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Nipa Palm (*Nypa fruticans* Wurmb) and the Intertidal Epibenthic Macrofauna East of the Imo River Estuary, Nigeria

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Abstract: The Niger Delta mangrove ecosystem has been under stress for about a century now, following the introduction, establishment and spread of an Indo-Pacific mangrove palm, *Nypa fruticans* (Wurmb) among other factors. The impact of this palm has been pronounced on the native mangrove macrophytes (including *Rhizophora* spp.) eliminating them in the wake of its establishment and spread. Its impact on intertidal epibenthic macrofauna has been a matter for speculation, with the claim that it has adversely affected populations of these fauna (among other negative effects) in its areas of occurrence. This paper summarizedd aspects of a field study which indicates that the palm does not adversely affect epibenthic faunal species richness in its areas of occurrence. Rather, it increases species richness through habitat heterogeneity. More studies are needed to provide a holistic spectrum of relationships between *Nypa fruticans* and intertidal mangrove fauna of the Niger Delta.

Key words: *Nypa fruticans* · Intertidal Epibenthos · Niger Delta · Nigeria

INTRODUCTION

The mangrove forest ecosystem of Nigeria has been under stress for about one century now, due significantly to the impact of an invasive mangrove palm, *Nypa fruticans* Wurmb (Arecaceae: Palmae). This impact has been described by King and Udo [1] as "aggressive vegetational succession involving, the replacement of the dominant native mangrove macrophytes". This impact is pervasive, spanning most of the Niger Delta Estuaries, including those of the Cross, Qua Iboe and Imo Rivers. The few remaining areas of pure native mangrove macrophytes still have sprinklings of nipa palm. *Nypa fruticans*, an Indo-Pacific mangrove palm, is reported to have been introduced into Calabar in 1906 [2] and later to Oron, from the Singapore Botanical Gardens, ostensibly to stabilize creek margins against erosion. This lofty goal has not been met as shall be made clear shortly. Earlier reports had noted [3] that Nipa Palm offers no benefits to the Nigerian society when compared to the indigenous mangrove plant species. This assertion is premised on numerous suppositions, among which are that: (i) it has thick, hard leaves which do not easily fall off and decompose as fast as native mangrove plant leaves and therefore, does not have the advantageous fertilizing effect as the indigenous mangrove plants that contribute high detritus to the sediment; (ii) when dislodged by wave-wash or other factors, a substantial part of the substratum is lost with it, which is antithetical to the reasons for its introduction previously stated; and (iii) floating "forests" of dislodged Nipa and the "sea" of Nipa fruits in spring tides are a nuisance to water navigation.

It is an established biological fact that the introduction of exotic species into an alien environment often causes shifts in species composition of the receiving environment. The effect of this invasive species on the native mangrove macrophyte species is easily discernible. As soon as this plant got firmly established in this new habitat, it spread mostly along sheltered creeks of the Nigerian coastal waters (with prolific powers of reproduction and aggressive growth and expansion), replacing native mangrove species and other plant species in large areas. However, its effect(s) on the animal community of the mangrove ecosystem (especially the intertidal macrobenthos) remain largely unknown. This study therefore, is a seminal field study aimed to determine whether Nipa Palm has adverse effects on the intertidal macrobenthic faunal populations in the chosen areas of study, especially on species richness and community structures of the populations of species present.

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This study was aimed at investigating the impacts of the invasive species, *Nypa fruticans* on the intertidal epibenthic fauna species richness of the Imo River Estuary area.

MATERIALS AND METHODS

Study Area: The study was carried out between December 2000 and November, 2002 in Eastern Obolo Local Government Area, located between latitudes 4°28' and 4°33' North and longitudes 7°30' and 7°50' East (Fig.1). It situates within the Imo River deltaic formation and has a total land area of c.a. 117.008km^2. Its shoreline stretches between the estuaries of the Imo and Qua Iboe Rivers, covering a distance of about 84km [4]. The swamps are characterized by daily tidal flooding, impaired draining in basin wetlands, a long rainy season and an organic substrate associated with high acid conditions [5]. According to Ibe and Antia [6], the development of large tracts of swamps in this and adjacent areas is aided by a low wave energy which enhances depositional processes. However, the wave energy in this area is not as low as claimed by the above authors. This is because the higher energy waves at the "Lagos" fishing port (opposite Down Below) at Obianga have drowned several metres of the supralittoral and epilittoral zones in this area, leading to loss of several metres of land and many houses and vegetation. The Imo River Estuary and its environs share the climatic conditions that prevail in the rain forest zone of southern Nigeria where the weather is permanently wet with an annual rainfall of up to 4000 mm distributed throughout the year. Samplings were carried out in three floristically different swamps so as to ensure realization of the aim of the studies. These swamps were the three sampling stations described hereunder and shown in Fig. 1.

