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Species Diversity and Regeneration Potential of Some Mixed Mangrove Forests in Escravos Communities Delta State Nigeria

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ABSTRACT

Mangrove forests are among the most productive ecosystems in the world. Regrettably, this resource is threatened by natural and anthropogenic factors. The failure rate of most restoration programs worldwide underpins the need to determine factors inhibiting natural mangrove regeneration. Paucity of such data in Nigerian mangroves justifies the need for this study. The research recorded 50 woody species across 31 families. *Elaesis guineensis* and *Nypa fructicans* are the most abundant species while *Pterygota macrophylla* and *Grewia auriculata* are the least abundant species. Species diversity was observed to vary between 20 (plot 7) to 28 (plot 2) with an average of 25 species per transect. Shannon and equitability indices had values ranging between 2.85 (plot 7) and 3, 25 (plot 2) and 0.95-0.98, respectively. The Regeneration Potential (RP) for each species was recorded. The average regeneration potential of 64.48% along transect 3 was the highest while that of 42.43% for transect 4 was the lowest.. A total of fourteen species had RP of at least 60% while 5 species had RP less than 45%. The study further revealed that the average regeneration potential (51.03%) of the 4 recorded mangrove species was lower than the RP for the entire study.

Key words: Delta state, ogidigben, regeneration potential, mangroves, species diversity

INTRODUCTION

Mangrove forests are among the most productive ecosystems and offer a wide range of resources and services including shoreline stabilization (Teas, 1977; Field, 1996), habitat, nursery and breeding ground for many fish species and other fauna (Teas, 1977; Collete, 1983; Ahmad, 1984; Kurian, 1984; Robertson and Duke, 1987; Ngoile and Shunula, 1992; Sasekumar *et al.*, 1992; wood for fuelwood, timber, poles, boats (Ahmad, 1984; Burbridge, 1984; Fredericks and Lampe, 1984; Aksornkoae, 1987; Dahdouh-Guebas *et al.*, 2000; Bosire *et al.*, 2003), establishment of restrictive impounds that offer protection for maturing offspring, filtering and assimilating pollutants from upland run-off and stabilization of bottom sediments (Saenger and Bellan, 1995) among other products. The common characteristics they all posses is tolerance to salt and brackish waters. Despite increasing awareness regarding value and importance, the destruction of mangrove forest continues to take place in many parts of the world under a variety of economic as-well-as political motives. In recent years, the pressures of increasing population, food production, industrial and urban development, introduction of alien invasive species and wood chipping have caused a reduction in the world's mangrove forests. In Nigeria, the mangrove of approximately 10515 km^2 (Saenger and Bellan, 1995) extends the littoral states of Lagos, Ondo, Cross river, Delta, Bayelsa, Rivers and Akwa-ibom, with the 'core' Niger Delta States (Delta, Bayelsa, Rivers and Akwa-ibom) with 1,0310.7 km^2 (UNDP, 2013), accounting for about 98.06% is being destroyed at an alarming rate. In Nigeria, the major factors for disappearance of mangrove forests are over extraction of fuel wood and charcoal, human settlements, oil exploration, conversion of mangroves into aquaculture and high incidence of invasive species. The Nigerian mangroves are comprised of 6 species in 3 families. These are: Rhizophoraceae (*Rhizophora racemosa*, *R. harrisonii* and *R. mangle*), Avicenniaceae (*Avicennia africana*) and Combretaceae (*Laguncularia racemosa* and *Conocarpus erectus*) (Abere and Ekeke, 2011). The realization that in some parts of the world mangrove ecosystems are being destroyed, with a consequent loss of inherent services has prompted an upsurge in the number of rehabilitation projects (Field, 1995). Examples of such mangrove rehabilitation projects are reported from, e.g., Thailand (Aksornkoae, 1996), Pakistan (Qureshi, 1996), Australia (Saenger, 1996), Bangladesh (Siddiqi and Khan, 1996) and Kenya (Kairo, 1995). Regrettably, the success rate of these restoration programs has not been encouraging since restoration management has, unfortunately, emphasized planting of mangroves as the primary tool in restoration, rather than first assessing the reasons for the loss of mangroves in an area and working with the natural recovery processes that all ecosystems have (Lewis, 2001). A baseline study to determine the failure of natural regeneration *in situ* is the first step in any successful regeneration program. It is in light of this that a baseline study to document the species list and then their natural regeneration potential in the deltaic communities under investigation.

