

ACHENE MORPHOLOGY AND ITS TAXONOMIC SIGNIFICANCE IN CYPERACEAE OF GOA, INDIA: 1. GENUS *FIMBRISTYLIS*

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ABSTRACT

Achene morphology of 21 species of *Fimbristylis* in Goa is elucidated by examining the achenes under light microscope and by interpreting the Scanning Electron Microscope (SEM) images. Achene shape, size and epidermal patterns were found distinctive and consistent for each taxon. Achenes in *Fimbristylis* are lenticular or trigonous and of different shapes, viz. obovate, obovoid, orbicular or linear-oblong. Achene surface is smooth or verruculose or tubercled, reticulate by the hexagonal or roundish epidermal cells or lineolate when the epidermal cells are linear. Surface is often trabeculate with longitudinal ribs connected by cross bars. Variation of epidermal cells is most evident with respect to size of the cell, nature of periclinal wall, and the number, thickness and sinuosity of anticlinal walls per cell. In the present study characteristics of epidermal cells are correlated with other morphological characters as well. The micromorphological characters of achene surface were found to be different in dissimilar taxa. However, there is close similarity of these characters in closely related taxa. Interpretation of the SEM images was found to be useful in determining the taxonomic relationship, identification and delimitation of different taxa of *Fimbristylis* at species level and infraspecific level.

Keywords: *Fimbristylis*, Goa, Achene Morphology, Anticlinal Wall, SEM Images

INTRODUCTION

The sedge family or Cyperaceae is one of the largest families of flowering plants and is the third largest of monocotyledons after Orchidaceae and Poaceae. According to Reznicek (1990) it is probably the seventh largest family worldwide. Bruhl (1995) estimated approximately 5,000 species of Cyperaceae in about 80 genera and Goetghebeur (1987, 1998) included same number of species under 104 genera. However, according to Mabberley (2009) there are 4450 species under 92 genera. Karthikeyan *et al.*, (1989) listed 537 species and 92 varieties of Cyperaceae under 38 genera in India and this number was later updated as 580 species under 39 genera (Karthikeyan, 1999). Singh & Prasad (2001) estimated about 570 species of 39 genera in India and at present it is estimated that the family comprises 580 belonging to 32 genera. In Goa, the family is represented by 105 taxa comprising 94 species, 2 subspecies and 9 varieties under 16 genera. The family is characterized by the achene type of fruits. Achene in sedges shows considerable diversity in their shape, size, colour, ornamentation and epidermal microstructures. Most of the achene characters are stable and hence reliable in the taxonomy of Cyperaceae. Size of the achene varies from species to species or at infra-specific level. Similarly, colour of the achene varies as different shades of brown, black, yellow and white. Even bluish achenes are found in the genus *Scleria*. Colour of the achene is not always very significant in identification of the species, because of the transitional change in colour as the achene matures. However, colour of the fully matured achene is dependable in identification. Surface structure of the achene varies from species to species or at infra-specific level. The surface can be smooth or with different kinds of ornamentations, viz. punctulate, verrucose, trabiculate, pitted, zonate or tessellate. The achenes of *Fimbristylis dipsacea* is characterized by some prominent glandular outgrowths. In *Bulbostylis* achenes are crowned by a button-like structure formed by the persistent style base. Presence of a disc-like or cup-like hypogynium is an important feature of the achenes in *Scleria*. The shape and size of these hypogynium are dependable in the identification of species in this genus.

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The genus *Fimbristylis* was established by Vahl (1805) by segregating species from *Scirpus*, which have spirally arranged glumes and flat, ciliate, distigmatic, deciduous style with enlarged base. He erected the genus *Abildgaardia* for the species having same flower structure, but with distichous glumes. However, Brown (1810) recognized the deciduous style articulated with the achene as the essential character of the genus *Fimbristylis* and added several tristigmatic Australian species to it. It is the fourth largest genus of the family Cyperaceae, having about 306 species distributed worldwide in tropical and temperate zones (Govaerts *et al.*, 2007). There are about 115 species in India and 21 in Goa.

