EPIDERMAL STUDIES IN EOPHYLLS (JUVENILE LEAVES) OF SOME ARECOID PALMS

S. K. BASU AND SAIBAL BASU

Botanical Survey of India, Howrah

ABSTRACT

The eophylls in palms are morphologically very consistent for each palm group and they show remarkable distinguishing characters. Epidermal studies on the eophylls of sixteen Arecoid palms show that in all, five different types of epidermal complexes can be recognised within the group and this information is of taxonomic importance.

INTRODUCTION

The post cotyledonary leaves or the plumular leaves in palms are generally bladeless, sheathing and scale-like and their number is more or less constant in each species. The first foliage leaf which develops in palm seedlings is termed as 'eophyll'. Its shape is varied and constant which in turn offers a good diagnostic character. Tomlinson (1960) cited three major shapes of eophylls and on the basis of their relationship with the adult leaves, categorised eleven distinct types.

The arecoid group palms are composed of 88 genera and 760 species (Moore Jr. 1973) and have distribution in the humid tropics of both the eastern and western hemispheres. Eophylls of most of the arecoid palms are bilobed, entire in Roystonea or pinnately compound in Howeia and Reinhardtia (Tomlinson 1961). The anatomy of leaves in palms and stomata in particular, has been studied by many workers. Among others, Tomlinson (1961) made a detailed morphological study of stomata, trichomes etc. of twentyfive arecoid species. Bavappa (1966) also made detailed observation on the epidermal characters of two arecoid species, Areca catechu Linn. and A. triandra Roxb.

Ghosh and Davis (1973) studied stomata and trichome characters in adult and juvenile leaves of Areca catechu Linn. along with six non-arecoid palms. The present study on 16 arecoid palms was undertaken to place on record further information on the epidermis of eophylls and the nature of stomatal complex. The resulting data have been evaluated in respect of their taxonomic importance.

MATERIALS AND METHODS

The eophylls from the arecoid species, namely, Areca triandra Roxb., A. macrocalyx Zipp. ex Bl., Archontophoenix alexandrae (F. Muell.) Wendl. et Drude, A. cunninghamiana Wendl. et Drude, Bentiokia nicobarica (Kurz) Becc., Carpentaria acuminata Becc., Chrysiodocarpus madagascariensis Becc., C. madagascariensis var. lucubensis Hort., Dictyosperma album (Bory) Wendl., Normanbya normanbyi (Hill) Bailey, Hydrasie Leone wendlandiana (F. Muell.) Wendl. et Drude, Ptychosperma macarthurii (Wendl.) Nichols., Rhopaloblaste augusta (Kurz) Moore, Roystonea borinquena Cook, R. regia (H.B.K.) Cook, Veitchia merrillii (Becc.) Moore, were collected from the seedlings raised at the Plant Introduction Nursery of the Indian Botanic Garden, Howrah, between the years 1971 to 1975. The seeds of Areca macrocalyx and
Normanbya normanbyi were collected by the senior author from the Central Plantation Crops Research Institute's Experimental Station at Vittal, South Kanara. Seeds of Hydriastele wendlandiana, Archontophoenix alexandrae and Carpentaria acuminata were obtained from Singapore Botanic Garden. Seeds of Roystonea borinquena and Veitchia merrillii were respectively received from Florida and Philippines. Seeds of the rest of the palms were from the Indian Botanic Garden's own collections. The seeds were sown by the method adopted by Basu and Mukherji (1972) and eophylls from seedlings of each species were collected and preserved in two sets, one set of voucher specimens deposited in the Garden Herbarium and the other set bearing the same collection numbers were fixed in F.A.A. for twentyfour hours and stored in 9:1 solution of ethyl alcohol and 10% glycerin. Before peeling, the middle portion of each eophyll was cut into small sectors and thoroughly washed in running water for five minutes.