Study area: The study area is a component part of the Upper floodplain forest and the lower flood plain mangrove in Delta state. The vegetation belt of the former is non-tidal and is characterized by a seasonally flooded forest mosaic of small lakes and broad-leafed species such as *Symphonia globulifera*, Raphia palm (*Raphia vinifera*) and the indigenous oil palm (*Elaeis guineensis*). The palm species *R. vinifera* is particularly abundant along the creeks. The lower flood plain mangrove is characterized by high tidal regime, reaching amplitude of about 1-3 m. The mangrove zone runs roughly parallel to the coast and reaches between 15-45 km inland. This deep belt of mangrove forest protects the freshwater wetlands in the Inner Delta (UNDP, 2013).

Study site: The study site covers 7 transects across the Ogidigben, Okegbe, Olegin and Madagho, Ugbagboro, Remure and Kpokpo communities in Warri North Local government Area of Delta state. Figure 1 shows the map of the study area.

MATERIALS AND METHODS

Floristic data were collected in each of the area using the plot less method of Curtice and Cottom (1956) at preselected points, approximately 5 km apart. At each point along the direction of the transect-Point Centre Quadrat (PCQ), the area was divided into 4 quarters. In each quarter, woody plants were identified and enumerated. The heights of the woody plants were also measured. The distance between the woody plants and the sample point (PCQ) was also measured ($D = 100^2\ \text{day}^{-2}$) where d is the average of the estimated distances in m^2. Wildings of the young species were also counted. The regeneration potential was obtained by dividing the wildling of individual species by the density of the woody stem.

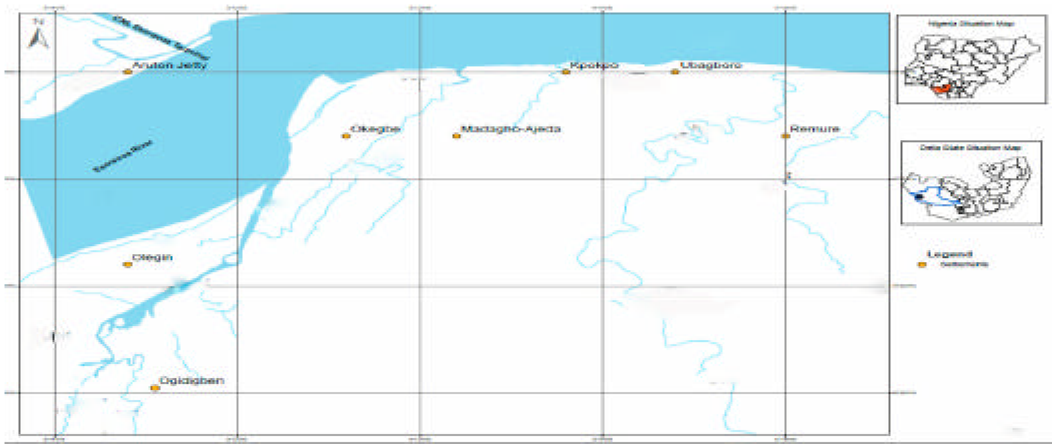

Fig. 1: Map of Study area showing study site

RESULTS

Flora: A total of 50 woody species, comprising mangroves species, fresh water species and tropical rain forest species were identified across the 7 transects established. Table 1 shows the checklist of the species, families, abundances and their stem densities.

Result on regeneration potential: The regeneration potentials of the various species for each transect is presented in Table 2.

DISCUSSION

Checklist: As could be seen in Table 1, a total of thirty-one families resulting in 50 species with an abundance of 2755 individuals were censured in the mixed mangrove forest of Ogidigben and associated communities, Delta state, Nigeria. The species comprised mangrove indicator genera (*Rhizophora, Avicenna* and *Laguncularia*), brackish indicator genera (*Nypa, Symphonia* and *Pandanus*) and typical low land rain forest species (*Klainedoxa, Diospyros, Canarium* amongst others). Species diversity ranged from 20 species along transect 7 to 28 along transect 2 with an average of 25 species per transect. This was further revealed by the Shannon index and abundance data which showed transect 2 with an abundance of 405 individuals and a species richness of 3.25 as the most luxuriant plot as against transect 7 with 309 individuals and a Shannon index of 2.85 as the least luxuriant plot. The probabihty (equitability) of inventorying any of the recorded species ranged varied between 0.95 (95%) along transects 1, 3, 4 and 7-0.98 (98%) along transect 5 with a study average of 0.96 (96%). Analysis of species density revealed a study average of 1294.286, with transect 5 (1716) and transect 1 (911) as the highest and least dense, respectively. *Elaesis guineensis, Alchornea cordifolia, Pandanus candelabrum, Nypa fructicans* and *Anthocleista vogelii* are the most abundant plant species across the study area. Species abundance data per transect indicated that *Alchornea cordifolia* (46 and 37 individuals), *Nephrolepsis* spp. (32 and 38 individuals) and *Nypa fructicans* (43, 45 and 32 individuals) were the most abundant species along transects 1 and 7, transect 2 and 6 and transects 3, 4 and 5, respectively. On the other hand *Pterygota macrophyla* (17), *Grewia auriculata* (20), *Beilschmiedia mannii* (22), *Ricinodendron huedelotti* (23) and *Clistopholis patens* (27) are the five least abundant species

