coptodon guineensis* and *Hemichromis fasciatus*)*;* Mugilidae (two species - *Mugil cephalus* and *Parachelon grandisquamis*)*;* Claroteidae (1 species - *Chrysichthys nigrodigitatus*)*;* Elopidae (1 species - *Elops lacerta*); Haemulidae (1 species - *Pomadasys* perotaei); and Lutjanidae (1 species - *Lutjanus dentatus*). Generally, the Cichlids were the dominant family with five species, recording higher totals of individual catches, with *S. melanotheron* as the dominant species (2,559). However, the *Coptodon zilli* were low in catch (9). All other families were low in total number of individual species caught, with the *Chrysichthys nigrodigitatus* (5)*; Elops lacerta* (2); *Pomadasys perotaei* (4); and *Lutjanus dentatus* (3), recording the least numerical composition of species.
The monthly species numerical composition (Table 2) showed fluctuation in species composition through the study period where; October recorded seven species, followed by a fall in November which recorded the lowest species composition of only four Cichlids. This was followed by a rise

in December with six species, and subsequent fluctuations up until March which recorded eight species, the highest in the study. However, the Cichlids were the dominant species through all the months, with the *S. melanotheron* recorded the most dominant species, recorded every month with a total of six hundred and seven samples caught, while the least occurring species was the *E. lacerta,* occurring only in October, with a total of two samples.

Fish Diversity

The monthly fin fish diversity of the Amadi Creek (Table 3) revealed that, the diversity varied through the period and was generally low, for all species. However, the Cichlid species, with exception of the *Coptodon zilli,* recorded moderately high diversities, than other species. The *Sarotherodon melanotheron* (0.26 - 0.36); *Sarotherodon galilaeus* (0.27 - 0.36); and *Hemichromis fasciatus* (0.13 – 0.36) recorded the highest and similar, and stable ranges of diversity across the study period. The *Coptodon guineensis*, though comparable in diversity *(*0.27 - 0.36) to the former, exhibited a high rise and fall in diversity. The Mugil cephalus recorded a moderate diversity. The rest seven species in the creek recorded lower diversities, with *Elops lacerta* (0.04) in its single occurrence, *Pomadasys perotaei* (0.02), and the *Lutjanus dentatus (*between 0.02 to 0.04) species with the least diversity.

The analysis of variance (ANOVA) for diversity (Table 4) showed that, the diversity of fish species within each month varied, throughout all the months. The ANOVA also showed that, in most months the high diversity species (*S. melanotheron*, *S. galilaeus, C. guineensis*, *H. fasciatus*, and *M. cephalus*) recorded diversities that may or may not be significant among themselves, but highly significantly different from the lower diversity species. Also, the lower diversity species, especially the *E. lacerta, P. perotaei C. zilli* and *C. nigrodigitatus,* were not significantly different in diversity among themselves, but significantly different from all other species, throughout all the months. For instance in October, among the higher diversity species, *S. melanotheron*, and *M. cephalus* were similar, but fairly significantly different from *H. fasciatus*. However, all of them were highly significantly different from the low diversity species, *E. lacerta, P. perotaei, C. zilli* and *C. nigrodigitatus,* which were similar to each other, but significantly different from other species.

Table 1: Checklist of the Fin Fishes of the Amadi Creek, Port Harcourt, Rivers State.

Family	Genus	Species	Common names	Total Catch
Cichlidae	*Sarotherodon*	*Sarotherodon melanotheron*	Black chin tilapia	2,559
		Sarotherodon galilaeus	Mango tilapia	490
	Coptodon	*Coptodon guineensis*	Guinean tilapia	385
		Coptodon zilli	Red belly tilapia	9
	Hemichromis	*Hemichromis fasciatus*	Banded jewelfish	358
Mugilidae	*Mugil*	*Mugil cephalus*	Flathead gray mullet	31
	Parachelon	*Parachelon grandisquamis*	Large scaled mullet	24
Clupeidae	*Sardinella*	*Sardinella maderensis*	Madeiran sardine	20
Claroteidae	*Chrysichthys*	*Chrysichthys nigrodigitatus*	Bagrid catfish	5
Elopidae	*Elops*	*Elops lacerta*	West African ladyfish	2
Haemulidae	*Pomadasys*	*Pomadasys perotaei*	Parrot grunt	4
Lutjanidae	*Lutjanus*	*Lutjanus dentatus*	African brown snapper	3
Total				**3,890**

