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Original Research Article

Pollen characterization of *Rhizophora* species in Nigeria

Abstract

Pollen characterization of mangrove species in Nigeria Niger Delta was conducted in permanent plots in Koko, Ogidigben (Delta State), Akakumama, Nembe (Bayelsa State), Olupiri-Epelema, Ugwede (Rivers State), Ikwe, Upenekang (Akwa Ibom State), Adiabo Ukanabio and Esighi (Cross River State) between 2013 - 2016. A total of three hundred and sixty four (364) *Rhizophora* pollen samples were obtained between the sea water-land interfaces to 604 metres inland (maximum Rhizophora occurrence landward). The samples were prepared using standard Erdtmanian methods. The result showed the presence of five different shapes of f tricolporate pollen. The exine sculptures were baculate, rugulate, striate and reticulate while the pollen shapes were either sub prolate, prolate or oblate. The polar shapes were circular in Operational Taxonomic Units (OTUs) 1 and 4, triangular in OTUs 2 and 3 and trilobate in OTU5. The grain arrangements for all five OTUs were monad. When this data was normalized and converted to numerical taxonomy using Euclidean distance, a strong homology was observed between OTUs 3 and 5 suggesting same species. Although affinity was displayed between OTUs 2 and 4, their relationship is suggestive of two sister species. OTU 1 showed a distant and distinct species. The finding contradicts the widely held notion that only three Rhizophora species exist in Nigeria. Edaphic review of the fourth Rhizophora species bears strong semblance to *R apiculata* of South East Asia.

Key words: *Rhizophora, apiculata, harisonii, mangle, Nembe, Unical*

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Background

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 fuel wood, timber, poles, boats (Ahmad, 1984; Burbidge, 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. It confers an excellent sense of place, aesthetic grandeur and serenity value to the inhabitants. They have been shown as excellent candidates for carbon capture and sequestration (de Groot et al. 2002). Mangrove habitat is found along the coastlines of Nigeria. It straddles such states as Lagos, Ondo, Delta, Bayelsa, Rivers, Akwa Ibom and Cross River. Hamilton and Casey 2016 placed Nigeria mangrove habitat as the eight largest in the world. There are five indicator genera of the mangrove environment in Nigeria. *Rhizophora, Avicinnia, Laguncularia, Conocarpus* and lately but regrettably, the invasive *Nypa.* Of them all, Rhizophora is the embodiment of the mangrove environment in Nigeria. Its root system, height and hanging roots make it easily distinguishable. The pore space it creates in the soil makes it an excellent keystone engineering species that houses the hermit crabs and lobsters. In turn, the presence of these invertebrates is attraction for varieties of Mona and Cercopithecus taxa. The inevitable role of Rhizophora in shoreline protection is better appreciated where and when the coastlines are inadvertently cleared of it. Coastline embankment costing millions of dollars has been spent in such instances. The efficiency and life cycle of such artificial embankments is incomparable to the natural Rhizophora species.

The functionality of an organism is not generic, rather specific. It is a trite that species is the only tangible unit of life. It is therefore intuitive to suggest that the ecological niche of one Rhizophora species just like other genera (for instance *Irvingia gabonensis* versus *Irvingia*

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Wombolu, Vernonia colarata versus *Vernonia amygdalina*) would differ albeit how little, from the other.

More so, the alarming rate of mangrove conversion in the country calls for urgent and species specific studies. FAO 2000 put the size of the Nigeria mangrove as 997,700 ha prior to 2000 as against the current size of 240,400ha in 2015 (Hamilton and Casey 2016). Worst still, the high rate of speciation in the tropics makes frequent species characterization inevitable.

Viewed against these backdrops, this study aims to characterize the various Rhizophora species in Nigeria using pollen information.

Methodology

Pollen Collection: Three hundred and sixty four (364) pollen samples were collected in ten permanent plots spread across five Niger Delta States (fig 1) over a four year period (2013-2016) as shown in table 1.