Kampa: (This village 7°42' E; 4°32'N) is located in the central portion of Eastern Obolo relatively far from the Atlantic Ocean (Fig.1). Here there are fairly large areas of swamp vegetation dominated by luxuriant native mangrove (*Rhizophora* spp.), with a sprinkling of Nipa Palms. The station is well sheltered from the Atlantic waves and was regarded as the "non-impacted zone" with reference to this study. Two distinct zones of sediment, clayey silt along the fringes of creeks and peaty fibrous mud (chikoko) at the back swamps were observed.

Emereoke: This island (7°40' E; 4°31'N) is close to the Atlantic, with the Okwan Obolo estuary being the major outlet draining its catchments area. The sampling locations were along sheltered creeks north of the island (Fig. 1). Many portions of the mangrove swamps vegetation consist of a mixture of native mangrove species with Nipa Palm in varying densities. This station was regarded as the "partially-impacted zone" and has the same sediment zones as at Kampa.

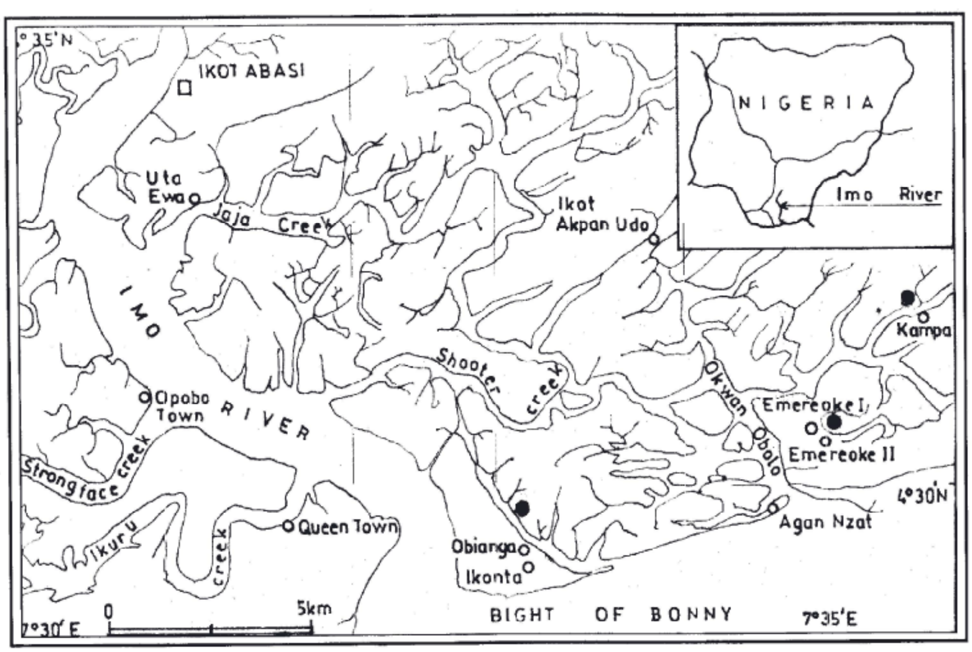

Fig. 1: Parts of the Coastal Basin of Imo River showing sampling sites, with closed cirsles. Inset: Map of Nigeria showing the position of Imo River

Obiang: Gthis is an island on the south-western tip of Eastern Obolo, located between 7°37'; 4°29'N, bounded by the Imo River on the west and the Atlantic Ocean on the south. Native mangrove macrophyte species have been completely eliminated from these swamps, with only few seedlings occurring in patches beneath dense canopies of luxuriant Nipa leaves carried by huge tussocks of the palm. These palms extend more than 60m into the swamps and accessibility was difficult until transects were cut. This station was designated the "impacted zone", also having the two distinct soil zones.

Since the mangrove ecosystem is a multidimensional ecosystem, the organisms could be found on the sediment surface, in the sediment, on physical substrates other than the sediment and in the water during flow tide. Different sampling methods were employed. Some surface dwelling decapod crustaceans (*Goniopsis, Uca, Cardisoma* and *Sesarma* species) and the mudskipper, *Periophthalmus* were sampled with two types of traps: unbaited conical valved basket traps (length 42 – 50cm; diameter of opening 14-17 cm; mesh size 0.2 – 0.5cm) and 2.5litre plastic bottles with screw caps. These were set as soon as the water receded form the swamps and inspected just before the next flow tide. The method of zoning trees vertically above ground level [7] was used to sample the mangrove oyster *Crassostrea gasar*.

Thais and *Littorina* species were sampled within 5 x $5m^2$ land quadrats. This same method was used to sample *Semifusus, Panopeus* and Menhippe species. Other species: *Clibernarius, Bostrychus*, *Melampus, Neritina, Penaeus, Callinectes* and *Tympanotonus*, were sampled with the use of $0.5m^2$ metal quadrats. Samples were washed and placed in appropriately labeled containers in the field, preserved in 10% formalin using clean estuarine water and transported to the laboratory where identification and measurements were carried out within one month of collection.