Table 2: Monthly Numerical Species Composition of the Fin Fishes of the Amadi Creek, Port Harcourt, Rivers State.

Species	October	November	December	January	February	March	
	Numerical composition	Numerical composition	Numerical composition	Numerical composition	Numerical composition	Numerical composition	Total
Sarotherodon melanotheron	111.2	68.4	116.4	166.5	87.5	57.46	607.46
Sarotherodon galilaeus	---	---	----	34.5	69.0	94.3	197.8
Hemichromis fasciatus	57.5	41.3	11.0	22.0	10	----	141.8
Coptodon guineensis	-----	3.7	59.5	12.0	60.5	----	135.7
Coptodon zilli	-----	2.0	----	----	2	4	8
Mugil cephalus	15.5	----	15	-----	----	----	30.5
Parachelon grandisquamis	4.5	----	----	5	5	3	17.5
Sardinella maderensis	----	-----	-----	6.5	----	2	8.5
Chrysichthys nigrodigitatus	2.0	----	----	----	-----	3	5
Elops lacerta	2.0	-----	---	----	----	----	2.0
Pomadasys perotaei	1.0	----	1.0	1.0	----	1	4.0
Lutjanus dentatus	-----	----	1.0	----	---	3	4.0
Monthly total	193.7	115.4	203.9	247.5	234.0	167.76	

Table 3: Diversity of the Fin Fishes of Amadi Creek, Port Harcourt, Rivers State.

Species	October		November		December		January		February		March	
	Species diversity	Species diversity (%)	Species diversity	Species diversity (%)	Species diversity	Species diversity (%)	Species diversity	Species diversity (%)	Species diversity	Species diversity (%)	Species diversity	Species diversity (%)
Sarotherodon melanotheron	0.31	28.58	0.31	36.11	0.32	29.60	0.26	24.24	0.36	27.54	0.33	30.07
Sarotherodon galilaeus	-----	---	----	----	----	---	0.27	24.97	0.36	26.96	0.36	33.25
Coptodon guineensis	-----	------	0.11	12.85	0.35	33.24	0.14	13.34	0.34	26.19	----	----
Hemichromis fasciatus	0.35	32.70	0.36	42.84	0.15	14.57	0.21	19.56	0.13	10.09	----	----
Coptodon zilli	----	-----	0.07	8.18	-----	----	-----	----	0.04	3.04	0.06	5.57
Mugil cephalus	0.20	18.98	----	----	0.19	17.75	---	----	----	-----	----	-----
Parachelon grandisquamis	0.08	8.24	----	----	----	-----	0.07	7.16	0.08	6.15	0.04	4.44
Sardinella maderensis	----		----	----	----	---	0.09	8.69	----	----	0.17	15.92
Chrysichthys nigrodigitatus	0.04	4.45	----	----	---	---	---	----	----	----	0.49	4.44
Elops lacerta	0.04	4.45	----	----	----	----	----	---	----	----	----	----
Pomadasys perotaei	0.02	2.57	----	----	0.02	2.40	0.02	2.02	----	----	0.02	1.82
Lutjanus dentatus	----	----	----	----	0.02	2.41	----	----	----	----	0.04	4.44

Table 4: Analysis of Variance (ANOVA) of monthly Diversity of Amadi Creek, Rivers State, Port Harcourt, Nigeria.