Vartak (1966) highlighted the importance of achene morphology in the classification of sedges. But he followed conventional method to study the morphology of achenes. As described by Schuyler (1971), achenes in sedges show a considerable amount of cell diversity which provides taxonomically useful information. Varma *et al.*, (1989) studied the epidermal surface patterns of the achenes in *Eleocharis*. Govindrajalu (1990) studied SEM images of *Pycreus* sect. *Muricati* and Wujek *et al.*, (1992) studied the achene micromorphology of some Indian species of *Cyperus*, *Fimbristylis*, *Pycreus*, *Scirpus* and *Scleria*. Also Menapace *et al.*, (2003) studied the achene micromorphology of some Indian species as a possible systematic aid to the taxonomic recognition of different sections in *Fimbristylis*. In the present study achene morphology of all the 21 taxa of *Fimbristylis* in Goa has been studied and interpreted for their similarities and dissimilarities.

MATERIALS AND METHODS

Achene samples were collected from the plant samples collected from different localities in Goa. The specimens collected were identified utilising available facilities in Botanical Survey of India, Pune and the herbarium in Goa University. The herbarium specimens from which achene samples were taken are deposited in BSI, except 2 in the Goa University Herbarium. For better result, fully matured specimens were selected to study the morphology of achene by conventional method using stereo microscope and by the advanced method of interpreting the Scanning Electron Microscope (SEM) images. The shape and size of the achenes of each species were recorded and the micro structure of the achene surface was studied using SEM images. For this, achenes were extracted from the spikelets and mounted on glass slides with sticky tape, mounted on SEM stubs and then sputter coated with platinum and examined under JOEL JSM6360 Scanning Electron Microscope. The images were then photographed at different magnifications. The SEM images of achenes of different species thus obtained were then interpreted with the help of relevant literature. Achene shape, size, its ornamentations and micro-epidermal structures such as periclinal wall, anticlinal wall and silica bodies were studied to find out the similarities or dissimilarities.

RESULTS AND DISCUSSION

A brief account of the important findings is depicted in Table 1 and the SEM images of the achenes are shown in plate 1 to 4.

In *Fimbristylis*, the style is articulated with the ovary but deciduous without leaving a button-like structure of style base on the achene. However, in *Bulbostylis*, a closely related genus the style base is persistent, leaving a button-like thickening at the apex of achene. In general, achene is biconvex or trigonous in *Fimbristylis* and the shape varies from obovoid to orbicular or at times linear-oblong. Achene of most species in Goa are biconvex, they are *F. acuminata*, *F. aestivalis*, *F. albiviridis*, *F. cymosa*, *F. dichotoma*, *F. ferruginea*, *F. merrillii*, *F. polytrichoides*, *F. pubisquama*, *F. schoenoides*, *F. tetragona* and *F. tomentosa*. Trigonous achenes are found in *F. lawiana*, *F. littoralis*, *F. ovata*, *F. tenera* and *F. woodrowii*. The largest achene was found in *F. ovata* (2-2.5 x 1.3-1.52 mm) and the smallest in *F. lawiana* (c. 0.52 x 0.19 mm). Out of the 21 species of *Fimbristylis* in Goa, SEM images of the achenes of 17 species were studied. Achene surface is reticulate when the epidermal cells are hexagonal or roundish, and lineolate when the epidermal cells are linear. Achene surface shows distinct differences among the species with respect to ornamentations, and in nature of the anticlinal and periclinal wall. Silica bodies are absent in the epidermal cells in all the species.

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Table 1: Macro- and Micromorphology of achenes in the genus *Fimbristylis*

