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Pollen morphology of selected true mangrove species in Kerala

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Abstract
A study on pollen morphology of fifteen common Indian mangroves from Kerala mangrove swamps. Pollen consists of 9 genera and 15 species belongs to 10 families of true mangrove species has been investigated by light microscope and scanning electron microscope. In present study all the taxa showed few variations based on the characteristics of apertures, ornamentation, size and shape. Through this study gives rise to an idea about pollen type of true mangrove flora in Kerala. Different pollen shapes encountered are Oblate-Spheroidal to Perprolate. Pollen grains were 3-colpate in *Acanthus*, 3-colporate in *Aegiceras, Avicennia, Bruguiera, Excoecaria, Kandelia, Rhizophora* and *Lumnitzera*, 3-pororate in *Sonneratia.* Exine ornamentation, size and shape of pollen grains are also taken into consider supplementary characters. Present study concluded that most primitive 3-colpate pollen occurs in Acanthaceae*;* while 3-colporate in five families and the most advanced porate condition in Sonneratiaceae. It appears that aperture evolution has most operated in Acanthaceae followed by Sonneratiaceae.

Keywords: Kerala, palynology, true mangroves, pollen morphology, acetolysis

Introduction
Angiosperm pollen is a highly reduced male gametophyte, adapt by higher plants for their reproduction. It forms a specific entity both with regard to form and structure and also function.

Palynology is the study of pollen, spore and other biological materials studied by means of palynological method, including other applications [1]. Pollen morphology gives an advantage for plant classification. It demonstrates the relationship in rank of families, tribes, genera and species [2].

Spores and pollen grains have a number of morphological and ultra structural features. These palynological characters have provided a wealth of characters that have been important in inferring phylogenetic relationship of plants. In addition, the features of spores and pollen grains can often be used to identify a particular plant taxon. The identity, density and frequency of pollen grains at a particular stratigraphic level can give information as to the plant species present at the time and place [3].

Palynological studies may reveal not only the past extent of mangroves, but the changes of environmental conditions over time as well. The establishment of correlation between species composition and extent of mangrove ecosystem over time thus appears to be the most important contribution that palynology can make to the understanding of contemporary mangrove ecosystems, their structure and dynamics [4]. Much has been reported on pollen grains of mangroves [5, 6] mainly on morphological and taxonomical aspects.

Materials and Methods
Materials were collected from mature flowers of well-identified fifteen members. *Acanthus ebracteatus* Vahl., *Acanthuus ilicifolius* Linn., *Aegiceras corniculata* (L.) Blanco, *Avicennia marina* (Forssk.) Vierh., *Avicennia officinalis* L., *Bruguiera cylindrica* (L.) Blume., *Bruguiera gymnorrhiza* (L.) Lam., *Bruguiera sexangula* (Lour.) Poir., *Excoecaria agallocha* L., *Kandelia candel* (L.) Druce., *Lumnitzera recemosa* Willd., *Rhizophora apiculata* Blume., *Rhizophora mucronata* Lam., *Sonneratia alba* Sm., *Sonneratia caseolaris* (L.) Engl were collected. Pollen morphological study was carried out with fresh air dried pollen grains using usual acetolysis method. For Scanning Electron Microscopy (SEM) pollen grains were sputter-coated with gold. The palynological characters were analysed by Nair's terminology. (Nair, 1966).

Result and Discussion
***Acanthus ebracteatus* Vahl**
Pollen grains are 3-zonocolpate, Perprolate. Grain size range (6.80-6.92 X 5.07-5.13 µm). Exine surface reticulate in polar axis and regulate in equatorial side. Colpus margin thick. Operculum present (Fig 1 C).

***Acanthuus ilicifolius* Linn.**
Pollen grains are 3-zono colpate, Prolate, Grain size range (7.40-8.25 X 3.34-3.38 µm) Exine surface reticulate in polar axis and regulate in equatorial side. Colpus margin thick. Operculum present (Fig 1 B).

***Aegiceras corniculata* (L.) Blanco**
Pollen grains are 3-zono colporate, Prolate- Spheroidal. Grain size range (3.24-3.39 X 2.73-2.84 µm) Exine surface punctate in equatorial axis and reticulate in polar axis. Ridges found inside the colpus (Fig 1 A).

***Avicennia marina* (Forssk.) Vierh.**
Pollen grains are 3-zono colporate. Oblate-Spheroidal. Grain size range (4.00-4.42 X 3.58-4.00 µm). Exine surface ornamentation reticulate. Colpus margins smooth. Colpus end tapering and acute (Fig 1 D).

***Avicennia officinalis* L.**
Pollen grains are 3-zono colporate, *Prolate*- Spheroidal. Grain size range (4.91-4.49 X 5.04-5.14 µm). Exine surface ornamentation reticulate. Colpus margins smooth. Colpus end tapering and acute (Fig 1 E).