The species community analysis was done using the Shannon-Weiner's Index for species Dominance and Similarity and Margalef's Index for species richness. The non-parametric Kruskal-Wallis method was used to test the mean density and biomass of the different species while the Pearson correlation coefficient was used to determine the spatial and temporal distribution of the organisms at the different stations.

RESULTS

Species Composition: A minimum of 15 species distributed among 12 genera and 11 families were recorded at station 1 (*Rhizophora* swamp); 14 species from 11 genera and 10m families at station 2 (mixed macrophytes swamp) and 23 species from 18 genera and 16 families at station 3 (*Nypa* swamp) (Table 1). Station 3 had eight species (34.78%) more than station 1 and nine species (39.13%) more than station 2. The family Muricidae was the most diversified, with 13.0% contribution to the total species richness. This was followed by the Diogenidae, Grapsidae, Penaeidae, Portunidae and Xanthidae with 8.7% contribution each. The remaining families were monotypic, with 4.3% contribution each. The most diversified genus was *Thais*, with 3 species, gfollowed by the genera *Penaeus, Clibernarius* and *Callinectes*, with 2 species each, while each of the remaining genera consisted of a single species.

Major Taxa Composition: Higher taxa assessment produced four groups namely, Decapoda, Pisces, Bivalvia and Gastropoda. A consistent hierarchical trend in abundance was exhibited in all stations, with the gastropoda being the most abundant, followed by the decapoda, the bivalvia and lastly the Pisces (Fig. 2: a-c). Higher taxa assessment on species basis produced a profile different from the numerical assessment (Fig. 2: d-f). The decapoda constituted 52.2% with twelve species, followed by the gastropoda with 34.8% from eight species. The Pisces contributed two species with 8.7% while 4.3% came from the monotypic bivalvia.

Community Structure: The macrobenthic community structure which was assessed through various mathematical indices, are shown in Tables 2 and 3. The Shannon-Weiner diversity index assessment (Table 2) shows that station 3 (*Nypa* swamp) had a slightly higher diversity than stations 2 and 1 in that order. However, statistical analysis showed that there were no significant differences between the stations in paired comparisons ($t = 0.356$; df 1; $p>0.05$ between stations 1 and 2; $t = 0.609$; df 1, $p>0.05$ between stations 2 and 3 and $t = 0.852$; df 1, $p>0.05$ between stations 1and 3). Thus, diversity was even between the stations. Evenness (or equitability) which measures the apportionment of individuals among the species, was highest at station 2 (mixed macrophyte swamp), followed by station 1 (Rhizopora swamp),

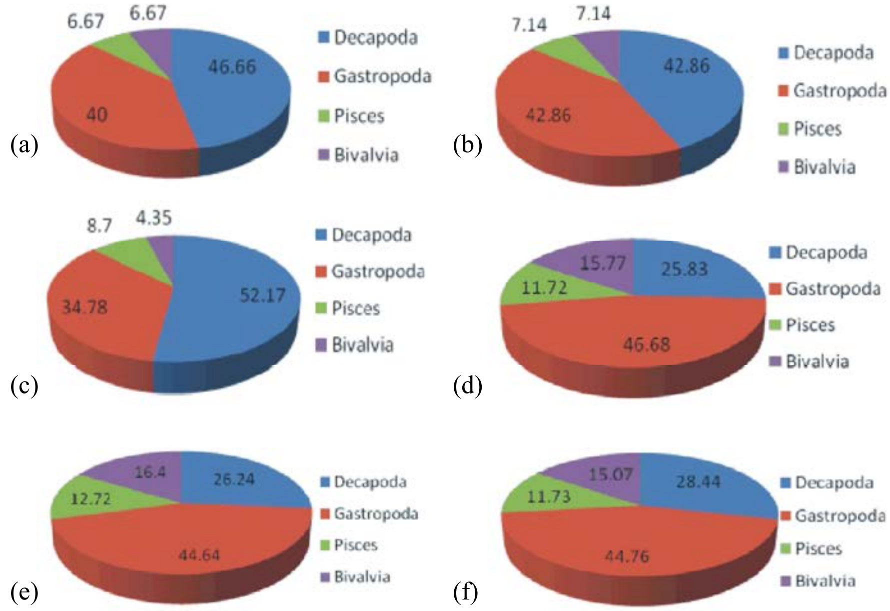

Fig. 2: Percentage composition of higher taxa of the epibenthic macrofauna from the three stations

Table 1: Check-list of the macrobenthic fauna of the three stations from the two years sampling (December 2000 – November 2002)