Sr. No.	Plant Name and Voucher Specimen	Macromorphology	Micromorphology
1.	<i>Fimbristylis acuminata</i> Vahl R.T. Patil 192700 (BSI). PLATE: 1	Biconvex with obtuse edges, obovate-orbicular, obtuse at apex, minutely stipitate, 1.97 x 1.63 mm.	Surface reticulate, with 5-8 wavy irregular transverse ridges. Epidermal cells distinct on ridges while inconspicuous in furrows, isodiametric, pentagonal or hexagonal; anticlinal wall thin, straight; periclinal wall smooth, flat, without silica bodies.
2.	<i>Fimbristylis aestivalis</i> Vahl R.T. Patil 3016 (BSI). PLATE:1	Biconvex, obovate-elliptic, obtuse at apex, short-stipitate at the cuneate base, 0.52 x 0.32 mm.	Epidermal cells in longitudinal rows, transversely elongated, hexagonal; anticlinal wall thick, straight, raised; periclinal wall smooth, slightly concave, with pits.
3.	<i>Fimbristylis alboviridis</i> C.B. Clarke R.T. Patil 192602 (BSI). PLATE: 1	Biconvex, obovate, obtuse at apex, shortly stipitate, 1.06 x 0.87 mm.	Epidermal cells in 10-16 vertical rows on each face, transversely elliptic-oblong, hexagonal; anticlinal walls 6, obscurely sinuous, two-layered in thickness; periclinal wall smooth, flat, without silica bodies.
4.	<i>Fimbristylis cymosa</i> R. Br. R.T. Patil 3022 (BSI). PLATE: 1	Biconvex, obovate, obtuse at apex, stipe not conspicuous, 0.97 x 0.74 mm.	Epidermal cells longitudinally elliptic; anticlinal wall distinctly sinuous, raised with omega-shaped pattern; periclinal wall smooth, concave with slight depression.
5.	<i>Fimbristylis dichotoma</i> (L.) Vahl R.T. Patil 192642 (BSI). PLATE: 2	Biconvex, obovate, acute at apex, shortly stipitate, with distinct constriction towards the base, 0.97 x 0.63 mm.	Achene surface with distinct ridges and furrows. Epidermal cells in 6-8 vertical rows, quadrangular, transversely elliptic-oblong; anticlinal wall highly thickened and straight; periclinal wall smooth, deeply concave.
6.	<i>Fimbristylis ferruginea</i>	Strongly compressed, biconvex, obovate to oblong-obovate,	Epidermal cells in 20-25 rows on each face, reticulated isodiametric, oblong, hexagonal; anticlinal wall highly thickened,

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	(L.) Vahl R.T. Patil 3021 (BSI). PLATE: 2	mucronulate at the obtuse apex, shortly stipitate, 1.11 x 0.70 mm.	straight, raised; periclinal wall verruculose, concave.
7.	<i>Fimbristylis lawiana</i> (Boeckeler) J. Kern R.T. Patil 3031 (BSI). PLATE: 2	Trigonous, oblong- obovoid, obtuse at apex, 0.52 x 0.19 mm.	Epidermal cells indistinct, transversely elongated, rectangular; anticlinal wall thick, sinuate with weak undulation, raised; periclinal wall smooth, flat, without silica bodies. <i>Note:</i> The achene used was immature and broken. Hence the epidermal sculpture was not clear.
8.	<i>Fimbristylis littoralis</i> Gaudich. R.T. Patil 192535 (BSI). PLATE: 2	Trigonous, obovoid, umbonulate at apex, shortly stipitate, 0.58 x 0.30 mm	Epidermal cells transversely linear- oblong; anticlinal wall sinuous; periclinal wall smooth, flat, with few scattered projections.
9.	<i>Fimbristylis merrillii</i> J. Kern R.T. Patil 192515 (BSI). PLATE: 3	Biconvex, shortly stipitate, minutely umbonulate, 0.85 x 0.68 mm.	Epidermal cells in 5 or 6(-9) vertical rows on either face, transversely oblong; anticlinal wall thick, slightly sinuous, otherwise straight; periclinal wall smooth, flat or slightly concave, partly verruculose.
10.	<i>Fimbristylis ovata</i> (Burm. f.) J. Kern V. Joshi & S. Rajkumar 937 (Herbarium, Goa University). PLATE: 3	Obtusely trigonous, broadly obovate, pyriform, rounded at apex, cuneately attenuate to a short stipitate base, 2.27 x 1.52 mm.	Epidermal cells inconspicuous, found at basal part only; epidermal surface almost muricate with pointed mesa-shaped projections.
11.	<i>Fimbristylis polytrichoides</i> (Retz.) Vahl R.T. Patil 192524 (BSI). PLATE: 3	Biconvex, obovate, rounded at apex, cuneate towards base, very shortly stipitate, 1.04 x 0.56 mm.	Epidermal cells in 15-20 vertical rows on either face, smaller, transversely linear-oblong; anticlinal wall thick, sinuous, raised; periclinal wall undulate, concave.