***Bruguiera cylindrica* (L.) Blume**
Pollen grains are 3-zono colporate, Oblate-Spheroidal. Grain size range (2.53-2.96 X 2.75-2.95 µm). Exine surface ornamentation reticulate in equatorial view and punctate(depressions minute) in polar side; low depressions of various size and shape. Colpus long and colpus membrane granular (Fig 1 G).

***Bruguiera gymnorrhiza* (L.) Lam**
Pollen grains are 3-zono colporate, Oblate-Spheroidal. Grain size range (3.24-3.39 X 2.65-2.93 µm). Exine surface ornamentation reticulate in equatorial view and faintly punctuate(depressions minute) in polar side. Colpus long and wide; colpus membrane granular (Fig 1 H).

***Bruguiera sexangula* (Lour.) Poir**
Pollen grains are 3-zono colporate, *Prolate*- Spheroidal. Grain size range (2.11-2.21 X 1.94-2.10 µm) Exine surface reticulate (Fig 1 I).

***Excoecaria agallocha* L.**
Pollen grains are 3-zono colporate, Oblate-Spheroidal. Grain size range (5.44-5.90 X 4.98-5.74 µm). Exine surface granules present inside the colpus. Ends tapering and acute. Ornamentation reticulate (Fig 1 F).

***Kandelia candel* (L.) Druce**
Pollen grains are 3-zono colporate, Oblate-Spheroidal. Grain size range (2.97-3.81 X 3.03-3.38 µm) Exine surface punctate. colpus long with rounded end and smooth membrane (Fig 1 J).

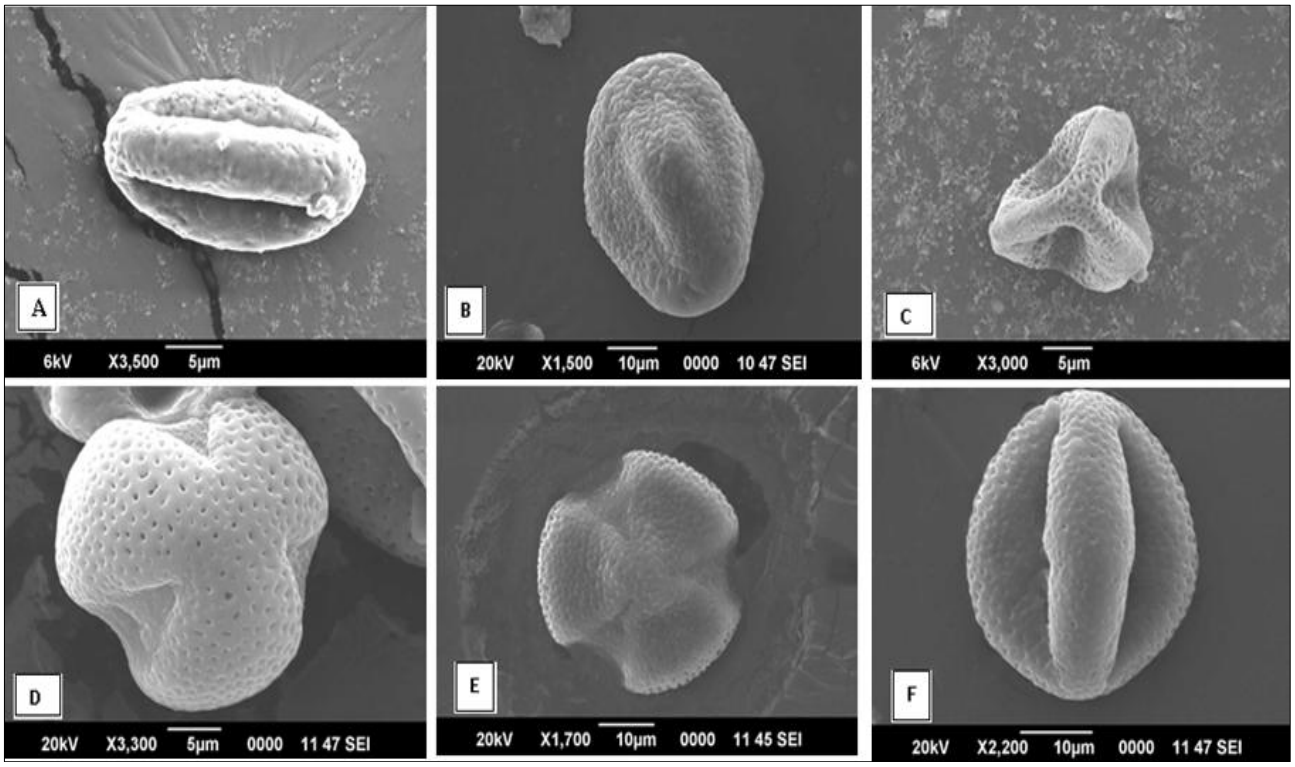
***Lumnitzera recemosa* Willd**
Pollen grains 3-zonocolporate; *Prolate*- Spheroidal in lateral view and hexagonal in polar view; heterocolpate, with three subsidiary colpi; grain size range (2.53-2.63 X 2.09-2.11µm),reticulate (Fig 1 K).