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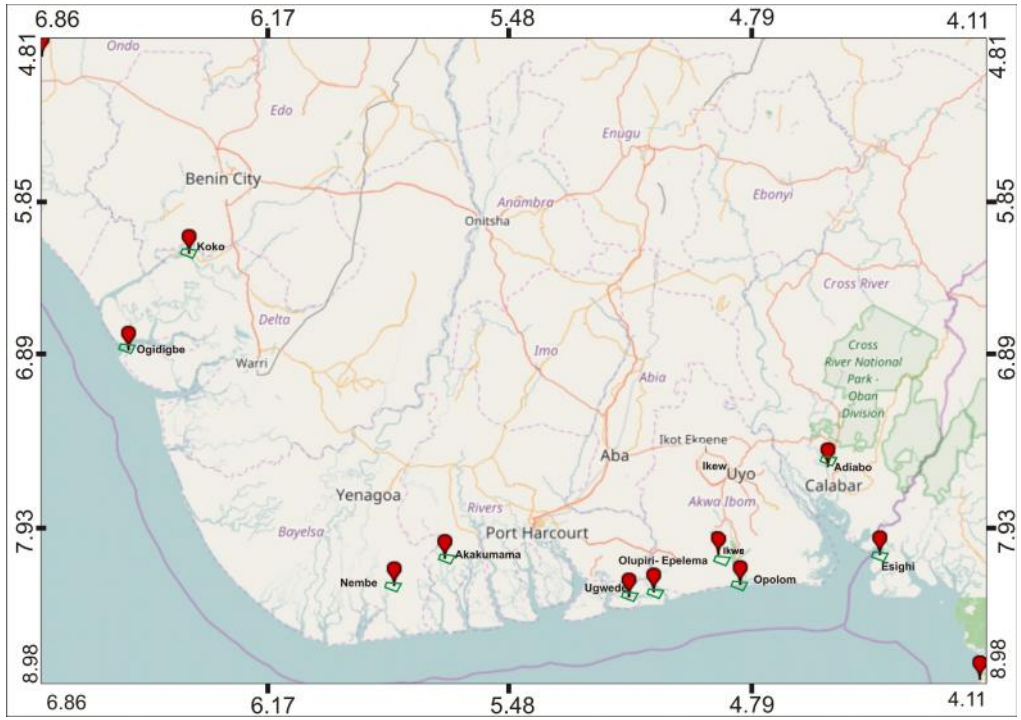

Fig 1: Study Area

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Table 1: Pollen sample collection

S/N	Sample Number	Location	State	Coordinates		Year of Collection
				N	E	
1	KOK 1-34	Koko	Delta	05^0 58' 33'' -5^0 59' 03''	005^0 23' 119'' - 005^0 24' 09''	2013
2	OGD 35-69	Ogidigben		05^0 23' 47'' - 05^0 24' 29''	005^0 39'42'' -005^0 41' 13''	2013
3	OBN 70-104	Akakumama	Bayelsa	04^0 36' 29''- 04^0 37' 16''	006^0 10' 35'' - 006^0 11'18''	2013
4	NEM 105-144	Nembe		04^0 37' 55'' - 04^0 38' 29''	006^0 14' 46'' - 006^0 15'28''	2013
5	0PM145-179	Olupiri-Epelema	Rivers	04^0 43 '35'' - 04^0 44' 48''	007^0 18'49'' - 007 19' 27''	2014
6	UGD180-214	Ugwede		04^0 40'05'' - 04^0 41' 33''	007^0 22'16'' - 007 23' 30''	2014
7	IKW215-249	Ikwe	Akwa Ibom	04^0 32' 08.6'' - 04^0 33' 02.6''	007^0 54' 24.0'' - 007^0 54' 56.7''	2015
8	UNK250-294	Opolom		04^0 32' 37'' - 04^0 33' 09''	007^0 55' 5'' - 007^0 55' 34''	2015
9	AUB 295-329	Adiabo Ukanabio	Cross River	05^0 02' 59'' - 05' 02' 33''	008^0 16' 36''- 008^0 17' 07''	2016
10	ESG 330-364	Esighi		004^0 54' 20'' -	008^0 26'43''	2016

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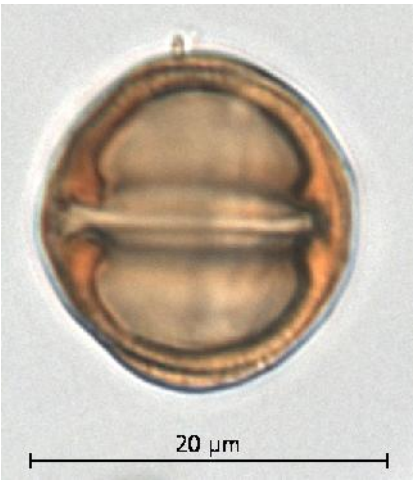
				004⁰ 55' 43''	- 008⁰ 27' 16''	