Table 1: Checklist of woody species in study site

Species	Family	1	2	3	4	5	6	7
Acrostichum aureum	Ceratopteridiaceaea		25			18	32	
Alchornea cordifolia	Euphorbiacea	43		20	28		29	37
Afzelia Africana	Caesalpinoideae	29	18		27			
Alstonia boonei	Apocynaceae			20		18		11
Anogeissus leiocarpus	Euphorbiaceae	8	12		18		16	
Anthocleista vogelii	Loganiaceae			27	18	19		29
Anthostema aubraunum	Euphorbiaceae	21	15				18	
Avicennia africana	Avicinnaceae			16	13	17	19	
Beilschmiedia mannii	Lauraceae	8						14
Canarium schwanfurthii	Bursaraceae		9	15			6	
Carapa procera	Meliaceae		14		16		17	
Chlorophora excelsa	Moraceae	20						9
Clistopholis patens	Cuppresiaceae		6			9	12	
Crystospema senegalensis	Araceae			17		23		
Dalbergia melanoxylon	Papilionoideae	18	12					12
Diospyros preusii	Ebenaceaea			23	16	10		
Funtumia elastica	Apocynaceaea	11	17				7	6
Elaesis guineensis	Arecaceae	26	24	31	28	16	19	30
Grewia auriculata	Tiliaceae		12			8		
Guarea cedrala	Meliaceae			13	6		9	16
Hallea leadermanii	Rubiaceae	10	16					13
Homalium spp.	Salicaceae			14	11	17		
Khaya ivorensis	Meliaceae		12				18	12
Klainedoxa gabunensis	Irvingiaceae	6		13	19	11		
Laguncularia racemosa	Combretaceae		18	14		16	10	
Lophira alata	Ochnaceae	16	11		13			10
Lovoa trichiliodes	Meliaceae			16			18	
Macaranga barteri	Euphorbiaceae	10	11			18	21	
Machaerium lancetum	Papilionoideae			15	18	12		
Mitragyna stipulosa	Rubiaceae		16				13	23
Musanga cevropoides	Cecropiaceae	31	24		16			18
Nauclea diderrichi	Rubiaceae			23	16	17		
Nephrolepsis spp.	Nephrolepidaceae	17	32				38	
Nypa fructicans	Arecaceae			43	45	32		
Nesogodonia papaverifera	Malvaceae	17	11				13	19
Oldfielda africanum	Euphorbiaceae			3	16	19		
Pandanus candalabrum	Pandanaceae	12	10	23	41	28	18	
Piptadeniastrum africanum	Mimoisoideae		17		12			19
Pterygota macrocarpa	Sterculiaceae	7		2			8	
Pycanthus angolensis	Myristaceae		2		13	16	19	
Raphia hookeri	Arecaceae	16	13			7		5
Rhizophora spp.	Rhizophoraceae	10		7	18	23	19	
Ricinodendron huedelotti	Euphorbiaceae		13	6				4
Sacoglottis spp.	Celastraceae	10			4	9	11	
Sarcocephalus diderrichii	Rubiaceae		12	5	7		9	
Symphonia globulifera	Clusiaceae	3		11		6	9	
Tillia americana	Tiliaceae		13		11			13
Turraeanthus africanus	Meliaceae	16	10			15	11	

Table 1: Continue

Species	Family	1	2	3	4	5	6	7
Uapaca heudolotii	Uapacaceae			10	6	7	9	
Voacanga africana	Apocynaceae	19			3	12		9
Species diversity		24	28	24	27	26	26	20
Shannon index		3.03	3.25	3.02	3.13	3.18	3.15	2.85
Abundance		384	405	387	448	411	411	309
Equitability index		0.95	0.97	0.95	0.95	0.98	0.97	0.95
Density (Woody stem ha^{-1})		911	1465	1012	1560	1716	1346	1050

Table 2: Regeneration potential of species in the mixed mangrove forest of Ogidigben and associated communities

