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Spatial distribution and occurrence of macro fauna on tidal flats of Calabar River, Niger delta region, Nigeria

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Abstract
Studies on the distribution of macro fauna on tidal flat of Calabar River was investigated at four different stations (Tinapa, Adax Petroleum, Itiat Ekpe and Esuk Nsidung). Sediments samples for macro fauna identification were collected at each station of Calabar River, twice monthly for three month (February- April, 2015) using a quadrant square of 50 by 50 cm^2 (0.25 m^2) in the exposed area and a corer of about 8 cm in diameter and 30 cm long was used in the sub-tidal area. Data obtained from the studies was calculated using biological indices such as; numerical abundance, percentage relative abundance, Margalef's index, Shannon- wiener index and Species equitability or evenness to estimate abundance and diversity of macro fauna species. A total number of 826 individual's organisms containing 28 species were encountered and identified in sediments samples using standard identification keys from the four sampling stations. The highest numbers of organisms were recorded at station 1with 318 individuals, followed by station 3 with 313 individuals and the least was station 4 with 60 individuals. Twenty-eight species belonging to four taxa were recorded. These included Mollusca with 8 species and 591 individuals which represented 71.55% of the macro fauna population. Annelida had 10 species with 81 individuals (9.81%), Crustaceans had 8 species with 146 individuals (17.68%) and Echinodermata contained 2 species and 8 individuals which represent (0.97%) of the macro fauna population. Margalef's diversity index d, ranged between 0.48 and 2.05, while Shannon-wiener index ranged between 0.93 – 2.91, and Evenness ranged between 0.28 – 0.87 indicating that the macro fauna assemblage in Calabar River were densely distributed at the 10 cm depth. The dominance of the group Mollusca in the sediments of Calabar River is understandable because these group of organisms are mainly filter feeders and can survive were other organisms cannot including poor nutrients areas. They filter water and obtain plankton and detritus or burrow through sediments, feeding on other inhabitants.

Keywords: Distribution; Occurrence; Macro Fauna; Tidal flats; Calabar River; Nigeria.

1. Introduction
Macro fauna are animals larger than 1mm and include large polychaeta worms, corals, shellfish and starfish. These organisms live on and in the bottom of sediments of the seafloor and form complex communities known as benthos. Benthic fauna include infauna animals that live in the substrate, including most burrowing worms, crustaceans and mollusks and epifauna animals that live or attached to the substrate, mostly crustaceans as well as echinoderms, mollusks, hydroids, sponges and hard and soft corals (Reis, 1983) [20].
Substrate is the single most important factor in the distribution of benthic macro fauna, although alterations in physico-chemical parameters such as temperature and salinity and food availability also play vital role in determining the extent of distribution and abundance of benthic macro fauna species in aquatic ecosystem. Macro fauna plays critical role in the functioning of estuaries and other aquatic bodies. These fauna constitute a major link in the aquatic food chain. Filter feeders in the benthic community pump large amount of water through their bodies. As the filter this water for food, they remove sediments and organic matter, cleaning the water. The remineralization of aquatic bodies by benthic organisms is another vital role exhibited by macro fauna. The remineralization of organic matter is an important source of nutrients to aquatic bodies and is critical in maintaining the high primary production in Estuaries. Macro fauna are important in the ecology of estuaries both as consumers of plankton and as food for bottom feeding fish. They provide key linkage between primary producers and higher trophic level in estuarine food chain (Schwinghamer, 1981). Polychaeta worms and shrimp-Like crustaceans contribute significantly to the diet of commercially important bottom feeding fishes, such as spot and croaker.

Amphipods are preferred food for striped bass, white clams and snakelike gastropods are often eaten by blue crabs (Schwinghamer, 1981) [21]. Most macro fauna remain within a relatively constrained area, often less than $5m^2$ for their entire adult lives. Therefore, unlike many biotic and chemical measures, benthos reflects conditions at a specific location. Many macro fauna are relatively long lived, with life span generally ranging from weeks, for some opportunistic worms to months or years for many larger taxa, leading to community structure that reflects average conditions integrated over a time period. The result of this finding is expected to compliment information on the existing data on the distribution and occurrence of macro fauna in the tidal flats of Calabar River.