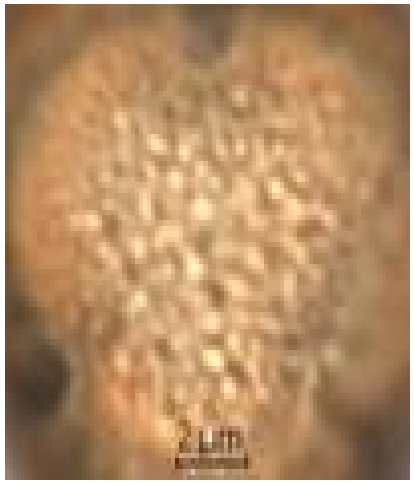
At each location, five samples were collected each at 1- 75m, 76-150m, and 151- 225m, 226-300m, 301-375m, 376-450m and 451-525m from the shoreline to the inland. No Rhizophora species was observed beyond the 525m distance except in Nembe where it was observed at 604m (hence an extra five samples were collected between 526-604m).

Pollen Analysis

Result

Five different shapes of the tricolporate pollen were observed as shown in plates 1-4 and table 2





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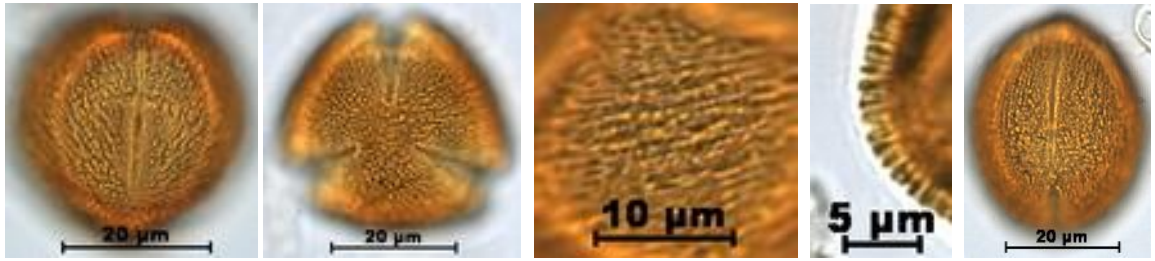
Equatorial, polar, surface ornamentation, special features, wall, aperture

Plate 1: Pollen characters for group 1



Equatorial View **Polar View** **Surface Pattern** **Wall** **Aperture**

Unique Features

Plate 2: Pollen Characters of Group 2

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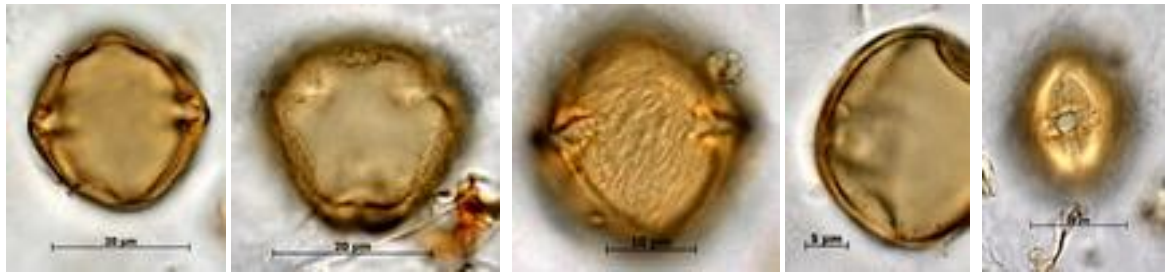
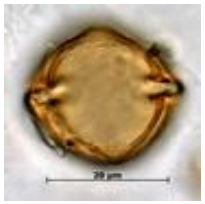