species	October	November	December	January	February	March
Sarotherodon melanotheron	0.31 ± 0.00^{ab}	0.31 ± 0.01^{b}	0.32 ± 0.01^{b}	0.26 ± 0.00^{a}	0.37 ± 0.00^{a}	0.33 ± 0.00^{c}
Sarotherodon galilaeus	0.00 ± 0.00^{b}	0.00 ± 0.00^{e}	0.00 ± 0.00^{f}	0.27 ± 0.00^{a}	0.37 ± 0.00^{a}	0.37 ± 0.00^{b}
Coptodon guineensis	0.00 ± 0.00^{b}	0.11 ± 0.00^{c}	0.35 ± 0.00^{a}	0.14 ± 0.00^{c}	0.34 ± 0.00^{b}	0.00 ± 0.00^{h}
Hemichromis fasciatus	0.35 ± 0.00^{ab}	0.37 ± 0.00^{a}	0.15 ± 0.00^{d}	0.21 ± 0.00^{b}	0.13 ± 0.00^{c}	0.00 ± 0.00^{h}
Coptodon zilli	0.00 ± 0.00^{b}	0.07 ± 0.00^{d}	0.00 ± 0.00^{f}	0.00 ± 0.00^{g}	0.04 ± 0.00^{e}	0.06 ± 0.00^{e}
Mugil cephalus	0.21 ± 0.00^{ab}	0.00 ± 0.00^{e}	0.19 ± 0.00^{c}	0.00 ± 0.00^{g}	0.00 ± 0.00^{f}	0.00 ± 0.00^{h}
Parachelon grandisquamis	2.39 ± 2.30^{a}	0.00 ± 0.00^{e}	0.00 ± 0.00^{f}	0.07 ± 0.00^{e}	0.08 ± 0.00^{d}	0.04 ± 0.00^{f}
Sardinella maderensis	0.00 ± 0.00^{b}	0.00 ± 0.00^{e}	0.00 ± 0.00^{f}	0.09 ± 0.00^{d}	0.00 ± 0.00^{f}	0.17 ± 0.00^{d}
Chrysichthys nigrodigitatus	0.04 ± 0.00^{b}	0.00 ± 0.00^{e}	0.00 ± 0.00^{f}	0.00 ± 0.00^{g}	0.00 ± 0.00^{f}	0.49 ± 0.00^{a}
Elops lacerta	0.04 ± 0.00^{b}	0.00 ± 0.00^{e}	0.00 ± 0.00^{f}	0.00 ± 0.00^{g}	0.00 ± 0.00^{f}	0.00 ± 0.00^{h}
Pomadasys perotaei	0.01 ± 0.00^{b}	0.00 ± 0.00^{e}	0.02 ± 0.00^{e}	0.00 ± 0.00^{g}	0.00 ± 0.00^{f}	0.02±0.00g
Lutjanus dentatus	0.00 ± 0.00^{b}	0.00 ± 0.00^{e}	0.02 ± 0.00^{e}	0.00 ± 0.00^{g}	0.00 ± 0.00^{f}	0.04 ± 0.00^{f}

Table 5: Relative Abundance and Score of Fin Fish Species of Amadi Creek, Port Harcourt, Rivers State.

Families	Species	October				December						March	
		Relative abundance	Legend of rarity	Relative abundance	Legend of rarity	Relative abundance	Legend of rarity	Relative abundance	Legend of rarity	Relative abundance	Legend of rarity	Relative abundance	Legend of rarity
Cichlidae	*Sarotherodon melanotheron*	57.40	C	59.27	C	61.13	C	67.27	C	37.39	F	57.46	C
	Sarotherodon galilaeus	----	----	----	-	----	-	13.93	R	29.48	R	36.36	F
	Coptodon guineensis	----	--	3.20	R	31.35	F	4.84	R	25.85	F	----	-
	Hemichromis fasciatus	29.68	F	1.73	R	5.77	R	8.88	R	4.27	R	-----	-
	Coptodon zilli	----	--	1.73	R	----	-	---	-	0.89	R	1.54	R
Mugilade	*Mugil cephalus*	8.00	R	---	-	0.78	R	---		--		----	
	Parachelon grandisquamis	2.32	R	-----	-	----	-	2.02	R	2.13	R	1.15	R
Clupeidae	*Sardinella maderensis*	---	--	----	-	---		2.62	R	----	-	6.77	R
Claroteidae	*Chrysichthys nigrodigitatus*	1.03	R	----	-	----	-	--	-	---	-	1.15	R
Elopidae	*Elops lacerta*	1.03	R	----	-	---	-	---	-	---	-	---	-
Haemulidae	*Pomadasys perotaei*	0.51	R	-----	-	0.52	R	0.40	R	---	-	0.38	R
Lutjanidae	*Lutjanus dentatus*	----	-	---	-	0.52	R	--	-	---	-	1.15	R