The clearing technique was followed from Ghose and Davis (1973) with little modification. The cleared epidermal sectors were stained in Safranin and Light green, dehydrated in 70% ethyl alcohol and mounted on glass slides in glycerin jelly. The cover slips were sealed with melted paraffin. The frequency of stomata and trichomes were calculated from field of $1 \times 1$ square; measurement of guard cells, trichomes, epidermal cells and camera lucida drawings and microphotographs were made with eyepiece objective combination of $15 \times 20$. The stomatal indices were calculated separately for adaxial and abaxial surfaces of all the sixteen arecoid species from a mean of ten observations. The description of eophylls was made from mounted specimens.

**Observation**

*Areca triandra* Roxb.

**Morphology:** Eophyll bilobed, lobes 10.0-13.0 cm long, 1.0-1.3 cm broad at the middle, two halves unequal one slightly broader, lanceolate, apex acute.

*Abaxial epidermis:* Stomata intercostal, irregular, widely spaced; lateral sub-cells 2, polar cells not distinct, slightly shorter than the epidermal cells and arching on the guard cell. Intercostal cells irregular, cell walls not sinuous. Costal cells uniformly elongated. Trichomes both costal and intercostal, longer than the stomata, cells sclerosed.

---


*Adaxial epidermis:* Guard cells of the stomata wide. Epidermal cells rhombohedral, straight walled. Trichomes mostly intercostal spherical to oval in shape, 2-3 sclerosed basal cells distinct.

**Material examined:** Basu 211, 271, 258.

*A. macrocalyx* Zipp. ex Blume

**Morphology:** Eophyll broadly bilobed about 12.0 cm long, 3.0 cm broad at the middle, prominently 6 nerved, apex obtuse.
Abaxial epidermis: Stomata intercostal in files; guard cells wide, lateral sub-cells 2, polars triangular in shape, short, arching on the guard cell, stomata a few on the costa with 4 lateral sub-cells, outer sub-cells double in size of the inner. Intercostal cells trapezoid, straight walled. Costal cells elongated in files, cell walls thick, oblique or straight. Trichomes costal and intercostal, cells sclerosed, distinct, costal trichomes much larger with multicellular bases.

Adaxial epidermis: Stomata and trichomes absent. Epidermal cells rhombohedral.

Materials examined: Basu 201.

Archontophoenix cunninghamiana Wendl. et Drude

Morphology: Eophyll bilobed, lobes 17.0-17.5 cm long, 1.5-1.6 cm broad at the middle, prominently 5 nerved, apex acuminate.

Abaxial epidermis: Stomata intercostal not in files; lateral sub-cells 2, distinct, parallel to the guard cells; polars not always distinct either spherical to oval or triangular. Intercostal cells irregular to slightly hexagonal. Costal cells elongated thick walled. Trichomes costal and intercostal; costal trichomes wider at the base, composed of 6-8 sclerosed cells.

Adaxial epidermis: Stomata and trichomes absent. Epidermal cells hexagonal, straight walled.


Bentinckia nicobarica (Kurz) Becc.

Morphology: Eophyll narrowly bilobed, lobes 14.0-16.0 cm long, 1.5 cm broad at the middle apex acuminate and toothed.

Abaxial epidermis: Stomata intercostal not in files; guard cells with thick outer walls, lateral sub-cells 2, or sometimes more, polars not distinct. Intercostal cells irregular in shape. Costal cells more or less uniformly rectangular in files. Trichomes costal and intercostal spherical in surface view, cell walls sclerosed.

Adaxial epidermis: Stomata and trichomes absent. Epidermal cells rhombohedral and straight walled.

Material examined: Basu 203.

Bentinckia nicobarica (Kurz) Becc.

Morphology: Eophyll bilobed, lobes 9.5 cm long, 1.5 cm broad at the middle, prominently 5 nerved, apex obliquely dentate.

Abaxial epidermis: Stomata intercostal not in files; guard cells with sinuous outer walls, lateral sub-cells 2, rarely 3, polars distinct. Intercostal cells elongated in files with sinuous walls. Costal cells uniform, cell walls deeply sinuous. Trichomes intercostal closely packed, oval in surface view, composed of 3 thick walled cells.