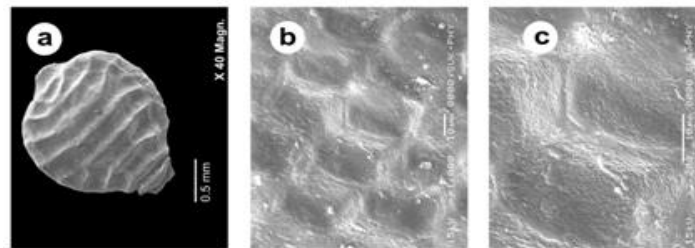
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| 12. | <i>Fimbristylis pubisquama</i>
J. Kern
<i>R.T. Patil</i> 192621 (BSI).
PLATE: 3 | Biconvex, obovate, rounded at apex, cuneate towards base, prominently conically stipitate, 1.00 x 0.71 mm. | Epidermal cells in 26-32 vertical rows on either face, hexagonal; anticlinal wall slightly sinuous, raised and beaded; periclinal wall smooth, flat. |
| 13 | <i>Fimbristylis schoenoides</i>
(Retz.) Vahl
<i>R.T. Patil</i> 192574 (BSI).
PLATE: 4 | Biconvex, obovate, rounded at apex, contracted to base, distinctly stipitate with obconical gynophores, 1.55 x 1.06 mm. | Epidermal cells in 18-23 vertical rows on either face, transversely elongated hexagonal; anticlinal wall slightly sinuous, raised and beaded; periclinal wall smooth, concave. |
| 14. | <i>Fimbristylis tenera</i> Schult.
<i>R.T. Patil</i> 192573 (BSI).
PLATE: 4 | Trigonous with convex faces, globular obovoid, pointed at apex, 0.9 x 0.54 mm. | Epidermal cells in 9 or 10 vertical rows, transversely oblong hexagonal; anticlinal wall sinuous, raised; periclinal wall smooth, slightly concave. Some protrusions were found at the junction of anticlinal walls. |
| 15. | <i>Fimbristylis tetragona</i> R.
Br.
<i>R.T. Patil</i> 192539 (BSI).
PLATE: 4 | Biconvex, oblong-cylindrical, slightly curved, obtuse at apex, with persistent style, prominently (0.5-1 mm long) stipitate, 2.05 x 0.47 mm. | Epidermal cells in 5-8 vertical rows on either face, transversely oblong, hexagonal; anticlinal wall thin, straight, raised; periclinal wall smooth, flat, without silica bodies. |
| 16. | <i>Fimbristylis tomentosa</i>
Vahl
<i>M. K. Janarthanam et al.</i> 247
(Herbarium, Goa University).
PLATE: 4 | Biconvex, orbicular-obovoid, umbonulate, prominently stipitate, 1.44 x 0.94 mm; stipe obpyramidal, 0.2-0.4 mm long. | Surface verruculose only on upper half towards apex. Epidermal cells isodiametric polygonal; anticlinal wall sinuous with omega-shaped pattern, raised; periclinal wall smooth, deeply concave. |
| 17. | <i>Fimbristylis woodrowii</i>
C.B. Clarke
<i>R.T. Patil</i> 192572 (BSI).
PLATE: 4 | Trigonous with prominent angles, obovoid, umbonulate, shortly stipitate, 0.72 x 0.43 mm. | Epidermal cells in 7 or 8 vertical rows, transversely linear-oblong, hexagonal; anticlinal wall straight, raised; periclinal wall smooth, flat. |
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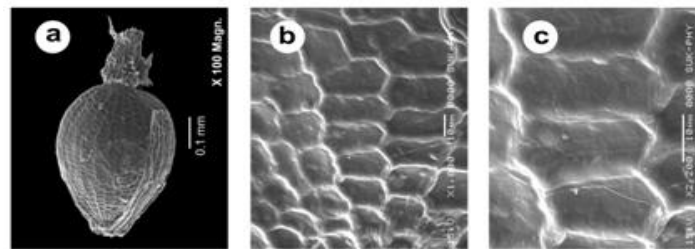
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Achene in *F. acuminata* is quite distinct than the achenes of other species by having 5-8 undulating wavy irregular transverse ridges on the surface. In *F. littoralis*, achene surface shows few projections on the periclinal walls. In *F. ovata*, surface of the achene is almost muricate with pointed mesa-shaped projections. In *F. tenera*, few protrusions are present at the junction of anticlinal walls. Anticlinal wall of the epidermal cells in the achenes of most species are more or less sinuous, except in *F. acuminata*, *F. aestivalis*, *F. dichotoma*, *F. ferruginea*, *F. tetragona* and *F. woodrowii*, where it is straight. Achenes of *F. cymosa* and *F. tomentosa* show distinctly sinuous anticlinal wall with omega-shaped pattern while in case of *F. pubisquama* and *F. schoenoides* anticlinal wall of the epidermal cells are slightly sinuous, raised and beaded. From the above details it is clear that, achenes in the genus *Fimbristylis* show wide range of variations in their gross morphology and micro-epidermal morphology, and such variations are of taxonomic significance.