Note : 1-50= Rare (R), 51-100= Few (F), 101-200= Common (C), 201-400= Abundant (A) and above 400= Dominant (D).

Fish Abundance

The monthly abundance of fish species (Table 5) revealed that in the Amadi Creek, the relative abundance varied between the months for all the species/families. However, the Cichlid species were recorded as the most abundant and dominant species every month in the study area, with *Sarotherodon melanotheron* (37.39% to 67.27%) and *Sarotherodon galilaeus* (13.93% to 36.36%) as the most abundant, whereas the *Coptodon zilli* unlike other Cichlids was low in abundance (0.89% to 1.73%). All other species/families in the creek also recorded low abundance, with the Haemulidae *Pomadasys perotaei,* recording the least abundance range of 0.38% to 0.52%.

Also, the trend in the monthly relative abundance revealed that, most species recorded fluctuations in relative abundance, with an increase in relative abundance from the onset through some months, followed by a drop, and then an increase again, as exemplified by *Sarotherodon melanotheron* whose relative abundance rose steadily from October (57.4%) to January (67.27%), and then dropped in February (37.39%), and later rose back in March (57.74). *Coptodon guineensis* recorded an erratic rise and fall in relative abundance through the months, exhibiting an increased abundance from November (3.20%) to December (31.35%), followed by a fall in January (4.48%), and a rise again in February (25.58%). The *Coptodon zilli r*ecorded relative abundance that was high in November (1.73%), fell in February (0.89%), and then rose again in March (1.54%). Another group of species, after a rise, recorded a fall in relative abundance, and became absent in the study area, such as *Hemichromis fasciatus,* which recorded a drastic drop in relative abundance from October (29.68%) to November (1.73%), followed by a slight, but low increase towards January (1.88%); followed by another drop in February (4.27%), and became absent in March.

Some other species recorded a decrease in abundance through their period of occurrence *Mugil cephalus* recorded a fall in relative abundance from 8.0% in October to 0.78% in December, in their two occurrences; *Parachelon grandisquamis* recorded a gentle decrease in abundance from October (2.32%) to March (1.15%), and also, the *Pomadasys perotaei* which recorded the least relative abundance in the study, exhibited a gentle drop from 0.51% in October to 0.38% in March. Meanwhile, other species recorded a continuous increase in abundance through the period they were found, such as the *Sarotherodon galilaeus* which recorded a gradual increase in relative abundance from January (13.93%) to March (36.36%); *Sardinella maderensis* recorded 2.62% (Jan.) to 6.77% (March); *Chrysichthys nigrodigitatus* recorded 1.03% (October) to 1.15% (March) and *Lutjanus dentatus* recorded from 0.05% (Dec.) to 1.15% (March). The abundance score showed that *Sarotherodon melanotheron* was common (C) all through the months with the exception of February when they were few (F). Some other Cichlids recorded periods of rare (R) and few (F) status, with *Sarotherodon galilaeus* rare (R) in January and February, but few (F) in March, *Coptodon guineensis* recorded alternate periods of rare (R) and few (F) from November to February, and *Hemichromis fasciatus* were few (F) in October, but became rare (R) from November to March. However all the other eight species *(Coptodon zilli, Mugil cephalus, Parachelon grandisquamis, Chrysichthys nigrodigitatus, Sardinella maderensis, Elops lacerta, Pomadasys perotaei a*nd *Lutjanus dentatus*) were rare (R) all through their occurrence.