***Rhizophora apiculata* Blume**
Pollen grains are 3-zono colporate, *Subprolate.* Grain size range (3.39-3.67 X 2.84-2.99 µm) Exine surface reticulate at polar side and regulate in equatorial plane. Margins of mesocolpium smooth (Fig 1 L).

***Rhizophora mucronata* Lam**
Pollen grains are 3-zono colporate. *Prolate*- Spheroidal. Grain size range (3.46-4.04 X 3.20-3.70 µm). Exine surface reticulate. colpus membrane smooth (Fig 1 M).

***Sonneratia alba* Sm**
Pollen grains are 3-zonoporate, Subprolate. Grain size range (6.66-6.69 X 4.44-4.99 µm). three well-developed ridges alternate with three apertural fields; aperture circular. Exine surface exine surface is verrucate in the apertural fields and verrucate-rugulate in the ridges. Each apertural field has a protruding pore at the centre smaller ridges are present, in each apertural field. These are parallel to the larger ridges and have a rugulate surface (Fig 1 N).

***Sonneratia caseolaris* (L.) Engl**
Pollen grains are 3-zonoporate, Prolate. Grain size range(6.25-6.50 X 3.29-3.46 µm) Exine surface aperture circular in ridges and apertural fields less prominent than in *S.alba*, but the apertures much protruding than *S.alba*. The exine surface ornamentation reticulate (Fig 1 O).