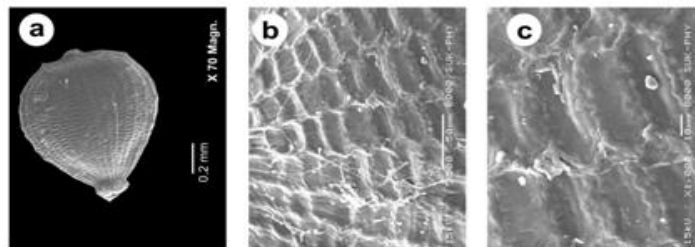
**SEM MICROGRAPHS OF FIMBRISTYLIS Vahl ACHENE
 PLATE : 1**



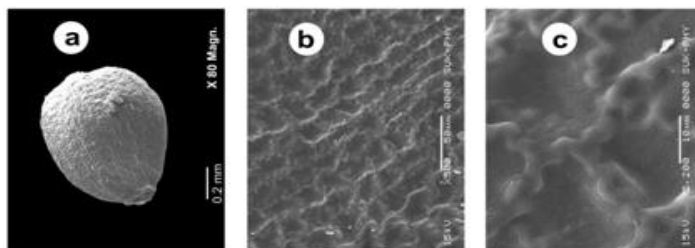
Fimbristylis acuminata Vahl - a. Achene, b & c. Epidermal cells