The analysis of variance for abundance (Table 6) showed that there were significant differences for most species within each month, especially between the high abundance species and the low abundance species. This was evident from October to March. In October for instance, *Hemichromis fasciatus* was significantly different from *Sarotherodon melanotheron and M. cephalus,* but was highly significantly different from low abundance *Coptodon zilli, Chrysichthys nigrodigitatus, Sardinella maderensis, Elops lacerta, Pomadasys perotaei a*nd *Lutjanus dentatus,* which were most months all similar and not significantly different among themselves.

DISCUSSION

The moderately low fin fish species composition in the Amadi Creek, with a total twelve species belonging to seven families, is in agreement with the late dry season fin fish species composition in the same creek, which similarly reported twelve species from seven families (Ibim and Iwalehin, 2019). It was also in agreement with the studies of the Okpoka Creek (Davies, 2009), a closely linked creek from the same source (Bonny River), which recorded a total of eleven (11) species from eight (8) families. However, it was not in agreement with the wet season fish composition of the Amadi Creek (Ibim and Njoku, 2018), which reported far lower composition of four species from three families. It was also not in agreement with other adjoining creeks that recorded higher compositions such as, the Elechi Creek in the Upper Bonny River, which recorded far higher composition a total 35 species belonging to 20 families (Allison *et al.,* 1997); the lower Nun River with 36 species from 22 families (Abowei, 2000); the Lower and Upper New Calabar River (Ibim *et al.,* 2016); and further down, the Middle Reaches of the Sombreiro River, which recorded 31 species in 20 families (Ibim and Bongilli*,* 2018). The moderately low composition of finfishes in this study, in comparison with the very low composition in the wet season in the same study area (Ibim and Njoku, 2018), could be attributed to seasonal differences in water quality parameters encountered in the creek. However, the higher compositions in other connecting rivers in the Niger delta Area in comparison to the lower composition in this study, could be attributed to the fact that, the Amadi Creek water has been reported to be polluted, in poor quality, and low in Oxygen, as a result of the destructive developmental and anthropogenic activities/substances in the water body (Agunwamba *et al*, 2006; Ideriah *et al*, 2010; Ezeilo and Dune, 2012; Elems and Ugbebor, 2018; Ibim and Iwalehin, 2019).

The monthly fluctuation in the fish species composition in this study is in agreement with the monthly fluctuation in fish species composition in the Amadi Creek by Ibim and Njoku (2018), and Ibim and Iwalehin (2019). This fluctuation is a common phenomenon, that can be attributed

Table 6: Analysis of Variance (ANOVA) of Fin Fish Abundance of Amadi Creek, Port Harcourt, Nigeria