	First Year			Second Year		
Family/species	1	2	3	1	2	3 *
Diogenidae						
Clibernarius chapini	+	+	+	+	+	+
Clibernarius senegalensis	+	+	+	+	+	+
Eleotridae						
Bostrychus africanus	0	0	+	0	0	0
Ellobiidae						
Melampus liberianus	0	0	+	0	0	0
Galeodidae						
Semifusus morio	+	+	+	+	+	+
Gecarcinidae						
Cardisoma armatum	+	0	+	0	0	0
Gobiidae						
Periophthalmus barbarus	+	+	+	+	+	+
Grapsidae						
Goniopsis pelii	0	+	+	+	+	+
Sesarma elegans	+	0	+	0	0	0
Littorinidae						
Littorina angulifera	+	+	+	+	+	+
Muricidae						
Thais callifera	+	+	+	+	+	+
Thais coronate	+	+	+	+	+	+
Thais haemastoma	+	+	+	+	+	+
Neritidae						
Neritina glabrata	0	0	+	0	0	0
Ocypodidae						
Uca tangeri	+	+	+	+	+	+
Osteidae						
Crassostrea gasar	+	+	+	+	+	+

Table 1: Check-list of the macrobenthic fauna of the three stations from the two years sampling (December 2000 – November 2002)

	First Year			Second Year		
Family/species	1	2	3	1	2	3 *
Penaeidae						
Penaeus notialis	0	0	+	0	0	0
Penaeus kerathurus	0	0	+	0	0	0
Portunidae						
Callinectes amnicola	0	0	+	0	0	0
Callinectes pallidus	0	0	+	0	0	0
Potamididae						
Tympanotonus fuscata var. radula	+	+	+	+	+	+
Xanthidae						
Menhippe nodifrons	+	+	+	+	+	+
Panopeus africanus	+	+	+	+	+	+
No. Species	15	14	23	14	14	14
No. Genera	12	11	18	11	11	11
No. families	11	9	16	10	10	10

*=Stations

Table 2: Mean (±SD) epibenthic macrofauna diversity and evenness indices

Station	Species richness	Diversity H'	Evenness E
1.	15	2.1981±0.0429	0.6228±0.0571
2.	14	2.2277±0.1081	0.6883±0.,0383
3.	23	2.3015±0.1660	0.5614±0.1033
Pooled	23	2.2598±0.0606	0.5452±0.1562

Table 3: Mean epibenthic macrofauna similarity/dissimilarity and dominance indices

Station pair	No. species common	Similarity	Dissimilarity	Station	Dominance	% dominance
1 & 2	14	0.9643	0.0357			
				1	0.1254	12.54
1 & 3	15	0.8947	0.1053			
				2	0.1158	11.58
2 & 3	14	0.8611	0.1389			
				3	0.1214	12.14
				Pooled	0.1229	12.29

Table 4: Results of Kruskal – Wallis Test on mean densities of the species common to all stations

	Station/Density			P*
Species	1	2	3	K-W test
Clibernarius senegalensis	1.59	1.87	4.67	13.129 p< 0.05
Periophthalmus barbarous	17.46	21.57	25.53	13.149 p<0.05
Goniopsis pelii	13.27	11.42	9.64	16.351 p <0.01
Littorina angulifera	16.45	16.82	15.32	Ns
Thais callifera	5.72	6.24	4.65	Ns
Thais coronata	4.81	3.87	4.19	Ns
Thais haemastoma	4.96	4.43	4.54	Ns
Uca tangeri	19.37	22.89	24.98	19.148 p<0.001
Crassostrea gasar	110.1	130.0	178.0	22.519 p<0.001
Tympanotonus fuscata var. *radula*	45.07	46.05	58.74	15.191 P<0.001
				d-test
Clibernarius chapini	0.5	0.37	0.81	1&2; 2&3; 1&3; ns
Semifusus morio	0.08	0.11	0.66	1&3; 2&3; p<0.01 1&2; ns
Cardisoma armatum	0.023	-	0.03	Ns
Menhippe nodifrons	0.12	0.05	0.19	1&3; 1&2 ns 2&3; p<0.05
Panopeus africanus	0.19	0.34	0.66	1&2; 2&3; ns 1&3; p<0.05

*P = level of significance of difference between stations, K – W = Kruskal Wallis

ns = not significant

while station 3 (Nypa swamp) displayed the least equitable apportionment of individuals among the species. Similarity (overlap) values (Table 3) showed high values, indicating high similarity in species composition between the stations pairs. Dissimilarity was very low between stations 1 and 2 (0.0357 or 3.57%) but relatively higher between stations 1 and 3 (0.1053 or 10.35%) and stations 2 and 3 (0.1389 or 13.89%). Dominance values were relatively low and very close among stations, with no statistically significant differences between them (d = 1.811, p>0.05 between stations 1 and 2; 0.667, p>0.05 between stations 1 and 3 and 0.691, p>0.05 between stations 2 and 3).