Adaxial epidermis: Stomata a few. Intercostal cells rhombohedral with slightly sinuous walls. Costal cell rectangular, cell walls deeply sinuous. Trichomes on the costa a few, cells not differentiated in surface view.

Material examined: Basu 261.

Carpentaria acuminata Becc.

Morphology: Eophyll bilobed, lobes 9.1 cm long, 8 mm broad at the middle, prominently 5 nerved, apex acute.

Abaxial epidermis: Stomata intercostal not in files; lateral sub-cells 2, polars dis-
Intercostal bands wide composed of long rectangular cells with oblique partition walls. Trichomes absent.

Adaxial epidermis: Stomata intercostal, widely spaced, smaller; guard cells with sinuous outer walls; lateral sub-cells 2, polar distinct, slightly arcing on the guard cells. Intercostal bands wide composed of rhombohedral to fusiformed cells in files. Costal cells narrowly elongated. Trichomes absent.

Materials examined: Basu 251, 216.

Chrysalidocarpus madagascariensis var. lucensis Hort.

Morphology: Eophyll bilobed; lobes 10.6 cm long, 1.5 cm broad at the middle, prominently 5 nervet, apex bifid and toothed.

Abaxial epidermis: Stomata intercostal irregular; lateral sub-cells 2, polar slightly arcing on the guard cells, oblique at opposite ends. Intercostal cells irregular to rhombohedral, straight walled. Costal cells elon-
gated in files, shorter walls oblique. Trichomes absent.

*Adaxial epidermis:* Stomata a few, mostly costal. Intercostal cells rhombohedral straight walled. Trichomes absent.

*Materil examined:* Basu 221, 250

**Dictyosperma album** (Bory) Wendl.

*Morphology:* Eophyll bilobed, lobes 12.5 cm long, 1.5 cm broad at the middle, prominently 5 nerved, apex truncate.

*Abaxial epidermis:* Stomata intercostal not in files; lateral sub-cells 2, nearly double the size of the guard cells. Intercostal cells rectangular to hexagonal, cell walls straight. Costal cells rectangular, elongated in files. Trichomes costal with multicellular bases, cell walls not distinct.

*Adaxial epidermis:* Stomata intercostal irregular, cell walls straight. Costal cells rectangular. Trichomes absent.

*Materil examined:* Basu 236.

**Normanbya normanbyi** (Hill) Bailey

*Morphology:* Eophyll bilobed, lobes 12.5 cm long, 2.5 cm broad at the middle, apex obliquely dentate.

*Abaxial epidermis:* Stomata intercostal in files; sub-cells 2, polars distinct slightly arching on the guard cells. Intercostal cells irregular fusiformed or in shape, cell walls deeply sinuous. Costal cells rectangular, elongated in files, narrower than intercostal cells, walls deeply sinuous. Trichomes both costal and intercostal.

*Adaxial epidermis:* Stomata a few, guard cells with thick sinuous walls. Intercostal cells fusiformed; longer walls sinuous. Costal cells rectangular in files; longer walls deep sinuous. Trichomes absent.

*Materil examined:* Basu 202, 248.

**Hydrastele wendlandiana** (F. Muell.) Wendl. et Drude

*Morphology:* Eophyll bilobed, lobes 12.6 cm long, 1.5 cm broad at the middle, apex narrowly truncate.

*Abaxial epidermis:* Stomata intercostal in files, sub-cells 2, distinct, polars arching on the guard cells. Intercostal cells regularly rhombohedral, straight walled. Costal cells rectangular, elongated and straight walled. Trichomes costal, oval shaped in surface view, cells not distinct.

*Adaxial epidermis:* Stomata a few or absent. Epidermal cells rhombohedral. Trichomes mostly on the costa, intercostal trichomes a few.

*Materil examined:* Basu 246.

**Ptychosperma macarthuri** (Wendl.) Nichols

*Morphology:* Eophyll bilobed; lobes 12.5 cm long, 2.5 cm broad at the middle, apex truncate.