Species	October	November	December	January	February	March
Sarotherodon melanotheron	1.11±0.11^{b}	68.40±0.10^{a}	1.16±0.20^{a}	1.66±0.11^{a}	87.50±0.05^{a}	1.49±0.00^{a}
Sarotherodon galilaeus	0.00±0.00^{g}	0.00±0.00^{e}	0.00±0.00^{f}	34.50±0.11^{b}	69.00±0.00^{b}	94.30±0.05^{b}
Coptodon guineensis	0.00±0.00^{g}	3.70±0.05^{c}	59.50±0.05^{b}	12.00±0.00^{d}	60.50±0.11^{c}	0.00±0.00^{g}
Hemichromis fasciatus	57.50±0.23^{a}	41.30±0.11^{b}	11.00±0.00^{d}	22.00±0.00^{c}	10.00±0.00^{d}	0.00±0.00^{g}
Coptodon zilli	0.00±0.00^{g}	2.00±.0.00^{d}	0.00±0.00^{f}	0.00±0.00^{h}	2.00±0.00^{f}	4.00±0.00^{c}
Mugil cephalus	15.50±0.30^{b}	0.00±0.00^{e}	15.00±0.00^{c}	0.00±0.00^{h}	0.00±0.00^{g}	0.00±0.00^{g}
Parachelon grandisquamis	4.50±0.10^{d}	0.00±0.00^{e}	0.00±0.00^{f}	5.00±0.00^{f}	5.00±0.00^{e}	3.00±0.00^{d}
Sardinella maderensis	0.00±0.00^{g}	0.00±0.00^{e}	0.00±0.00^{f}	6.50±0.11^{e}	0.00±0.00^{g}	2.00±0.00^{e}
Chrysichthys nigrodigitatus	2.00±0.00^{e}	0.00±0.00^{e}	0.00±0.00^{f}	0.00±0.00^{h}	0.00±0.00^{g}	3.00±0.00^{d}
Elops lacerta	2.00±.0.00^{e}	0.00±0.00^{e}	0.00±0.00^{f}	0.00±0.00^{h}	0.00±0.00^{g}	0.00±0.00^{g}
Pomadasys perotaei	1.00±0.00^{f}	0.00±0.00^{e}	1.00±0.00^{e}	1.00±0.00^{g}	0.00±0.00^{g}	1.00±0.00^{f}
Lutjanus dentatus	0.00±0.00^{g}	0.00±0.00^{e}	1.00±0.00^{e}	0.00±0.00^{h}	0.00±0.00^{g}	3.00±0.00^{d}

to fluctuations in water quality parameters associated with seasons in this creek (Agunwamba *et al*, 2006; Ideriah *et al*, 2010; Ezeilo and Dune, 2012; Elems and Ugbebor, 2018; Ibim and Iwalehin, 2019) and other rivers (Onwuteaka, 2015). Also, it could be attributed to fishing pressure especially on the very scarcely encountered high demand fish species (Ibim and Njoku (2018), like the *Lutjanus dentatus* and the *Chrysichthys nigrodigitatus*.

The dominance and high numerical composition of the Cichlid species, with the exception of *C. zilli* with a low numerical composition, and the lower composition of other families/species is in agreement with the previous studies in the Amadi Creek (Ibim and Njoku,2018; Ibim and Iwalehin. 2019). The high Cichlid composition and number of species, could be attributed to their ability to survive a wide range of environmental conditions, and resilience (Welcome 1979; Pullin and Lowe-McConnell, 1982). Also, Awiti (2011), reported that, the Cichlid species are highly fecund and prolific, and can therefore dominate aquatic environments. The low composition of the other families/species in this study could be attributed to several conditions such as poor adaption to the environment as they may be migratory and so do not dwell there (Chindah *et a.,*1999), or maybe as a result of anthropogenic substances and activities occurring in the creek, which could have affected the water quality, such as the extremely low dissolved oxygen observed in this study, in Ideriah *et al* (2010), Ibim and Iwalehin (2019), among others.

The generally low diversity observed in this study was in agreement with the studies of Ibim and Njoku (2018) and Ibim and Iwalehin (2019) in the Amadi Creek, and Davies (2009), in the adjoining Okpoka Creek. This was in contrast with higher diversities reported in other closely linked rivers and creeks such as, the Bonny River(Chindah and Osuamkpe, 1994), New Calabar River (Ibim *et al.,*2016), Mid-Sombriero River (Ibim and Bongili, 2017). This is could be attributed to the poor water quality of the Amadi Creek, especially the low oxygen content of the water body as it receives series of anthropogenic materials from the surroundings (Agunwamba *et al*, 2006; Ideriah *et al*, 2010; Ezeilo and Dune, 2012; Elems and Ugbebor, 2018; Ibim and Njoku, 2018; Ibim and Iwalehin, 2019).