2. Materials and Methods

2.1 Study Area

The study lies geographically between latitude 4º50'N and longitude 8º10'E, located in Cross river system, south eastern Nigeria. It encloses Tinapa in Odukpani local government area, Adax Petroleum in and Esuk Nsidung and Itiat Ekpe in Calabar south. The Calabar river takes its rise from the Oban hills in Akampa, Nigeria and flows southwards through the high rain forest of the south east coast of Nigeria before discharging into the Cross River Estuary at Calabar (Ewa *et al*., 2013) [10].

The climate of the area is characterized by a long wet season from April to October and dry season from November to March. Mean annual rainfall is about 2000 mm (Akpan and Offem, 1993) [2]. A short period of drought occurs in the wet season around August/September which is called the August drought. There is usually a cold dry and dusty period between December and January referred to as the harmattan season. Human activities in the area include, timber logging, fishing and sand mining (Fig 1).

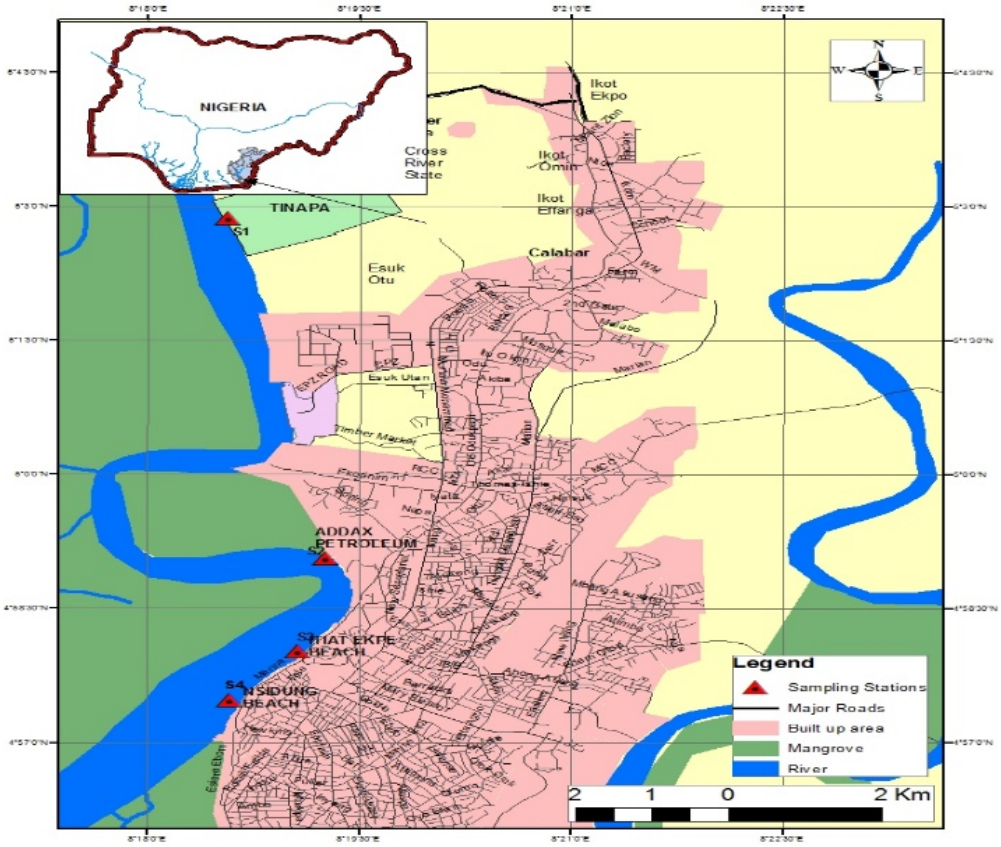

Fig 1: Map of Study Area

2.2 Sampling Stations

Four sampling stations were selected for the study namely; Tinapa (Latitude: 5^0 02' 820'' N and Longitude: 8^0 19' 16'' E), Adax petroleum (Latitude: 4^0 58' 988"N and Longitude: 8^0 16' 872"E), Itiat Ekpe Beach (Latitude: 4^0 32' 124 ''N and Longitude: 8^0 16' 872 ''E) and Esuk Nsidung Beach (Latitude: 4^0 57' 326'' N and Longitude: 8^0 18' 557'' E).

2.3 Collection of Samples

Sediments samples for macro fauna identification were collected at each station (Tinapa, Adax Petroleum, Itiat Ekpe Beach and Esuk Nsidung Beach) of Calabar River, twice monthly for three month (February- April, 2015) using a quadrant square of 50 by 50 cm^2 (0.25 m^2) in the exposed area and a corer of about 8cm in diameter and 30 cm long was used in the sub-tidal area. Four transect were established at four stations. Component sediments samples were usually taken at each site and four successful hauls formed the composite for a station. Sediments sample were extracted from 10 cm depth and usually washed with water at in-situ using a 1 mm rectangular mesh size to separate and remove debris and collect the small size in-faunal organisms. Sorted macro faunas were preserved in 4% formalin solution in well labeled containers and transported to the laboratory for identification.

2.4 Sample Analysis

In the laboratory the macro fauna's samples were washed with tap water to remove the preservative and identified to species level using taxonomic references provided by ; Edmunds (1978) and EPA (1998) and the number were counted.