*Abaxial epidermis:* Stomata in files close to the costa; lateral sub-cells 2, much wider than the guard cells, polars slightly arching, not always differentiated. Intercostal cells irregular in wide bands. Costal cells elongated in files with oblique partition walls, straight or sometimes sinuous. Trichomes oval in surface view, cells sclerosed; distinct.

*Adaxial epidermis:* Stomata a few near the costa. Intercostal cells with deeply sinuous walls. Costal cells uniformly elongated in files, longer walls sinuous. Trichomes absent.

*Materil examined:* Basu 245.

**Rhiz腓e augusta** (Kurz) Moore

*Morphology:* Eophyll imparipinnate, 7.0-11.0 cm long, leaflets usually 13, terminal leaflet bilobed, lobes 5.0-6.0 cm long, 4.5 cm broad.

*Abaxial epidermis:* Stomata intercostal, irregular, not in file. Intercostal bands wide, composed of fusiformed cells; cell walls sinuous, some central cells in the intercostal band straight walled. Costal cells rectangular to rhombohedral with deeply sinuous longer walls. Trichomes both costal and intercostal; cells sclerosed, not distinct.

*Adaxial epidermis:* Stomata absent. Intercostal and costal cells have distinct deeply sinuous walls. Trichomes abundant on the costa.

*Materil examined:* Basu 247.
Roystonea borinquena Cook

Morphology: Eophyll solitary, entire, linear-lanceolate, 21.3 cm long, 1.1 cm broad at the middle; midnerve prominent, apex narrowly truncate.

Abaxial epidermis: Stomata intercostal, widely spaced, in files; lateral sub-cells 2, wider than the guard cells, polars larger, indistinct but arching on the guard cells. Intercostal cells much elongated, narrow with oblique partition walls. Costal cells rectangular and straight walled. Trichomes absent.

Adaxial epidermis: Stomata a few. Epidermal cells rectangular, longitudinally extended. Trichomes absent or a few.

Materials examined: Basu 213, 249.

Roystonea regia (H.B.K.) Cook

Morphology: Eophyll solitary entire, linear-lanceolate, 22.0 cm long, 1.3 cm broad at the middle, apex acuminata.

Abaxial epidermis: Stomata intercostal in files; lateral sub-cells wider than the guard cells, polars sometimes triangular, arching on the guard cells. Stomata with a common polar cell frequent. Intercostal cell irregularly elongated. Costal cells in files with oblique partition walls. Trichomes absent.

Adaxial epidermis: Stomata intercostal, polar cells indistinct but arching on the guard cells. Costal and intercostal cells distinctly elongated. Trichomes have multicellular bases.

Materials examined: Basu 253.

Veitchia merrillii (Becc.) Moore

Morphology: Eophyll bilobed, lobes equal in length, 12.5-13.0 cm long, 2.2 cm broad at the middle, apex truncate.

Abaxial epidermis: Stomata intercostal not in files; lateral sub-cells 2, deeply curved, polar cells small, oval, slightly arching on the guard cells. Intercostal cells rectangular to rhombohedral or fusiformed, longer walls sinuous. Costal cells rectangular in files, cell walls deeply sinuous. Trichomes only on the costa.

Adaxial epidermis: Stomata absent or a few near the costal bands. Epidermal cells rectangular to rhombohedral, cell walls deeply sinuous. Trichomes absent.

Materials examined: Basu 209.

STOMATAL FREQUENCIES AND MEASUREMENT OF GUARD CELLS

Stomatal frequencies from 1 mm square of the adaxial and abaxial epidermis of eophylls of sixteen arecoid species were cal-
culated with a lens combination of 15 x 20, the observations were recorded in Table-I. The frequency of stomata on the abaxial side ranges from 15 to 25 per unit area except in Roystonea borinquena where number of stomata was 9.2 only. The length of guard cells shows that Dictyosperma album has the smallest guard cells and Rhopaloblaste augusta has the largest. The cutinised ledges (Tomlinson 1961) are prominent in guard cells.