Faunal Densities: Mean densities of species common to all stations are shown in Table 4. Low densities of the hermit crabs *Clibernarius chapini* and *C. senegalensis* and the giant hairy melongena, *Semifusus morio*, the stone crab *Menhippe nodifrons* and the African mud crab *Panopeus africanus*, were recorded. The mangrove oyster, *Crassostrea gasar*, had the highest densities in all stations, with station 3 having highest values when compared to other stations. The purple mangrove crab *Goniopsis pelii*, was the only animal whose densities at stations 1 and 2 were higher than those at station 3. The periwinkle *Littorina angulifera* was the only species that showed significant temporal variation in density (chi-square = 36.57, p>0.0091, df 11) with the highest mean density occurring in March (18.02/m^2±1.299 and the lowest in December (14.84/m^2±2.375). Estimated mean densities were used to determine the pattern of spatial distribution of the species in the three stations as shown in Table 5. In all stations most species were distributed regularly (13 species: 86.6% at station1), 11 species (78.6%) at station 2 and 17 species (73.9%) at station 3. One species each was distributed in clumped and random patterns (6.7% each) at station. At station 2, 2 species (14.3%) were dispersed randomly and one species (7.1%) distributed in clumped pattern. At station 3, five species (21.7%) had clumped pattern of distribution, with one species distributed randomly.

Associations Between Plants and Animals: Tables 6-8 show the intensities of association between vegetation type and animal densities at the three stations. Table 6 columns 1 and 2 show the intensity of association of each species of animal with *Rhizophora* spp. at station 1. Only *Thais haemastoma* indicated a significant inverse association with *Rhizophora* spp (r = 0.826, p<0.05).

Table 5: Mean densities and spatial distribution patterns of the macrobenthos

	Station 1			Station 2			Station 3		
Species	Mean	Variance	Distribution	Mean	Variance	Distribution	Mean	Variance	Distribution
Clibernarius chapini	0.5	0.202	Regular	0.37	0.096	Regular	0.81	0.372	Regular
Clibernarius senegalensis	1.59	0.865	Regular	1.87	1.346	Regular	4.67	7.129	Clumped
Bostrychus africanus	-	-	-	-	-	-	0.05	0.006	Regular
Melampus liberianus	-	-	-	-	-	-	0.87	3.842	Clumped
Semifusus morio	0.08	0.017	Regular	0.11	0.032	Regular	0.66	0.36	Regular
Cardisoma armatum	0.025	0.002	Regular	-	-	-	0.03	0.012	Regular
Periophthalmus barbarus	17.48	9.548	Regular	21.57	14.669	Regular	25.53	9.486	Regular
Goniopsis pelii	13.27	2.161	Regular	11.42	3.459	Regular	9.64	2.624	Regular
Sesarma elegans	-	-	-	-	-	-	0.008	0.0009	Regular
Littorina angulifera	16.45	8.066	Regular	16.82	8.585	Regular	15.32	5.76	Regular
Thais callifera	5.72	3.96	Regular	6.24	7.129	Random	4.65	4.121	Regular
Thais coronata	4.81	5.198	Random	3.87	2.161	Regular	4.19	2.958	Regular
Thais haemastoma	4.96	2.822	Regular	4.43	2.756	Regular	4.54	6.35	Clumped
Neritina glabrata	-	-		-	-	-	0.7	2.102	Clumped
Uca tangeri	19.37	1.416	Regular	22.89	7.562	Regular	24.98	11.834	Regular
Crassostrea gasar	110.1	469.59	Clumped	130	445.21	Clumped	178	996.66	Clumped
Penaeus notialis	-	-	-	-	-	-	0.03	0.008	Regular
Penaeus kerathurus	-	-	-	-	-	-	0.0008	0.000006	Regular
Callinectes amnicola	-	-	-	-	-	-	0.017	0.004	Regular
Callinectes pallidus	-	-	-	-	-	-	0.017	0.004	Regular
Tympanotonus fuscata	45.07	14.364	Regular	46.05	54.317	Random	58.74	71.572	Random
Menhippe nodifrons	0.118	0.032	Regular	0.05	0.01	Regular	0.19	0.058	Regular
Panopeus africanus	0.19	0.073	Regular	0.34	0.096	Regular	0.66	0.449	Regular

Table 6: Correlation matrix showing the intensity of association between *Rhizophora* spp. Densities and animal species densities (columns 1 and 2) at station 1