Species	1	2	3	4	5	6	7	Average species regeneration potential	Species regeneration potential (%)
Acrostichum aureum		0.008			0.006	0.017		0.010	59.30
Alchornea cordifolia	0.032		0.012	0.006		0.015	0.017	0.016	55.63
Afzelia Africana	0.013	0.004		0.005				0.007	34.46
Alstonia boonei			0.013		0.006		0.006	0.008	61.67
Anogeissus leiocarpus	0.004	0.005		0.004		0.008		0.005	51.74
Anthocleista vogelii			0.019	0.005	0.006		0.013	0.011	53.26
Anthostema aubraunum	0.011	0.007				0.005		0.008	52.10
Avicennia africana			0.009	0.005	0.005	0.007		0.007	54.69
Beilschmiedia mannii	0.014						0.008	0.011	108.60
Canarium Schwanfurthii		0.003	0.010			0.004		0.006	72.22
Carapa procera		0.007		0.004	0.005			0.005	53.33
Chlorophora excelsa	0.003						0.005	0.004	34.60
Clistopholis patens		0.003		0.002		0.007		0.004	62.03
Crystospema senegalensis			0.012		0.006			0.009	58.37
Dalbergia melanoxylon	0.009	0.005					0.005	0.006	50.99
Diospyros preusii			0.015	0.006	0.002			0.008	52.85
Funtumia elastica	0.011	0.008				0.001	0.004	0.006	61.25
Elaesis guineensis	0.004	0.010	0.021	0.006	0.006	0.010	0.013	0.010	51.47
Grewia auriculata		0.006			0.001			0.004	47.50
Guarea cedrala			0.007	0.001		0.005	0.006	0.005	47.57
Hallea leadermanii	0.011	0.008					0.007	0.009	77.02
Homalium spp.			0.009	0.003	0.006			0.006	55.72
Khaya ivorensis		0.006				0.007	0.010	0.008	73.25
Klainedoxa gabunensis	0.003		0.008	0.006	0.002			0.005	46.93
Laguncularia racemosa		0.008	0.008		0.004	0.006		0.007	63.49
Lophira alata	0.004	0.004		0.005			0.006	0.005	48.68
Lovoa trichiliodes			0.010			0.009		0.010	65.87
Macaranga barteri	0.010	0.005			0.006	0.009		0.008	67.42
Machaerium lancetum			0.009	0.006	0.003			0.006	50.95
Mitragyna stipulosa		0.006				0.004	0.011	0.007	48.18
Musanga cevropoides	0.003	0.009		0.006			0.008	0.007	65.83
Nauclea diderrichi			0.014	0.005	0.005			0.008	53.62
Nephrolepsis spp.	0.021	0.013				0.009		0.014	67.25
Nypa fructicans			0.024	0.013	0.006			0.014	44.52
Nesogodonia papaverifera	0.012	0.004				0.004	0.010	0.008	52.18

Table 2: Continue

Species	1	2	3	4	5	6	7	Average species regeneration potential	Species regeneration potential (%)
Oldfielda africanum			0.002	0.004	0.006			0.004	53.74
Pandanus candalabrum	0.009	0.002	0.015	0.006	0.012	0.004		0.008	48.65
Piptadeniastrum africanum		0.009		0.004			0.010	0.008	60.19
Pterygota macrocarpa	0.003		0.002			0.001		0.002	51.39
Pycanthus angolensis		0.001		0.003	0.005	0.004		0.003	55.41
Raphia hookeri	0.008	0.005			0.003		0.003	0.005	58.74
Rhizophora spp.	0.002		0.004	0.005	0.008	0.004		0.005	41.42
Ricinodendron huedelotti		0.006	0.004				0.001	0.004	52.78
Sacoglottis spp.	0.007			0.001	0.003	0.03		0.010	48.62
Sarcocephalus diderrichii		0.005	0.003	0.002		0.001		0.003	46.70
Symphonia globulifera	0.002		0.008		0.001	0.002		0.003	50.33
Tillia americana		0.007		0.003			0.010	0.007	67.99
Turraeanthus africanus	0.009	0.004			0.005	0.003		0.005	50.05
Uapaca heudolotii			0.006	0.001	0.001	0.002		0.003	34.64
Voacanga africana	0.013			0.001	0.004		0.006	0.006	58.93
Total plot regeneration potential	0.218	0.168	0.244	0.118	0.123	0.178	0.159		
Average plot regeneration potential	0.009	0.006	0.010	0.004	0.005	0.007	0.008		
Regeneration potential (%)	60.91	62.31	64.48	42.43	50.60	49.38	56.07		
Mean of study area regeneration potential						0.00696± 0.0012			
Mean percentage of study area regeneration potential									55.68

across the study area with *Symphonia globulifera* (3 and 6), *Pycanthus angolensis* (2), *Pterygota macrophyla* (3), *Voacanga africana* (3), *Canarium schwanfurthii* and *Ricinodendron huedelotti* (4) as the least abundant across transects 1 and 5, 2, 3, 4, 6 and 7, respectively. The frequency of species per plot and for the entire study area was equally checked. *Elaesis guineensis* occurred along all transects sampled. *Pandanus candelabrum* was recorded along all but one (transect 7) of the transects, *Alchornea cordifolia* and *Rhizophora* species occurred in all but two {(2 and 5) (2 and 7)} of the transects. Nineteen other species were recorded along 4 transects, 22 along 3 transects and 5 along 2 transects. No species was recorded in only one transect.