### TABLE 1

<table>
<thead>
<tr>
<th>St. No.</th>
<th>Name</th>
<th>Stomatal indices</th>
<th>Stomatal frequency</th>
<th>Epidermal cells</th>
<th>Trichomes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adaxial</td>
<td>Abaxial</td>
<td>Adaxial</td>
<td>Abaxial</td>
<td>Length</td>
</tr>
<tr>
<td>1</td>
<td>Areca triandra</td>
<td>1.8</td>
<td>4.0</td>
<td>1.6</td>
<td>15.62</td>
</tr>
<tr>
<td>2</td>
<td>Areca macrocalyx</td>
<td>Nil</td>
<td>3.5</td>
<td>Nil</td>
<td>15.6</td>
</tr>
<tr>
<td>3</td>
<td>Dictyosperma album</td>
<td>Nil</td>
<td>5.4</td>
<td>Nil</td>
<td>23.5</td>
</tr>
<tr>
<td>4</td>
<td>Rhopaloblaste augusta</td>
<td>Nil</td>
<td>5.0</td>
<td>Nil</td>
<td>16.25</td>
</tr>
<tr>
<td>5</td>
<td>Roystonea regia</td>
<td>9.0</td>
<td>8.2</td>
<td>6.25</td>
<td>25.0</td>
</tr>
<tr>
<td>6</td>
<td>R. borinquena</td>
<td>0.05</td>
<td>3.4</td>
<td>3.3</td>
<td>9.9</td>
</tr>
<tr>
<td>7</td>
<td>Carpentaria acuminata</td>
<td>2.8</td>
<td>8.1</td>
<td>1.1</td>
<td>15.9</td>
</tr>
<tr>
<td>8</td>
<td>Normanbya normanbyi</td>
<td>0.7</td>
<td>7.7</td>
<td>1.9</td>
<td>22.5</td>
</tr>
<tr>
<td>9</td>
<td>Archontophoenix alexandrae</td>
<td>Nil</td>
<td>5.2</td>
<td>Nil</td>
<td>15.2</td>
</tr>
<tr>
<td>10</td>
<td>A. cunninghamiana</td>
<td>Nil</td>
<td>5.2</td>
<td>Nil</td>
<td>18.7</td>
</tr>
<tr>
<td>11</td>
<td>Psychosperma macarthurii</td>
<td>1.4</td>
<td>8.6</td>
<td>1.4</td>
<td>26.8</td>
</tr>
<tr>
<td>12</td>
<td>Benzoinia nicobarica</td>
<td>1.7</td>
<td>7.8</td>
<td>6.2</td>
<td>28.1</td>
</tr>
<tr>
<td>13</td>
<td>Hydriastele wendlandiana</td>
<td>0.9</td>
<td>3.6</td>
<td>3.7</td>
<td>12.5</td>
</tr>
<tr>
<td>14</td>
<td>Veitchia merrillii</td>
<td>Nil</td>
<td>5.2</td>
<td>Nil</td>
<td>15.6</td>
</tr>
<tr>
<td>15</td>
<td>Chrysalidocarpus magdascariensis</td>
<td>2.4</td>
<td>7.3</td>
<td>5.2</td>
<td>18.7</td>
</tr>
<tr>
<td>16</td>
<td>C. magdascariensis var. lucubensis</td>
<td>2.7</td>
<td>11.5</td>
<td>10.5</td>
<td>21.0</td>
</tr>
</tbody>
</table>

The stomatal index from the abaxial epidermis of arecoid palms shows a range of 3.5 to 11.5 and Areca macrocalyx, Roystonea borinquena, Hydriastele wendlandiana, Areca triandra, have relatively low index number. The stomatal indices were in the higher range found in Chrysalidocarpus magdascariensis var. lucubensis, Psychosperma macarthurii, Roystonea regia and Carpentaria acuminata. Stomata absent in the adaxial side of six arecoid species, the rest shows a comparatively low stomatal index number.