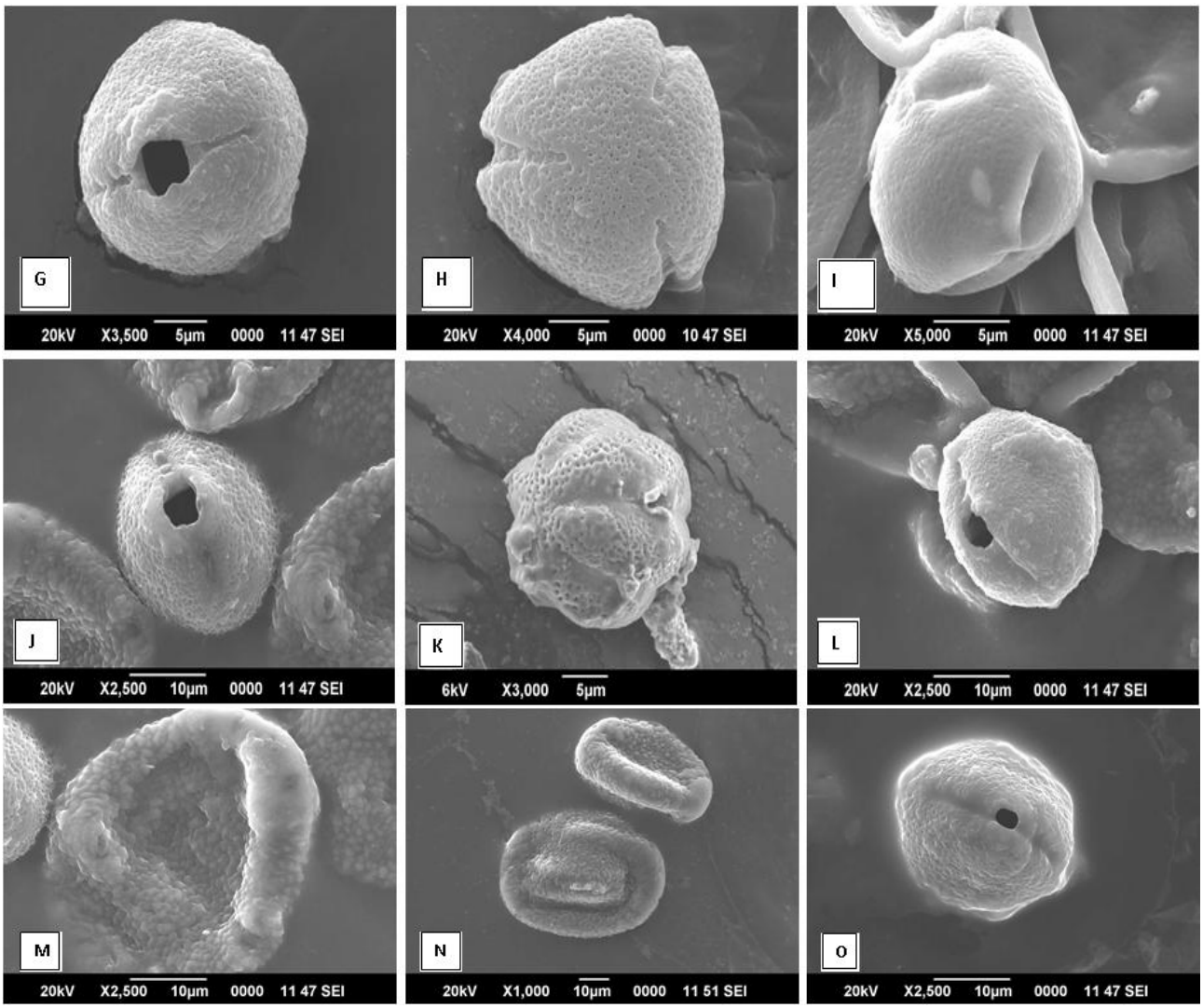


Fig 1(A-O): SEM images of pollen grain; A: *Aegiceras corniculata;* B: *Acanthuus ilicifolius;* C: *Acanthus ebracteatus*; D: *Avicennia marina*; E: *Avicennia officinalis;* F: *Excoecaria agallocha*; G: *Bruguiera cylindrica;* H: *Bruguiera gymnorrhiza;* I: *Bruguiera sexangula;* J: *Kandelia candel*; K: *Lumnitzera recemosa;* L: *Rhizophora apiculata;* M: *Rhizophora mucronata;* N: *Sonneratia alba;* O: *Sonneratia caseolaris.*

Table 1: A summary of the main morphological characteristics and size measurements specimens examined (µm)

Species/Genous	Family	Aperature	Ornamentation	PXE	P/E
Acanthuus ilicifolius Linn.	Acanthaceae	3-zonocolpate	reticulate	7.40-8.25 X 3.34-3.38	7.62-3.25
Acanthus ebracteatus Vahl.	Acanthaceae	3-zonocolpate	reticulate to regulate	6.80-6.92 X 5.07-5.13	7.03-4.62
Aegiceras corniculata (L.) Blanco	Myrsinaceae	3-zonocolporate	punctate to reticulate	3.24-3.39 X 2.73-2.84	11.16-1074
Avicennia marina (Forssk.) Vierh.	Avicenniaceae	3-zonocolporate	reticulate	4.00-4.42 X 3.58-4.00	4.74-4.21
Avicennia officinalis L.	Avicenniaceae	3-zonocolporate	reticulate	4.91-4.49 X 5.04-5.14	4.92-4.09
Bruguiera cylindrica (L.) Blume.	Rhizophoraceae	3-zonocolporate	reticulate to punctate	2.53-2.96 X 2.75-2.95	2.84-3.06
Bruguiera gymnorrhiza (L.) Lam.	Rhizophoraceae	3-zonocolporate	reticulate to punctate	3.24-3.39 X 2.65-2.93	2.27-2.25
Bruguiera sexangula (Lour.) Poir.	Rhizophoraceae	3-zonocolporate	reticulate	2.11-2.21 X 1.94-2.10	12.23-11.81
Kandelia candel (L.) Druce.	Rhizophoraceae	3-zonocolporate	punctate	2.97-3.81 X 3.03-3.38	2.94-2.58
Lumnitzera recemosa Willd.	Combretaceae	3-zonocolporate	reticulate	2.53-2.63 X 2.09-2.11	2.94-2.84
Rhizophora apiculata Blume.	Rhizophoraceae	3-zonocolporate	reticulate to regulate	3.39-3.67 X 2.84-2.99	4.14-3.15
Rhizophora mucronata Lam.	Rhizophoraceae	3-zonocolporate	reticulate	3.46-4.04 X 3.20-3.70	3.09-2.81
Excoecaria agallocha L.	Euphorbiaceae	3-zonocolporate	reticulate	5.44-5.90 X 4.98-5.74	4.26-4.24
Sonneratia caseolaris (L.) Engl.	Sonneratiaceae	3-zonoporate	reticulate	6.25-6.50 X 3.29-3.46	6.49-4.32
Sonneratia alba Sm.	Sonneratiaceae	3-zonoporate	verrucate-rugulate	6.66-6.69 X 4.44-4.99	6.40-4.80

PXE = Polar grain size showing mean for polar axis (P) and equatorial diameter (E), P/E = shape of the pollen grain expressed in ratio.

Conclusion

Because of variation of 15 taxa in included in this study, there is a notable variation of pollen morphology of true mangrove flora in Kerala. It can be divided into mainly 9 pollen types based on characteristic of apertures, shapes and ornamentations. Although each pollen types might have variations in pollen morphology, the result of this study gives rise to an idea about pollen types of true mangrove flora in

Kerala. Moreover, the constructed key to pollen types and the pollen type short descriptions can be used as a tool to identify plant species

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