	Y	CC	CS	SM	CA	PB	GP	LA	TCA	TCO	TH	UT	CG	TF	MN	PA
Y	1.000															
CC	0.295	1.000														
CS	-0.548	-0.199	1.000													
SM	0.111	0.323	-0.720	1.000												
CA	-0.126	0.253	0.111	-0.273	1.000											
PB	-0.753	-0.428	-0.82	0.312	-0.123	1.000										
GP	0.666	0.087	-0.591	0.461	0.084	-0.401	1.000									
LA	0.430	-0.151	-0.336	0.136	-0.860*	-0.052	-0.066	1.000								
TCA	0.103	-0.169	0.315	-0.763	0.738	-0.371	0.011	-0.488	1.000							
TCO	0.487	0.312	-0.079	-0.083	-0.608	-0.417	-0.234	0.810	-0.309	1.000						
TH	-0.826*	-0.125	0.623	-0.352	0.631	0.402	-0.465	-0.822*	0.387	-0.692	1.000					
UT	-0.154	0.064	0.009	-0.300	0.955**	0.044	0.021	-0.746	0.769	-0.617	0.599	1.000				
CG	0.678	-0.077	-0.548	0.353	0.021	-0.398	0.982**	0.010	0.072	-0.216	-0.495	-0.010	1.000			
TF	0.785	0.478	-0.799	0.401	0.293	-0.436	0.724	0.031	0.133	0.070	-0.521	0.285	0.660	1.000		
MN	-0.117	-0.275	0.636	-0.925**	0.583	-0.314	-0.247	-0.452	0.927**	-0.236	0.514	-0.590	-0.166	-0.255	1.000	
PA	0.444	0.740	-0.574	0.747	-0.349	-2.07	0.302	0.369	-0.692	0.492	-0.604	-0.462	0.176	0.498	-0.809	1.000

*Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

CC = *Clibernarius chapini*; CS = *Clibernarius senegalensis*; SM = *Semifusus morio*; CA = *Cardisoma armatum*; PB = *Periophthalmus barbarus*; GP = *Goniopsis pelii*; LA = *Littorina angulifera*, TCA = *Thais callifera*; TCO – *Thais coronata*; TH = *Thais haemastoma*; UT = *Uca tangeri;* CG = *Crassostrea gasar*, TF = *Tympanotonus fuscata*; MN = *Menhippe nodifrons*, PA = *Panopeus africanus*

Table 7: Correlation matrix showing the intensity of associations between mixed macrophytes vegetation densities and animal densities (columns 1 and 2) at station 2

	Y	CC	CS	PB	GP	SM	LA	TCA	TCO	TH	UT	CG	TF	MN	PA
Y	1.000														
CC	-0.495	1.000													
CS	-0.450	-0.401	1.000												
PB	-0.460	0.064	-0.075	1.000											
GP	0.018	-0.163	0.371	-0.402	1.000										
SM	-0.069	0.493	-0.732	0.293	-0.873*	1.000									
LA	0.085	-0.429	0.187	-0.016	-0.659	-0.652	1.000								
TCA	0.012	0.047	-0.029	-0.084	-0.865*	-0.590	-0.412	1.000							
TCO	-0.329	0.119	0.597	-0.319	-0.021	-0.160	0.610	-0.412	1.000						
TH	-0.032	-0.479	0.204	0.051	0.262	-0.398	0.864*	0.270	0.585	1.000					
UT	-0.513	0.203	0.408	0.135	0.715	-0.641	0.345	0.751	0.141	0.056	1.000				
CG	0.471	0.492	-0.868*	-0.266	-0.415	0.757	-0.473	-0.194	-0.210	-0.441	-0.522	1.000			
TF	0.271	-0.691	0.651	-0.526	0.102	-0.459	0.035	-0.371	0.493	-0.203	0.285	0.396	1.000		
MN	0.127	0.288	-0.178	-0.178	0.719	-0.310	0.484	0.930**	-0.430	0.048	-0.607	-0.170	-0.540	1.000	
PA	0.084	-0.281	0.229	0.003	-0.704	0.355	-0.654	-0.946**	0.540	-0.292	-0.653	0.016	0.580	-0.943*	1.000

*Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

CC = *Clibernarius chapini*; CS = *Clibernarius senegalensis*; SM = *Semifusus morio*; PB = *Periophthalmus barbarus*; GP = *Goniopsis pelii*; LA = *Littorina angulifera*, TCA = *Thais callifera*; TCO – *Thais coronata*; TH = *Thais haemastoma*; UT = *Uca tangeri;* CG = *Crassostrea gasar*, TF = *Tympanotonus fuscata*; MN = *Menhippe nodifrons*, PA = *Panopeus africanus*

Table 8: Intensity of association between *Nypa fruticans* densities and animal densities at station 3

	Plant Species
Animal Species	Y1
Clibernarius chapini	0.683
Clibernarius senegalensis	-0.526
Bostrychus africanus	0.682
Melampus liberianus	-0.03
Semifusus morio	-0.092
Cardisoma armatum	-0.038
Periophthalmus barbarus	-0.352
Goniopsis pelii	-0.655
Sesarma elegans	0.359
Littorina angulifera	-0.285
Thais callifera	0.018
Thais coronata	0.295
Thais haemastoma	0.912*
Neritina glabrata	-0.006
Uca tangeri	0.541
Crassostrea gasar	0.880*
Penaeus notialis	0.878*
Penaeus kerathurus	0.878*
Callinectes amnicola	0.078
Callinectes pallidus	-0.359
Tympanotonus fuscata	-0.112
Menhippe nodifrons	0.23
Panopeus africanus	-0.027

*Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

At station 2, of the 14 associations, none was statistically significant (Table 7 columns 1 and 2). At station 3(table 8) four species of animals showed significant positive associations with *Nypa fruticans*. These were *Thais haemastoma* (= 0.912, p. <0.05). *Crassostrea gasar* (r=0.878, p. 0.05), *Penaeus kerathurus* and *Penaeus notialis* (r =- 0.878, p <0.05 in each case). Other statistical associations were statistically insignificant.