Fimbristylis aestivalis Vahl - a. Achene, b & c. Epidermal cells

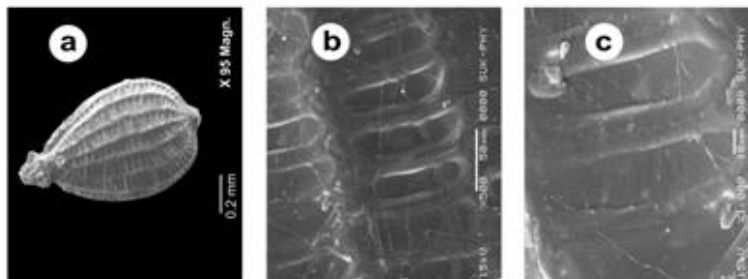


Fimbristylis alboviridis C.B. Clarke - a. Achene, b & c. Epidermal cells

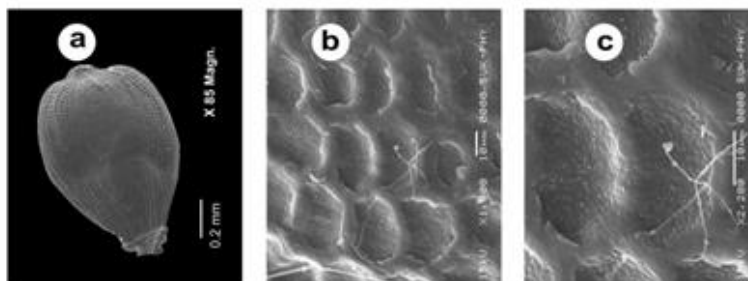


Fimbristylis cymosa R. Br. - a. Achene, b & c. Epidermal cells

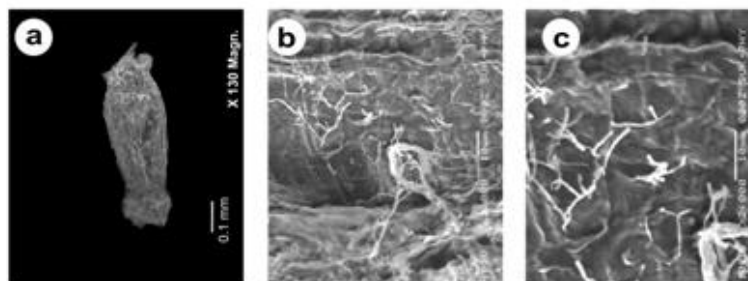
PLATE : 2



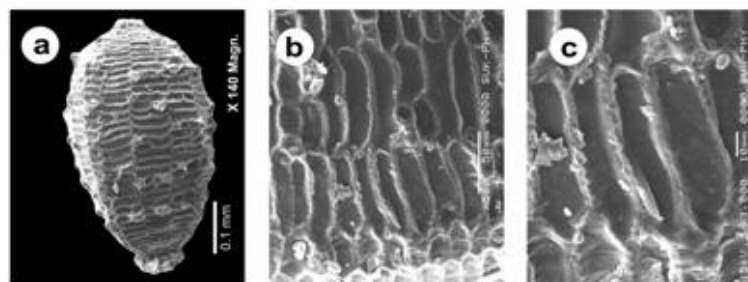
Fimbristylis dichotoma (L.) Vahl - a. Achene, b & c. Epidermal cells



Fimbristylis ferruginea (L.) Vahl - a. Achene, b & c. Epidermal cells

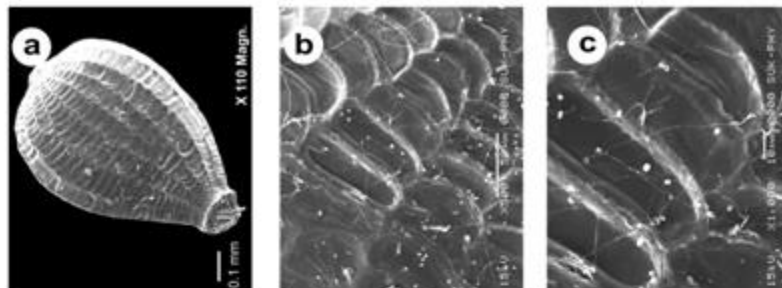


Fimbristylis lawiana (Boeckeler) J. Kern - a. Achene, b & c. Epidermal cells

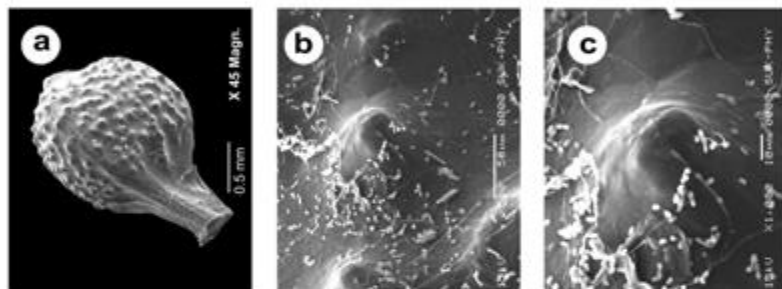


Fimbristylis littoralis Gaudich. - a. Achene, b & c. Epidermal cells

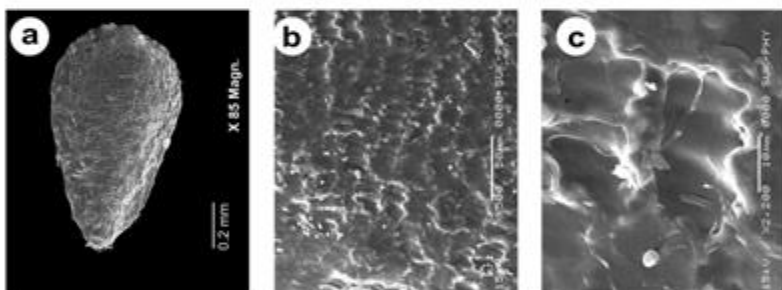
PLATE 3



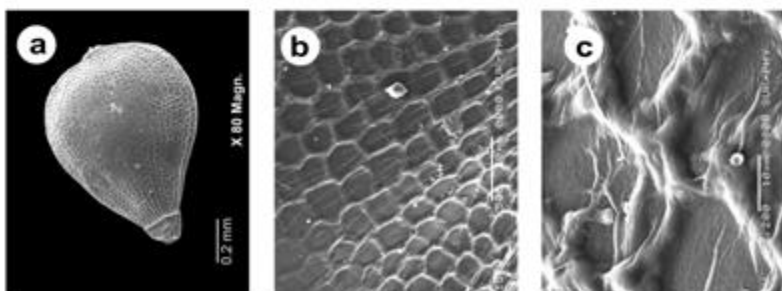
Fimbristylis merrillii J. Kern - a. Achene, b & c. Epidermal cells