2.5 Determination of biological parameters

The percentage occurrence and relative numerical abundance of benthic macro fauna was calculated using biotic indices such as Margalef's index and Shannon- wiener index to estimate abundance and diversity of species.

Numerical Abundance

After identification and sorting, the macro fauna species were counted individually. The sum of each individual macro fauna from the Calabar River was added to give numerical abundance of macro fauna from the Calabar River.

Relative abundance (%)

Relative abundance (%) of macro fauna from the Calabar River was calculated according to Ali *et al*., (2003) as follows:

$\%\ R_a = {}^{n}/_{N} \times 100$ (Ali *ET AL*., 2003).

Where: $\%_{Ra}$ = relative abundance
n = number of individuals
N = total number of all individuals.

Margalef's diversity index d was used in determining the very current ecological status of the river using the formular:

$$d = \frac{S-1}{Ln\ (N)}$$ (Margalef 1978; Ogbeibu, 2006).

Where: S = number of species in each macro fauna taxa
N = total abundance in each macro fauna taxa
ln = natural or Naperian logarithm ($\log_e$).

Shannon-wiener index was used to determine the species density of the macro fauna taxa using the formular:

$$H = \frac{N \log N - fi \log fi}{N}$$ (Shanon and Weiner, 1949; Ogbeibu, 2006).

Where H = Shannon-wiener index
N = Numerical abundance of all macro fauna taxa
fi = number of each macro fauna taxa.

Species equitability or evenness (E) (Pielou, 1966) will be determined by the equation:

Evenness (E) is given as: $E = \frac{H}{In\ S}$

Where;
H = Shannon-weiner index
S = total number of species in sample
In = natural or Naperian logarithm ($\log_e$).

2.6 Data Analysis

One-way analysis of variance (ANOVA) powered by (SPSS, version 20.0) was used to test for significant spatial variation in the distribution pattern of macro fauna in Calabar river using data collected from the four stations.

3. Results

The macro fauna species encountered in Calabar River during the study is presented in table 1. The organisms cover a wide variety of species but primarily include members from the phylum Mollusca, Annelida, Crustacean and Echinodermata. Mollusca were represented by 8 species, Annelida 10 species, Crustacean 8 species and Echinodermata represented by 2 species (Table 1). Table 2 shows the distribution of the different phylum in the four stations. The largest number of benthic macro fauna was recorded at station 1 with (318 individuals) followed by station 3 with (313 individuals), station 2 with (135 individuals) and station 4 with (60 individuals).