The flora of Niger Delta is one of the most poorly studied in West Africa despite obvious high level of endemism (Campbell and Hammond, 1989). Most of the few that had been conducted remained largely inaccessible as they are held as propriety rights of the multinational oil companies. Nonetheless, (Kumar, 2005) described the delta as consisting of 3 main ecological zones buttressed by Niger (2012) as the upper freshwater riverine floodplain, the lower tidal floodplain (estuaries, mangroves and creeks) and the outer chain of barrier islands. The study area, a component part of the 2863.1 km^2 lower floodplain mangrove and the 13,271.5 km^2 upper flood plain forest (FORMECU, 1999) was depicted vegetationally by Kumar (2005) as comprising of *Rhizophora, Avicinnia, Mitragyna, Phoenix, Raphia, Elaesis, Alstonia, Acrostichum, Paspalum, Polygnium, Pistia* and *Tectona*. Blench and Morakinyo (2013) although added low land rainforest as the fourth ecological zone, agreed with the check list provided by Kumar (2005) and added *Eichornia crassipes* while Adegbehin and Nwaigbo (1990) reported the occurrence of *Calamus* and *Alchornea* spp.

on the river fringe with *Irvingia gabonensis*, *Symphonia globulifera*, *Alstonia boonei*, *Berlinia* spp. on the higher levees. Osuji and Ezebuiro (2006) listed *Antidesma* spp. *Paullina pinnata*, *Ouratea* spp., *Chassalia* spp., *Cuvaria* spp., *Dryopteris* spp., *Memecylon*, *Blackiodes*, *Agelaea oblique* and *Psychotria manii* as candidate species in the Delta. SPDC (2004, 2008) reported *Albizia adianthefolia*, *Nauclea diderrichii*, *Triplochiton scleroxylon*, *Cleispholis patens*, *Funtumia elastica*, *Terminalia ivorensis* and *Entradrophragma angolense* amongst others while (Abere and Ekeke, 2011) revealed the existence of *Conocarpus erectus*. Aremu *et al.* (2009) showed the dominant plant species of Gele gele reserve as *Lophira alata*, *Uapaca standtii*, *Macaranga bacteri*, *Millettia griffoniana* and *Raphia hookeri*. Akinnibosun and Omatsola (2011) showed *Tricalysis*, *Pentaclethra* and *Sterculia tragacantha* amongst others. Adoki (2012) listed some transitional species of the Niger Delta to include *Ceiba pentandra*, *Lophira alata*, *Chlorophora excelsa*, *Bombaxbuonopozense*, *Sterculia tragacantha*, *Bligha sapida*, *Piptadeniastrum africanum*, *Cleiostopholis patens*, *Alstonia boonei*, *Acio bateri*, *Dichrostachys cinerea* and *Cynometra megalophylla*. Others are *Harungana madagascariensis*, *Musanga cecropioides*, *Symphonia globulifera*, *Uapaca heudelotii*, *Entandrophragma cylindicum*, *Terminalia superba* and Cola. LNG (1999) and Okafor (2005) listed additional species members of the Delta to include *Oncocalamus mannii*, *Pierreodendron africanum*, *Pararistolochia goldieana* and *Spondianthus preussii*. Floristic diversity studies by Edet *et al.* (2012) in Afi forest and Aremu *et al.* (2009) in Gele-gele reserve in the eastern and western flank of the delta estimated Shannon index for the forests as 4.35 and 3.85, respectively.