Equatorial View **Polar view** **Surface Pattern** **Wall**

Aperture



Unique Features

Plate 3: Pollen Characters of Group 3

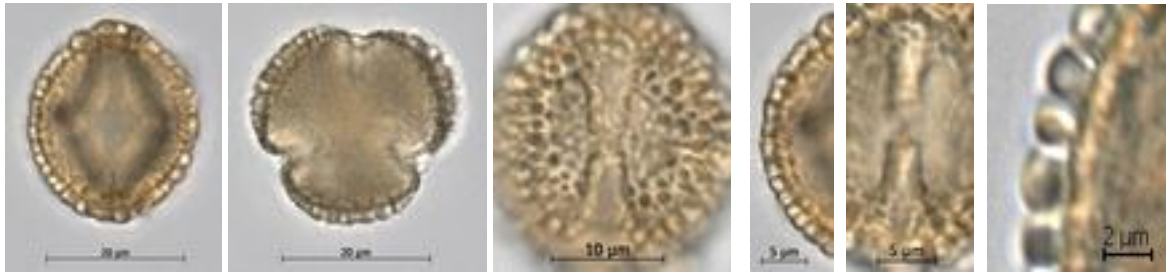


Plate 4: Pollen Characters of Group 4

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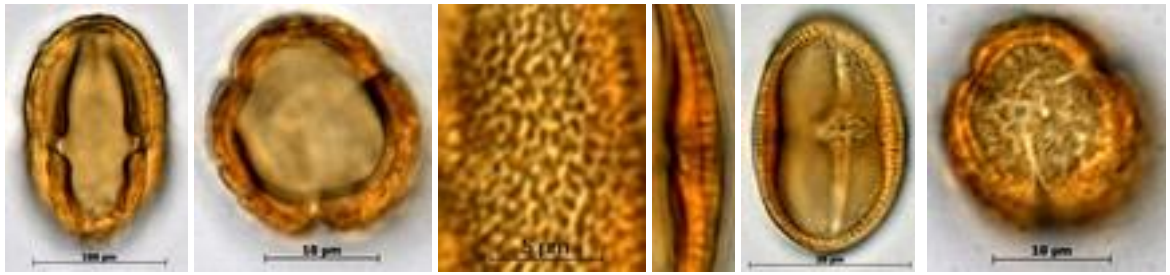

Plate 5: Pollen Characters of Group 5

Table 2: Summary of Pollen characters in the Genus Rhizophora

Pollen Morphology	Surface Pattern	Equatorial Size			Polar Size			Equatorial Shape	Polar Shape	Grain Arrangement
		Min	Max	Mean	Min	Max	Mean			
Tricolporate	Reticulate	17.2	19.3	16.4	14.7	16.2	15.5	Sub prolate	Circular	Monad
Tricolporate	Baculate	32.9	38.6	34.86	28.1	31.6	29.15	Prolate	Triangular (convex)	Monad
Tricolporate	Strai Rugulate	23.5	27.5	25.0	21.0	25.0	24.0	Oblate	Triangular	Monad
Tricolporate	Gemmate	27.2	34.3	30.2	22.8	27.8	24.6	Oblate	Circular	Monad
Tricolporate	Reticulate	18.6	20.2	15.4	26.4	29.2	27.9	Prolate	Trilobate	Monad

As evident across plate 1-5 and table 2, the basic pollen type in the genus is Tricolporate. However four different surface patterns were observed. They are reticulate, baculate, straite regulate and germate. The equatorial shape on the other hand ranged from sub prolate to prolate to oblate as against triangular, circular and trilobate for the polar shape. The grain arrangement across the samples was uniform, Monad.

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Discussion

Table 3 shows the set of pollen data to be transformed.

Table 3: Pollen data for transformation

Species / Pollen Character	1	2	3	4	5
Polar size (μ)	15.5	29.15	24.0	24.6	27.9
Equatorial size (μ)	16.4	34.86	25.00	30.2	28.1
P/E ratio (μ)	0.95	0.84	0.96	0.81	0.99
Number of Apertures	3	3	3	3	3

Normalization of the data in table 3 was carried out as shown in table 4 preparatory to application of cluster analysis.

Table 4: Data Standardization

Species/Pollen character	1	2	3	4	5
Polar	1.19	1.46	1.38	1.39	1.45
Equatorial	1.21	1.54	1.40	1.48	1.45
P/E	-0.02	-0.08	-0.02	-0.09	-0.01
Aperture	0.48	0.48	0.48	0.48	0.48

As could be seen in table 4, the transformed values ranged from negativity in the P/E ratio to positivity in the other three parameters. Similarity and distance among the five operational taxonomic units was obtained using Euclidean index. The result is as shown in table 5.

Table 5: Euclidean index of Similarity and Distances among Five OTUs

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Taxonomic Units	OTU 1	OTU 2	OTU 3	OTU 4	OTU 5
OTU 1	0	0.43052	0.26382	0.33963	0.34666
OTU 2	0.43052	0	0.17703	0.097803	0.11924
OTU 3	0.26382	0.17703	0	0.11088	0.083857
OTU 4	0.33963	0.097803	0.11088	0	0.10753
OTU 5	0.34666	0.11924	0.083857	0.10753	0

Principal Component Analysis to depict the relationship of the five OTUs is shown in fig 2