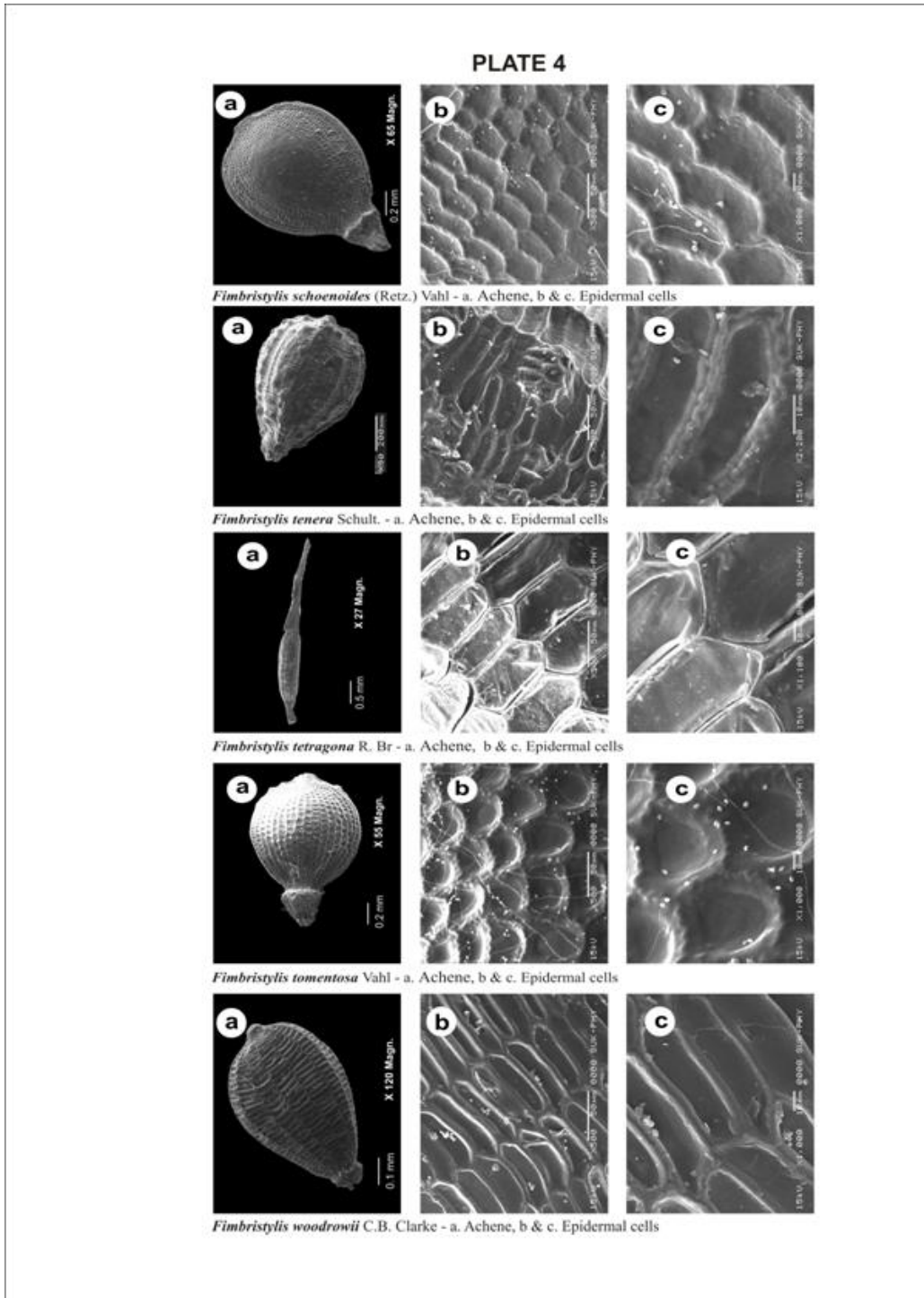
Fimbristylis ovata (Burm.f.) J. Kern - a. Achene, b & c. Epidermal cells



Fimbristylis polytrichoides (Retz.) Vahl - a. Achene, b & c. Epidermal cells



Fimbristylis pubisquama J. Kern - a. Achene, b & c. Epidermal cells



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