**DISCUSSION**

Observations from the adaxial and abaxial epidermis of sixteen arecoid palms show the tetracytic type of stomata and a majority of them are irregularly arranged in the intercostal region. The concentration of stomata is higher in the abaxial side which is in conformity with the stomatal arrangement found in their adult leaves. Areca macrocalyx, Normanbya normanbyi, Psychosperma macarthurii, Hydriastele wendlandiana, Roystonea borinquena and R. regia, however, show stomata in files. Tomlinson (1961) reported that in arecoid genera Archontophoenix, Dictyosperma and a few others, stomatal arrangement is in files in the adult leaves. In our observations an irregular arrangement of stomata was noted in the eophylls of these two species. Ghose and Davis (1973) have pointed out from their comparative studies in the juvenile and adult leaves of eight palm species that the number of stomata per unit area increases manifold in the adult leaves (exception only in Hyphaene thebaica). The subsidiary cells are basically four in the stomata of arecoid palms, the lateral subsidiary cells having walls of various thickness, the polar cells, two in numbers being not always dis-
tinct from the adjoining epidermal cells but variously arching on the guard cells. Stebbin and Khus (1961) observed 2, 4 and 6 subsidiary cells in palms. According to them, four subsidiary cells having two laterals and two roundish polar cells are characteristic of the adult leaves of *Phoenix*, *Washingtonia* and others. Their observation in juvenile leaf of *Phoenix* shows an increased number of subsidiary cells. Ghose, and Davis (1974), however, did not find change in the number of subsidiary cells in the juvenile and adult leaves in *Phoenix sylvestris*.
The adaxial and abaxial epidermal cells from the eophylls show two distinct cell-wall types. The sinuous condition is mostly restricted to the anticlinal walls and found in *Carpentaria acuminata*, *Normanbya nor- manbyi* and *Rhopaloblaste augusta*. In *Ptychosperma macarthurii* and *Veitchia merrillii*, only the adaxial epidermal cells show sinuous anticlinal walls. These sinuous epidermal cells are a characteristic of the Lepidocaryoid, Coryphoid and Borassoid palms and to some extent of the Phoenicoid palms. The sinuous nature is due to cuticular deposits on the anticlinal walls (Torn- linson 1961).

Along the straight-walled types both *Roystonea regia* and *R. borinquena* have the characteristic long narrow epidermal cells which isolate this genus in the arecoid group. On the basis of the nature of the adaxial epidermal cells the palms studied can be distinguished into the following categories:

- **A. Adaxial epidermal cells rectangular, longitudinally extended**
  - *Rhopaloblaste augusta*, *Ptychosperma macarthurii*, *Veitchia merrillii*
  - *Carpentaria acuminata*, *Normanbya nor- manbyi*.

- **B. Adaxial epidermal cells rhombohedral, anticlinal walls sinuous**

- **C. Adaxial epidermal cells rhombohedral, straight walled**
  - *Archontophoenix*.

- **D. Adaxial epidermal cells hexagonal, straight-walled**
  - *Roystonea regia*, *R. borinquena*.

**Eophyll characters** have long been recognised in the diagnosis of palm taxa (Cook, 1935; Eames, 1953; Moore, 1957, 1973; Wessel Boer, 1965). As shown above, the epidermal characters of the eophylls seem to be equally of significance in the taxonomy of the palms.

**ACKNOWLEDGEMENTS**

We express our thanks to Dr. T. A. Davis, Coconut Agronomist, F.A.O., L.P.T.I., Jalan Siswa Barat, North Sulawesi, Indonesia; Dr. N. M. Nayar, Joint Director, Central Plantation Crops Research Institute, Vittal, South Kanara, Karnataka and the Director, Botanical Gardens, Singapore for supply of arecoid palm seeds. We are also grateful to the Deputy Director, Indian Botanic Garden, Howrah for providing facilities in the department and to Shri C. C. Mukherji for solving photographic problems. We express our gratitude to the Director, Botanical Survey of India for his encouragement on palm studies.

**REFERENCES**