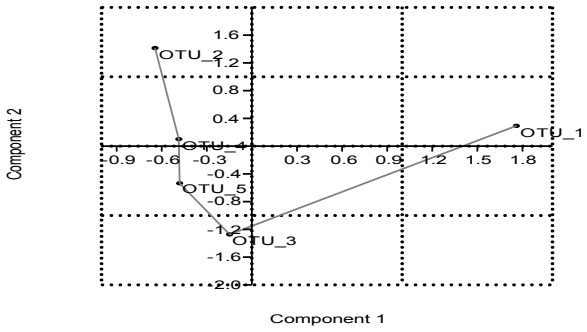

Fig 2: Principal Component Analysis

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Fig 2 exposes two distinct taxonomic relationships. First, OTUs 1, 4 and 2 lies in the positive half of the Y-axis while OTUs 3 and 5 lies in the negative half. Second, OTU 2 and OTU 4 had similarity values lying on the Top Left Hand Side of the graph as against OTU 1 which is distantly placed in the Right Hand Side. This is suggestive of strong affinities between OTUs 3 and 5 on one hand and between OTUs 2 and 4 on the other hand. OTU 5 does not show close homology to any of the other four OTUs.

Cluster analysis utilizing paired group as the algorithm and Euclidean as the measure of similarity confirmed the close relationship established by PCA. The result of the cluster analysis is shown in fig 3

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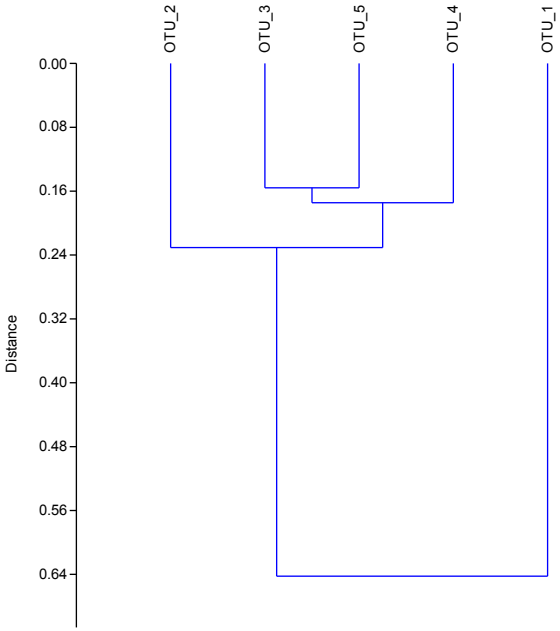

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Fig 3: Cluster Analysis

Three possible analyses could be deduced from the established relationships. OTU 3 and 5 is same Rhizophora species. OTU 2 and 4 though similar are 2 different species. OTU 5 is a distinct Rhizophora species. Put succinctly, there are more than three Rhizophora species in Nigeria contrary to established claims. A fourth species is obvious from this study but could be more.

Lewis 2000 reported controversies on the mangrove types in Nigeria suggesting the possible existence of more than three that are often quoted but confirmed the presence of racemosa and mangle and to a little extent harisonii. Albert and Ekine 2012 and Ebigwai and Akomaye 2014 confirmed the presence of the three species in Rivers state but gave an indication of species type with distance from shoreline. While the report situated racemosa at the fringes of the water bodies, harisonii at the middle and mangle at the upper landward part. Hartoungh 1996 reported differences in the species along soil types. The report reserved the exclusive presence of racemosa on the silty shoreline, harisonii and mangle on the peaty soil and the saline soil supports the growth of scrubby racemosa and harisonii. Onwugbta-Enyi et al 2008 agreed with this categorization. It is inferred from the above reports that Rhizophora types differ with distances away from the shoreline as do soil types. This position strengthens the functionality of salinity differentials as a major criterion for Rhizophora species types. The findings of harisonii on peaty soil and also on saline soil need re examination. Peter and Sivasothi 2001 equated peaty soil with the different loamy soils in the textural triangle. In this study, three morphological indistinct Rhizophora samples were obtained on peaty-loamy soils as shown in plate 1.

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(A) (B) (C)

Plate 6: Rhizophora in Loamy Soil across the Study Areas in Niger Delta

In other mangroves of the world, loamy or peaty soil as it may be called has been shown to support the presence of R. apiculata in Singoparian mangrove (Peter and Sivasothi 2001), Malaysian mangrove (Chandral et al 2011) and Philippians mangroves (Galung et al 2003).

Conclusion

It is evident from this study that there are more than three Rhizophora species in Nigeria, most likely four. More studies is needed to confirm its identity as R apiculata or otherwise.

Recommendation

Samples and the permanent plots established for this study should be further examined for anatomical, morphological and phytochemical analysis. Such studies may reveal more interesting finds.

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