Twenty-eight species belonging to four taxa were recorded. These included Mollusca with 8 species and 591 individuals which represented 71.55% of the macro fauna population. Annelida had 10 species with 81 individuals (9.81%), Crustaceans had 8 species with 146 individuals (17.68%) and Echinodermata contained 2 species and 8 individuals which represent (0.97%). (Table 3, Fig 2, Fig 3).

Margalef's diversity index d, ranged between 0.48 and 2.05, while Shannon-wiener index ranged between 0.93 – 2.91, and Evenness ranged between 0.28 – 0.87 indicating that the macro fauna assemblage in Calabar River were densely distributed at the 10cm depth (Table 3).

Table 1: Species with Number of Organisms Encountered in 0.25m^2 of Sediments during the Study from the four Stations.

Taxa	Species	Station 1	Station 2	Station 3	Station 4
Mollusca	*Tympanostomus Sp.*	212	35	200	25
	Hydrobia Sp.	19	16	25	12
	Pachymelina Sp.	4	8	-	-
	Tubifax Sp.	-	2	3	-
	Terebra micans	5	-	8	-
	Thais haemostoma	-	-	10	-
	Nerita senegalensis	3	-	2	-
	Neritina rubricata	-	-	2	-
Annelida	*Aphrodite aculeate*	-	-	5	-
	Marphysa belli	2	-	3	-
	Polydora ciliata	3	2	2	-
	Scolopos armiger	4	2	5	-
	Heteromastus filiformis	6	-	2	-
	Capitella Sp.	2	3	-	-
	Notomastus filiformis	6	2	-	-
	Arenicolides cristata	-	6	9	1
	Capitella capitata	2	10	-	-

	Glycera Convulata	2	2	-	-
Crustacean	*Uca tangeri*	20	22	18	-
	Pachygrapsus gracilius	14	15	6	
	Goniopsis pellii	3	5	-	-
	Sesarma elegance	2	-	2	-
	Callianassa subterranean	-	-	3	-
	Eurydice pulchra	5	-	-	12
	Gammanus dueberic	4	-	-	3
	Squilla desmaresti	-	5	5	2
Echinodermata	*Holothuria coronate*	-	-	2	3
	Holothuria forskali	-	-	1	2
Total no of Individual/ station		314	135	313	60
Total no of species / station		19	15	20	8

Table 2: Numerical Distribution of Taxa in the Different Station during the Study

Taxa	Station 1	Station 2	Station 3	Station 4
Mollusca	243	61	250	37
Annelida	27	27	26	1
Crustacean	48	47	34	17
Echinodermata	-	-	3	5
Total no of Individual / station	318	135	313	60

Table 3: Summary of the Distribution of the Major Macro Fauna in the Calabar River, Nigeria during the Study Period.

Taxa	Numerical Abundance (n)	Number of Species (S)	(%n)	D	H	E
Mollusca	591	8	71.55	1.10	0.93	0.28
Annelida	81	10	9.81	2.05	2.73	0.82
Crustacean	146	8	17.68	1.41	2.53	0.76
Echinodermata	8	2	0.97	0.48	2.91	0.87
Total abundance (N)	826	28	100.01	5.04	9.1	2.73