Regeneration potential: The natural regeneration potential was analyzed for plots and species. The regeneration potential for the plots varied between 0.118 along transect 4 to 0.244 along transects 3 with an average of 0.007. When this data was computed on a percentage basis, plots, 3 with 64.48% had the highest regeneration rate, followed closely by transect 2 (62.31%) and transect 1 (60.91%). Transects 4, 6, 5 and 7 had the lowest regeneration potential with 42.43, 49.38, 50.60 and 56.07%, respectively. The overall percentage regeneration potential for the plots was 55.17%. When this data was subjected to statistical analysis at the 0.05 confidence limit, a statistical significant ($p<0.001$) difference was obtained among the regeneration potentials of the plots. Furthermore, the regeneration potential for each species revealed wide variations in regeneration ability. *Beilschmiedia mannii*, (108.60%), *Hallea leadermanii* (77.02%), *Khaya ivorensis* (73.25%), *Canarium schwanfurthii* (72.22%), *Tillia americana* (67.99%), *Macaranga barteri* (67.42%), *Nephrolepsis* spp. (67.25%), *Lovoa trichiloides* (65.87%), *Musanga cecropoides* (65.83%), *Laguncularia racemosa* (63.49%), *Clistopholis patens* (62.03%), *Alstonia boonei* (61.67%), *Funtumia elastica* (61.25%), *Piptadeniastrum africanum* (60.19%), are 14 species with regeneration potential of at least 60%. On the other hand, 5 species had less than 45% regeneration potential. These are *Afzelia africana* (34.46%), *Chlorophora excelsa* (34.60%), *Uapaca heudolotii* (34.64%), *Rhizophora* spp. (41.42%) and *Nypa fructicans* (44.52%). Thirtyone species had regeneration potentials of between 45 and 59%. The study had an overall regeneration potential of 55.68%.

Similarly as could be seen in Table 3, when the regeneration potentials for each of the transect was computed, 12 species had regeneration potentials of 60% and above along transect 1 with *Beilschmiedia mannii*, *Nephrolepsis* spp., *Hallea leadermanii* and *Musanga cercropoides* having a regeneration potential above 100%.

Table 3: Sapling number and regeneration potential of species per transect

Plot 1 Saplings	%	2 Saplings	%	3 Saplings	%	4 Saplings	%	5 Saplings	%	6 Saplings	%	7 Saplings	%	Species RP T. of saplings	Saplings (%)
		12	48.0					10	55.6	23	71.9			45	60.0
29	67.4			12	60.0	10	35.7			20	69.0	18	48.7	89	56.7
12	41.4	6	33.3			8	29.6							26	35.1
				13	65.0			10	55.6			6	54.6	29	59.2
4	50.0	8	66.7			6	33.3			11	68.7			29	53.7
				19	70.4	8	44.4	10	52.6			14	48.3	51	54.8
10	47.6	10	66.7							7	38.9			27	50.0
				9	56.3	8	61.5	9	52.9	10	52.6			36	55.4
13	100.0											8	57.1	21	77.8
		5	55.6	10	66.7					5	83.3			20	66.7
		10	71.4			6	37.5	8	47.1					24	51.1
3	15.0											5	55.6	8	27.6
		4	66.7			3	33.3			9	75.0			16	59.3
				12	70.6			11	47.8					23	57.5
8	44.4	7	58.3									5	41.7	20	47.6
				15	65.2	10	62.5	4	40.0					29	59.2
10	90.9	11	64.7							2	28.6	4	66.6	27	65.9
4	15.3	14	58.3	21	100.0	10	35.7	10	62.5	13		14	46.7	86	52.4
		9	75.0					2	25.0					11	55.0
				7	53.8	2	33.3			7	77.8	6	37.5	22	50.0
10	100.0	11	68.8									7	53.9	28	71.8
				9	64.3	4	36.4	10	58.8					23	54.8
		9	75.0							10	55.6	10	83.3	29	69.0
3	100.0			8	61.5	10	52.6	3	27.3					24	52.2
		11	61.1	8	57.1			7	43.8	8	80.0			34	58.6
4	25.0	6	54.5			8	61.5					6	60.0	24	48.0
				10	62.5					12	66.7			22	64.7
9	90.0	7	63.6					10	55.6	12	57.1			38	63.3
				9	60.0	10	100	5	41.7					24	64.9
		9	56.3							6	46.2	12	52.2	27	51.9
3	9.7	13	54.2			10	62.5					8	44.1	34	38.2
				14	60.9	8	50	8	47.1					30	53.6
19	100.0	19	59.4							12	31.6			50	56.2
				24	55.8	20	44.4	10	31.3					54	45.0

Table 3: Continue

Plot															
1		2		3		4		5		6		7		Species RP	
Saplings	%	Saplings	%	Saplings	%	Saplings	%	Saplings	%	Saplings	%	Saplings	%	T. of saplings	Saplings (%)
11	64.7	6	54.5							6	46.2	10	52.6	33	55.0
				2	66.7	7	43.8	10	52.6					19	50.0
8	66.7	3	30.0	15	65.2	10	24.4	20	71.4	6	33.3			62	47.0
		13	76.4			6	50					11	57.9	30	62.5
3	42.9			2	100.0					2	25.0			7	41.2
		2	100.0			5	38.5	8	50.0	5	26.3			20	40.0
7	43.8	7	53.8					4	57.1			3	60.0	21	51.2
2	20.0			4	57.1	8	44.4	14	60.9	6	31.6			34	44.2
		9	69.2	4	66.7							1	25.0	14	60.9
6	60.0					2	50	5	55.6	4	36.4			17	50.0
		7	58.3	3	60.0	3	42.9			2	22.2			15	45.5
2	66.7			8	72.7			2	33.3	3	33.3			15	51.7
		10	76.9			4	36.4					10	76.92	24	64.9
8	50.0	8	80					9	60.0	4	36.4			29	55.8
				6	60.0	2	33.3	2	28.6	3	33.3			13	40.6
12	63.2					1	33.3	7	58.3			6	66.7	26	60.5