DISCUSSION

The macrobenthic fauna of the study areas have been grouped into two categories viz: permanent members and members that move in and out with the tides (itinerant or non-permanent members). Five species namely, *Penaeus kerathurus, P. notialis, Callinectes amnicola, C. pallidus* and *Cardisoma armatum* are non-permanent members of these saline wetlands. The permanent (resident) species constituted 82.61% of the swamp fauna.

The closeness of station 3 to the mouths of the Imo River and the Ebon Okwan Obianga ensures ready access of non-permanent species into the swamps during flow tides and increased species richness as against stations 1 and 2 which are farther away from the mouths of rivers having direct links with the Atlantic Ocean. However, *Cardisoma armatum* is not a tide-dependent immigrant but occupies the relatively drier supralittoral fringes from where it makes periodic incursions into the swamps. The structure of nipa palm (*Nypa fruticans*) provides numerous microhabitats for species to hide and so escape predators. During the field phase of this study some crab species sought refuge in the axils of this palm at ebb tide whenever they missed their holes during my intrusions. The African mud crab *Panopeus africanus*, the stone crab *Menhippe nodifrons* and the giant hairy *melongena Semifusus morio*, seem to use these microhabitats as their permanent abodes, though *Semifusus* occurred more in depressions around the bases of these plants. Moreover, *Nypa* leaf bases provide larger surface areas for encrustation by the tree fauna, especially *Crassostrea* and *Thais* spp. This habitat heterogeneity may then explain highest abundance of species and individuals in station 3 and higher abundance of individuals in station 2 than station 1, thereby negating the popular claim that this invasive palm has negatively affected species richness in these mangrove wetlands [1, 3]. Paradoxically, King and Udo [1] reported no significant difference in mean conditions (relative well-being) of populations of *Periophthalmus barbarus* in the *Nypa* and *Rhizophora* swamps of the Imo River Estuary. Etukudo [8] and Ubom [9] have listed the economic benefits derivable from commercial utilization of this plant, stating that the leaves, fruits and rhizomes could all be used industrially to produce valuable items for the home and industries as well.

The gastropod mollusks are major players in the ecology of these swamps and some are of commercial value. For example, the winkle *Tympanotonus fuscata* var *radula* was the most dominant gastropod in all stations and it is of commercial importance. Fishing pressure on this species does not seem to adversely affect the stocks especially at station 3 where accessibility into the back swamps is difficult. The periwinkle *Littorina angulifera* are not collected for consumption and if at all collected for food, very few people do. *Neritina glabrata* and *Melampus liberianus* are very tiny snails with no food value. *Semifusus morio* is not common but is a highly priced delicacy, along with *Thais* spp. These species are actively sought for and collected for subsistence and minimal sales, since available stocks do not support large-scale commercialization.

The numerical dominance by gastropods in all stations agrees with the report of Ajao and Fagade [10] in Lagos Lagoon where more gastropods were obtained, but is at variance with the findings of Chukwu and Nwankwo [11] in which low abundance was recorded from Porto Novo Creek also in Lagos. This was attributed to stress imposed by land-based pollutants (effluents) as well as substrate instability. However, Powell [12] reported that among the benthic fauna at Funiwa (during the Funiwa – 5 Blowout oil spill of 1980), gastropods and the wood-boring bivalves (the shipworm *Psiloteredo*) survived the spill even in the worst hit areas. According to Egborge [13] intertidal molluscan fauna of Nigeria in the Niger Delta segment are apparently threatened by industrial pollution. The large number of decapod crustacean *species* in these swamps agrees with the report of Swennen, *et al*. [14] that the macrobenthos of the intertidal mudflats of the Surinam coast of South America was dominated by crustaceans. Apart from *Callinectes* species and *Cardisoma armatum* which are accepted for food, most of the people of Eastern Obolo do not eat *Uca tangeri* or *Goniopsis pelii*, or the other crabs. However, Ibibio women from adjoining villages hunt for *Goniopsis* at night and always spend the whole night in the swamps during such hunting trips, selling them in their markets the following day.

Periophthalmus barbarus was the more conspicuous of the two piscine representatives in these swamps. It is eaten by both the Andonis and their Ibibio neighbours. Teenage boys are adept at hunting this species and often move in groups of 3 or more, with gourd containers hung on their shoulders. These intense hunting pressures have led to reductions in the number and size of individuals. At the Oron area where this species is not eaten, individuals over 20cm in length are very common. The monotypic littoral bivalvia, *Crassostrea gasar*, is very conspicuous and abundant. It is the most patronized of the littoral fauna of these areas, but harvesting is tedious, time consuming and dangerous. Although the rate of renewal of stocks of *C. gasar* may not catch up with the rate of harvesting, it nevertheless is abundant; the threat to its abundance may well be the increasing rate of deforestation which could further reduce the number of suitable substrates available for encrustation and further development to harvestable size.