4. Discussion

A total number of 826 individual organisms containing Twenty-eight species belonging to 4 taxa of macro-fauna invertebrates were recorded in the study area viz., Mollusca, Annelida, Crustacean and Echinodermata. Mollusca had 8 species and 591 individuals which represented 71.55% of the macro fauna population, Annelida had 10 species with 81 individuals (9.81%), Crustaceans had 8 species with 146 individuals (17.68%) and Echinodermata contained 2 species and 8 individuals which represent (0.97%) of the macro fauna population observed during the study. The faunal composition was highest at station 1with 318 individuals, followed by station 3 with 313 individuals and the least was station 4 with 60 individuals. The low diversity of the benthic macro-invertebrates in this study is not unusual in the Nigerian coastal environment. Umeozor (1995) [24]. Reported 23 species from New Calabar River; Hart and Zabbey (2005) [13]. reported 30 species belonging to 20 families and 5 classes in Woji Creek in the upper reaches of Bonny River in the Lower Niger Delta; while Sikoki and Zabbey (2006) [23]. Identified fourteen species representing eleven families of macro invertebrates in Imo River; Ansa (2005) [4]. Reported 28 families, 6 classes and 5 Phyla and George *ET AL*. (2010) [11]. Reported 19 species from Okpoka creek sediments. The results of the benthic macro- fauna invertebrate composition in this study are also similar to other studies of benthic macro-invertebrates from other water bodies in Nigeria. Victor and Dickson (1985) [25]. Recorded only 9 species from Ikpoba River and Edokpayi and Osimen (2001) [6]. Reported 84 species from Ibiekuma River.

Low macro benthic abundance and composition from the Lagos Lagoon was also reported by Nkwoji *et al*., (2010) [15]. The differences in species composition and abundance may be attributed to ecological differences of the different habitat locations, season of investigation, water quality alteration, substrates type and food availability as observed during the study may have affected the abundance and distribution of the macro-invertebrates communities in the study area.

The observed dominance of Mollusca contributing 71.55% of the macro fauna population in this study agrees with the report of (Emmanuel *et. al*., 2009) [8] in a tropical lagoon ecosystem, but in contrast with the findings of (Umeozor 1995; Hart and Zabbey, 2005; Eretemeijer and Swennen, 1990; George *ET AL*., 2010) [24, 13, 9 11]. Who reported Polychaetes species as the dominant group during their studies?

The observed trend that Annelida was more dominant in terms of species richness, with ten species followed by Mollusca and Crustacean with eight species each in this study is in agreement with the studies of Ombu (1987) [18]. In the Bonny River. In his report Polychaeta was the highest in species richness with 68.78% followed by Oligochaetes and Crustacean with 6.5% each. Zabbey, (2002) [26]. Also had similar results for Woji creek in the upper reaches of Bonny River. In contrast, Hart (1994) [12]. Reported the predominance of crustaceans, polychaetes, and gastropods, while Nwadiaro (1987) [16]. Recorded a dominance of crustaceans and insects followed by molluscs and annelids in a lower Niger Delta river (River Sombriero). The dominance of polychaetes in the area can be attributed to their high level of pollution-tolerance. This assertion is in agreement with the observation of Ajao and Fagade (1990) [1]. They reported that the polychaetes, capitella capitata, Nereis sp. and Polydora sp. were found associated with sites grossly polluted with

organic matter heavy metals and petroleum hydrocarbons (Ajao and Fagade, 1990) [1].

However, the numerical numbers of the individual species recorded per station in this study were low. This suggests that he mud flat of station two and four is not grossly polluted presently. The diversity of benthic macro-fauna invertebrates in the study area estimated by the Margalef, Shannon-Wienner, and Pielou Dominance indexes in the stations were generally low and compared favorably with Nkwoji *et al.* (2010) [15] who reported low values for Margalef's species richness and Shannon – Wienner diversity Index.

5. Conclusion

The distribution of benthic macro fauna in Calabar River during the study period were influenced by sediment distribution pattern, alteration in physico-chemical parameters such as temperature and salinity and probably may be also linked to the duration of study and season. The dominance of the benthos by the phylum Mollusca may be attributed to the ability of mollusk to adapt easily in various sediments types. The least abundant were the echinoderms which were restricted to only station 3 and 4. The benthic faunal distribution was also affected by the availability of food which is dominated by detrital material from the mangrove lining the fringes of the River. The study shows that the dominant fauna will be used in future to trace the paleo-ecological history of Calabar River.

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