Other species in this category include *Funtumia elastica* (91.67%), *Macaranga barteri* (90.91%), *Pandanus candelabrum* (69.23%), *Alchornea cordifolia* (68.09%), *Symphonia globulifera* (66.67%), *Sacoglottis* spp. (63.64%), *Nesogodonia papaverifera* (63.16%) and *Voacanga africana* (61.9%). *Chlorophora excelsa* (13.64%,), *Elaesis guineensis* (13.79%), *Rhizophora* spp. (18.18%), *Lophira alata* (27.22%), *Pterygota macrophyla* (37.5%), *Afzelii africana* (40.63%), *Klainedoxa gabunensis* (42.86%), *Raphia hookeri* and *Anogeissus leiocarpus* (44.4%) are 9 species with less than 45% regeneration potential along transect 1.

Along transect 2, 17 species had regeneration potential of at least 60%. They species are *Pycanthus angolensis* (100%), *Tillia americana* (77.78%), *Clistopholis patens, Grewia auriculata, Khaya ivorensis, Piptadeniastrum africana* (75%), *Hallea leadermanii* (72.72%), *Anthostema macrophylla* (70%), *Carapa procera* (70%), *Funtumia elastica* (*Laguncularia racemosa, Ricinodendron heudolotii* (66.67%), *Anogeissus leiocarpus, Dalbergia melanoxylon, Elaesis guineensis, Macaranga barteri* and *Sarcocephalus diderrichii* (62.5%) had at least 60% regeneration potential along transect 2 while *Pandanus candalabrum* (28.57%) and *Afzelii africana* (33.33%) are the only 2 species with less than 45% regeneration potential in plot 2.

The 79.16% of the 19 species recoded along transect 3 had a regeneration potential of 60% and above. The only exceptions are *Rhizophora, Nypa, Laguncularia, Grewia* and *Avicinnia* with values between 50 and 59%. No species within this transect had regeneration potential less than 50%.

Avicinnia africana (62.5%), *Lophira alata* (62.5%), *Diospyros preusii* (60%) and *Musanga cercropoides* (60%) are 4 species with regeneration values of at least 60% along transect 4. Six species; *Voacanga africana, Sarcocephalus diderrichii, Piptadeniastrum africanum, Nauclea diderrichii, Machaerium lancetum* and *Klainedoxa gabunensis* are species within the 45-59% regeneration potential bracket. Seventeen other species had values less than 45%.

The 9 species (*Pandanus Candalabrum, Raphia hookeri, Elaesis guineensis, Rhizophora* spp., *Alstonia boonei, Homalium* spp., *Macaranga barteri, Sacogglottis* spp. and *Acrostichum aureum*) had regeneration values between 60 and 75% along transect 5. Conversely, 8 species (*Grewia auriculata, Machaerium lunatum, Diospyros preusii, Klainedoxa gabunensis, Symphonia globulifera, Nypa fructicans, Uapaca heudolotii* and *Laguncularia*) had values less than 45%.

Along transect 6, 9 species (*Canarium schwanfurthii* (100%), *Laguncularia racemosa* (85.71%), *Clistopholis patens* (77.77%), *Elaesis guineensis* (71.43%), *Guarea cedrela* (71.43%), *Acrostichum aureum* (70.83%), *Lovoa trichiloides* (69.23%), *Alchornea cordifolia* (68.18%) and *Anogeissus leiocarpus* (66.67%) had regeneration values of at least 60%. *Macaranga barteri* (56.25%), *Khaya ivorensis, (*53.85%) and *Avicennia africana* (50%) are 3 species with regeneration potential values between 50 and 59%. There are 14 species with regeneration potential less than 45% along transect 6. Notable among them are, *Funtumia elastica* (20%), *Rhizophora* spp. and *Symphonia globulifera* (28.57%) and *Pandanus candelabrum* (30.77%) are among those with less than 45% regeneration potential.