Taxa richness increased at Station 3 relative to other stations due to habitat heterogeneity, larger surface area for encrustation by tree fauna and tide-dependent immigrations. Perturbation is believed to alter the biodiversity of an ecosystem from the polydiverse toward the oligodiverse range [15], by reducing spatial heterogeneity which translates to reduced microhabitats, microclimates and places to hide from predators [16] thus impacting negatively on biotic integrity [17]. The high similarity in species composition between the three stations suggests that in addition to climatic conditions, they share the same sediment types acceptable to all mud-dwelling species. The lack of any marked differences in sediments characteristics between the stations [18] corroborates this stance. The adaptability of the tree fauna to encrustation on Nipa Palm surfaces overrides any shifts in animal species composition of the swamps that would have arisen with the introduction, establishment and spread of the invasive mangrove palm, *Nypa fruticans*. Thus, biotic pollution by this species apparently affects plants and does not appear to affect the epibenthic macrofauna adversely. Whether it affects fin fishes of commercial importance that may be using these swamps as nursery grounds has yet to be ascertained.

Generally, the species occurred in lower densities in station 1 relative to the other stations except for a few species. This could be related to factors such as distance from the coast and exploitation pressure on edible species. Nevertheless, densities of such species as *Tympanotonus fuscata, Crassostrea gasar, Periophthalmus barbarus, Goniopsis pelii, Littorina angulifera* and *Uca tangeri* were high. Ekweozor, *et al*. [19] reported baseline densities of 10 and 18 crabs/m^2 at Port Harcourt: 5/m^2 at Okrika, while at Ford Point it was 32/m^2 and less than 5/m^2 at Bonny for the fiddler crab *Uca tangeri*. Results of the present study, measured per 0.5m^2 gave higher density values for the fiddler crab in all the stations over those reported by the above authors. Highest densities of most of the species at station 3 relative to other stations is at variance with notions of a deleterious effect of *Nypa* (the dominant vegetation here) on these mangrove fauna. Molles [20] points out that ocean tides and river flow drive the complex currents in estuaries and are at the heart of the ecological processes of any estuary because among other functions, they also facilitate transport of organisms. These indeed may explain the apparent distance-related differences in faunal densities from this study.

Odum [21] stated that random distribution pattern is relatively rare in nature and would occur where the environment is very uniform in the absence of a tendency to aggregate, citing the mudflat ecosystem as example. The rarity of random distribution of species in the present study agrees with this claim except the underlying factor of environmental homogeneity. Although the sediments of the three swamps were significantly homogeneous in attributes analyzed [18] the floristic components were very different, introducing heterogeneity. Jackson [22] reported age-specific distribution of the clam *Gemma gemma* on an intertidal mudflat, where second year individuals were randomly distributed but not the first year individuals, nor the total population of *Gemma* which were clumped because of the ovoviviparous reproduction. The predominance of the regular pattern of dispersion could not be attributed to the influence of *Nypa fruticans* (station 3) since the epibenthos at Station 1 (*Rhizophora* swamp) and station 2 (mixed macrophytes swamp) also showed predominantly regular pattern of dispersion. A wide variety of animals are known to produce pheromones which affect the behavior of others. Philips [23] pointed out that while organisms are capable of receiving signals from their environment, they are also capable of emitting them, adding that many animals that are found to be gregariously distributed, possess either spontaneous, or chemically-mediated behavioural mechanisms (or a combination of both) which bring about and maintain the spatial organisation and distribution of the population. Similar mechanisms, he stressed, exist in uniformly dispersed animals.

The inverse relationship between *Thais haemastoma* and *Rhizophora* species (indicating its sensitivity to the plant) is somewhat surprising since the species were collected mostly from *Rhizophora* prop roots in the non-impacted and partially-impacted swamps. However, [24] has shown that *T. haemastoma* tended to occur most at station 3. Perhaps its sensitivity to the plant led to its low numbers at station 1. The unavailability of historical data on these dog whelks does not enable us ascertain whether this species is native to these swamps or is an invasive species. The absence of any significant association between the macrofauna and the mixed macrophytes species at station 2 is difficult to explain, but may be related to what Odum [21] calls "variety of chemical accommodations" which are part of the basis of high species diversity of an ecosystem. At station 3, a 1.0:1.01 positive inverse ratio which was not significantly different from unity emerged, indicating a balancing of negative and positive influences. However, the occurrence of 4 significant positive relations and no significant negative relationships indicated more positive relationships than negative ones, suggesting further that *Nypa fruticans* has no deleterious effects on the intertidal epibenthic macrofauna, contrary to the widely held view that it does.

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