The fish fauna diversity of this early dry season study in the Amadi Creek was moderately low, in contrast with the study of Ibim and Njoku (2018), in the wet season. But it was in agreement with the late dry season study in the same creek (Ibim and Iwalehin, 2019), and in the Okpoka Creek (Davies, 2009). The difference in diversity with the study of Ibim and Njoku (2018), and the similarity to the diversity reported by Ibim and Iwalehin (2019), could be attributed to differences in season of study. The study of Ibim and Iwalehin (2019) was carried out in the dry season similar to this study, whereas the study of Ibim and Njoku (2018) was carried out in the wet season unlike this study. It was reported that, seasons are a major factor affecting species diversity, as the seasons influence directly, the fluctuation of water quality parameters, food availability, migration for reproduction (Davies, 2009; Ideriah *et al*, 2010; Ezeilo and Dune, 2012; Ibim and Douglas, 2017). However, the higher diversities exhibited by the Cichlid species with the exception of *C. zilli*, as compared to other species/families that recorded far lower diversities, was in agreement with the report of Ibim and Njoku (2018), and Ibim and Iwalehin (2019). Similar studies revealing higher Cichlid diversities were also reported in closely linked rivers in the Niger delta Basin such as, the Upper Sombrero River (Ibim and Douglas, 2016); and farther rivers (Ethiope River (Odum, 1995) River Jamieson (Ikomi and Sikoki, 1998). This could be associated with the resilience/hardiness and ability of the Cichlids species to tolerate a wide range of habitats and water quality (Pullin and Lowe-McConnell, 1982). They added that, the Cichlids are capable of tolerating salinity ranges of 0-45ppt, and can utilize a wide range of foods in the lower trophic level. The lower diversities exhibited by some species can be attributed to the low dissolved oxygen levels reported for the Amadi Creek (Agunwamba *et al*, 2006; Ideriah *et al*, 2010; Ezeilo and Dune, 2012; Elems and Ugbebor, 2018). Also, the lower diversity of the *C. zilli* unlike other Cichlids could be attributed to the high dissolved oxygen requirement (18 – 22mg/l) of this species as reported by Moelants (2010). Inter-specific or intra-specific competition, as reported among Cichlids (Winkleman *et al*., 2014), and among other species could not be ruled out for the low diversities. Also, fishing pressure have been implicated in low diversities of fishes. According to Roberts (1995), overfishing reduces diversity of fish species leading to local or global extinction.

Species Abundance

Generally, the species abundance was moderately higher than the study of Ibim and Njoku (2018) in the wet season, but in agreement with Ibim and Iwalehin (2019), in the late dry season. This slightly higher species abundance though not much, could be attributed to the effect of season/water quality as the wet season is known to record fewer species, whereas dry seasons record higher species abundance (Ibim and Douglass 2016; Ideriah *et a*l, 2010). Also, food availability in the ecosystem as recorded in dry seasons, is a reason for increased fish fauna population (Ibim and Douglas, 2016).

The higher abundance and dominance of the Cichlid species, with the exception of the *Coptodon zilli,* is in agreement with the previous studies in the creek by Ibim and Njoku (2018), and Ibim and Iwalehin (2019). However this pattern of higher Cichlid abundance did not agree with the fish abundance in the closest rivers to the Amadi Creek, the Lower Bonny (Chindah and Osuamkpe, 1994) and Okpoka Creek (Davis 2009), which reported *Sardinella maderensis* and *Mugil cephalus* to be the dominant fish species. This high abundance of the Cichlids, could be attributed to the higher tolerance rate of the Cichlids unlike the other species in aquatic ecosystem. The Cichlids were reported to be highly resilient, euryhaline, feed on a wide range of foods, and especially, lives in environments with dissolved oxygen as low 0.1ppm (Pullin and Lowe-McConnel, 1982; Awiti, 2011).

The fluctuation in abundance for some fin fish species can be attributed to fluctuations in environmental parameters in some cases (Ibim and Douglass, 2016), and in other cases to the environmental pollution encountered in the Amadi creek, leading to very poor dissolved oxygen in the environment (Ideriah *et a*l, 2010; Elems and Ugbebor, 2018).