Transect 7 had 8 species (40%) with regeneration potential of at least 60%. They are *Khaya ivorensis* (90.91%), *Tilia americana* (83.33%), *Funtumia elastica* (66.67%), *Voacanga africana* (66.67%), *Beilschmiedia mannii* (61.54%), *Alstonia boonei* (60%), *Lophira alata* (605) and *Raphia hookeri* (60%). Three other species; *Elaesis guineensis* (44.83%)

Table 4: Ranking of the recorded species as a function of their regeneration potential

S/N	Species	RP (%)	S/N	Species	RP (%)	S/N	Species	RP (%)
1	*Beilschmiedia mannii*	108.6	18	*Crystospema senegalensis*	58.37	35	*Machaerium lancetum*	50.95
2	*Hallea leadermanii*	77.02	19	*Homalium* spp.	55.72	36	*Symphonia globulifera*	50.33
3	*Khaya ivorensis*	73.25	20	*Alchornea cordifolia*	55.63	37	*Turraeanthus africanus*	50.05
4	*Canarium schwanfurthii*	72.22	21	*Pycanthus angolensis*	55.41	38	*Lophira alata*	48.68
5	*Tillia americana*	67.99	22	*Avicennia africana*	54.69	39	*Pandanus candalabrum*	48.65
6	*Macaranga barteri*	67.42	23	*Oldfielda africanum*	53.74	40	*Sacoglottis* spp.	48.62
7	*Nephrolepsis* spp.	67.25	24	*Nauclea diderrichi*	53.62	41	*Mitragyna stipulosa*	48.18
8	*Lovoa trichiliodes*	65.87	25	*Carapa procera*	53.33	42	*Guarea cedrala*	47.57
9	*Musanga cevropoides*	65.83	25	*Anthocleista vogelii*	53.26	43	*Grewia auriculata*	47.50
10	*Laguncularia racemosa*	63.49	27	*Diospyros preusii*	52.85	44	*Klainedoxa gabunensis*	46.93
11	*Clistopholis patens*	62.03	28	*Ricinodendron huedelotti*	52.78	45	*Sarcocephalus diderrichii*	46.70
12	*Alstonia boonei*	61.67	29	*Nesogodonia papaverifera*	52.18	46	*Nypa fructicans*	44.52
13	*Funtumia elastica*	61.25	30	*Anthostema aubraunum*	52.10	47	*Rhizophora* spp.	41.42
14	*Piptadeniastrum africanum*	60.19	31	*Anogeissus leiocarpus*	51.74	48	*Uapaca heudolotii*	34.64
15	*Acrostichum aureum*	59.30	32	*Elaesis guineensis*	51.47	49	*Chlorophora excelsa*	34.60
16	*Voacanga africana*	58.93	33	*Pterygota macrocarpa*	51.39	50	*Afzelia africana*	34.46
17	*Raphia hookeri*	58.74	34	*Dalbergia melanoxylon*	50.99			

*RP: Regeneration potential

Guarea cedrela (40%) and *Ricinodendron heudolotii* (25%). Seven others, *Piptadeniastrum africanum*, *Mitragyna stipulosa*, *Hallea leadermanii* and *Chlorophora excelsa* are among species with regeneration values between 45 and 60%.

As could be seen in Table 4, the mangrove species represented by *Laguncularia racemosa*, *Avicennia africana*, *Nypa fructicans* and *Rhizophora* spp., are ranked 10th, 22nd, 46th and 47th, respectively among regeneration potentials for 50 species. Their average regeneration potential was 51.03%.

Natural regeneration potential of these mangroves could have been affected by several biological and physical factors. There are several published articles on the various causal factors influencing natural regeneration potentials of mangrove species. They include soil stability and flooding regime (Pulver, 1976), site elevation (Hoffman *et al.*, 1985), salinity and fresh water runoff (Jimenez, 1990), tidal and wave energy (Lewis, 1982; Field, 1996), propagule availability (Loyche, 1989) propagule predation (Dahdouh-Guebas *et al.*, 1997, 1998; Dahdouh-Guebas, 2001) and hydrological regime (Field, 1996, 1999). Elster *et al.* (1999) reported the effects of flooded soil, high temperature above 45°C, wind, wave and phytophagous insects on the regeneration potential and response of *Avicinnia africana* and *Laguncularia racemosa*. Hoyos *et al.* (2013) showed the effect of bare soil, sediment load and seasonal variations on the natural regeneration pattern of *Rhizophora racemosa*.

CONCLUSION

Absence of basic understanding of the biological and physical processes operating in the mangrove has been the bane of most mangrove restoration projects worldwide. It is expected that further studies utilizing flower production in relation to regeneration potential should be undertaken. If conducted, it shall serve a complimentary data for which further studies on hydrological regime prevailing in the mangrove would be conducted. These would serve the baseline data needed for any future restoration program in the Niger Delta.

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