The drop in abundance of *H. fasciatus* could be as a result of the increased salinity in the environment as the dry season progressed towards March. This is because they are generally fresh water species. However drop in abundance for other species such as *C. nigrodigitatus* and other species could be attributed to other environmental parameters, besides the increased salinity, as they were mainly brackish water species. The drop in the very rare *E.lacerta* maybe as a result of its reproductive migration (Moelants, 2010). The drop in abundance could also be associated with fishing pressure as most of these fishes were large size, high value fishes, among several other abiotic and abiotic factors. Rise in abundance of the *S. galilaeus* may have been as a result of the avoidance of this smaller species, and the fishing preference of the larger, high value species that where present only in the dry season (Ibim and Iwalehin, 2019).

Specifically, the abundance score revealed that only *Sarotherodon melanotheron*, *Sarotherodon galilaeus*, *Coptodon guineensis*, and *Hemichromis fasciatus* were dominant whereas the rest eight species including the Cichlid *Coptodon zilli,* were rare. This was in agreement with the studies of Ibim and Njoku (2018) and Ibim and Iwalehin (2019). The reason for the rarity of these species could not be identified, but it could be as a result of anthropogenic materials/activities which have led to low dissolved oxygen levels in the Amadi Creek (Agunwamba *et al*, 2006; Ideriah *et al*, 2010; Ezeilo and Dune, 2012; Elems and Ugbebor, 2018;.Ibim and Njoku, 2018; Ibim and Iwalehin, 2019), and probably poor plankton fauna for food in the polluted water(Chindah and Osuamkpe, 1994). Fishing pressure is also a key factor suspected for low abundance/rarity of many of these species, as the creek is in the middle of the densely populated Port Harcourt metropolis, and fish is a major source of protein in the Rivers State (Ibim and Francis, 2014). According to

Roberts (1995), overfishing is the result of major direct and indirect effects on the community structure of fishes. Furthermore, Olopade *et al.* (2017), stated that, overfishing has been recognized as a major threat to the sustainability of fisheries in most inland water bodies in Nigeria. Fish migration as a reproductive mechanism, can also be responsible for the rarity of these species, as reported in Froese and Pauly (2017) most of the rare species are known to exhibit migratory tendencies during reproduction. Whitehead (1990), and Moelants (2010) reported the *Elops lacerta* to reproduce in the sea, and so the young migrate to the seas, but later in their adult stages can migrate into fresh water. The caught species could have migrated into the Amadi Creek just to spawn, whereas others which were not available, could have left to spawn in inland fresh waters

CONCLUSION AND RECOMMENDATION

The early dry season fish community structure of the Amadi Creek, in similarity to the late dry season recorded a moderately low fish composition of twelve species from seven families, moderately low diversity and abundance. The families consisted of a dominant, highly diverse and abundant Cichlid species, but a low diversity and abundance Mugilidae, Claroteidae, Clupeidae, Elopidae, Haemulidae and Lutjanidae. The abundance score also revealed that besides the Cichlids (*Sarotherodon melanotheron*, *Sarotherodon galilaeus*, *Coptodon guineensis*, and *Hemichromis fasciatus,* with the exception of the *C. zilli*), were the dominant species, although they were common /few in the study. All the other species in the study area were rare. The reason for this is not known.

This study is important as a document used as reference point, in conjunction with the previous studies (Ibim and Njoku, 2018; Ibim and Iwalehin, 2019), for knowledge development on the seasonal fish community structure, for future research/ biomonitoring purposes, and for proper management and conservation of the fish population of the Creek.

It is therefore recommended that it is of urgent importance to carry out;

- A longer and more elaborate research study to uncover the true reasons for the status of the fish community structure of the Amadi-Creek.
- Regular Biomonitoring, identification of appropriate management/regulation strategies and its implementation to curb discharge of anthropogenic materials (untreated waste and industrial effluents) into the environment.
- Regular stakeholders town hall meetings and retreats to continually work together on the preservation of the fish species of the Creek to enhance fish species, environment and livelihoods sustainability as well as fish food security.

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