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ACHENE MORPHOLOGY AND ITS TAXONOMIC SIGNIFICANCE IN THE GENUS PYCREUS (CYPERACEAE) OF GOA, INDIA

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ABSTRACT:

Taxonomic relationship among the species of *Pycreus* in Goa is elucidated by examining the scanning electron microscope (SEM) images of their achenes. Morphology of the achenes and their epidermal cells has been studied for this purpose with a taxonomic viewpoint. Achene shape and epidermal patterns were found distinctive and consistent within the species or infraspecific taxon. Variation in the epidermal cells is most evident with respect to size of the cell, nature of periclinal wall, the number, thickness and sinuosity of anticlinal walls and presence or absence of silica bodies. 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 *Pycreus* at species level and infraspecific level.

Key words: - *SEM images, Achene morphology, Pycreus, Silica bodies, Anticlinal wall.*

INTRODUCTION:

INTRODUCTION

The family Cyperaceae is one of the ten largest families of flowering plants and is the third largest of monocotyledons after Orchidaceae and Poaceae. Bruhl (1995) estimated approximately 5,000 species in about 80 genera and Goetghebeur (1998) included same number of species under 104 genera. But according to Mabberley (2009) there are 92 genera and 4450 species, and Govaerts et al. (2015) reported 97 accepted genera and 5486 species of Cyperaceae. Singh and Prasad (2001) estimated about 570 species of 39 genera in India and the present number is estimated to be about 580 species belonging to 32 genera (Patil and Prasad, (2016). In Goa it is represented by 94 species, 2 subspecies and 9 varieties belonging to16 genera.

The genus *Pycreus* P. Beauv. of this family is very similar to *Cyperus* L. and hence, often treated together under the later *sensu lato*. However, *Pycreus* can be easily separated from *Cyperus* by an unique and constant character, i.e. its laterally compressed achenes, with one of the two edges towards the rachilla. But in *Cyperus* one face of the trigonous or laterally compressed achenes is towards the rachilla. At global level the genus has about 100 species (Mabberley, 2009) and is confined to tropical countries. A total number of 38 species of *Pycreus* are reported from India of which 7 have been reduced to synonyms by Prasad (2009, 2015). A total number of 8 species and one variety have been reported from Goa (Patil, 2013) and all were studied for their achene morphology. All the species have a wide range of distribution except *P. malabaricus* C.B. Clarke which is endemic to western and southern India, in the states of Maharashtra, Goa, Karnataka, Kerala and Tamilnadu.

The first basic study on epidermal silica bodies of the achenes was accomplished by Schuyler (1971) on two species of *Scirpus* L. and *Eriophorum* L. that lead to the development of a new set of characters that could re-evaluate the systematics of Cyperaceae. 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) did the achene micromorphology of some Indian species of *Cyperus, Fimbristylis, Pycreus,*

Scirpus and *Scleria*. Also Menapace *et al.* (2003) did the achene micromorphology of some Indian species as a possible systematic aid to the taxonomic recognition of different sections in *Fimbristylis*. Recently Patil and Prasad (2016, 2016a) revealed the micromorphology of the achenes of the genera *Fimbristylis* and *Eleocharis* found in Goa.

In the present study achenes of 9 taxa belonging to genus *Pycreus* in Goa have been studied and interpreted for their similarities and dissimilarities. The study includes gross morphology such as achene size, shape etc. using conventional methodology and the micro-epidermal cell structures like nature of periclinal wall and anticlinal wall, presence or absence of silica bodies, if present the shape and number of silica bodies per cell, etc. using SEM images.

MATERIAL AND METHODS :-

Achene samples were collected from the plant specimens 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. For better result, mature specimens were selected to study the morphology of achenes 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 the 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 nature of periclinal walls, anticlinal walls and silica bodies were studied to find out the similarities or dissimilarities.

RESULT & DISCUSSION

The genus *Pycreus* is characterized by bilaterally flattened achenes with one angle facing the rachilla of the spikelet. In all the 8 species, achene is biconvex and the shape in general is obovate or oblong with variations like obovate to obovate-elliptic in *P. diaphanus,* obovate to oblong-elliptic in *P. flavidus,* globose-obovate in *P. malabaricus*, broadly obovate to orbicular in *P. sanguinolentus,* broadly elliptic to obovate-orbicular in *P. stramineus,* oblong in *P. polystachyos,* oblong to obovate in *P. macrostachyos* and oblong-obovate in *P. pumilus*. The largest achene is found *P. macrostachyos* (1.5-2 x 0.6-1.37 mm) while the smallest in *P. pumilus* (0.5-0.8 x 0.3-0.5 mm). Achene in the variety *gracilescens* of *P. diaphanus* is smaller than the typical variety. Important findings are provided in table 1 and the SEM images of the achenes are shown in plate 1 & 2.

All the eight species were studied for their achene morphology. Besides the shape, size and colour of the achene, its surface is very important in the classification of the species of *Pycreus*. Achene surface is transversely wrinkled with longitudinally oblong epidermal cells in *P. diaphanus, P. malabaricus* and *P. stramineus*. But in all other species in Goa achene surface is smooth to finely reticulate with isodiametric epidermal cells. Both *Pycreus diaphanus* and *P. flavidus* possess inconspicuous, smaller silica bodies without elevation at the centre of each epidermal cell. But these two can be differentiated by the presence of prominent nodular projections at the junction of anticlinal walls of nearby cells in *P. diaphanus* and by the inconspicuous projections in *P. flavidus*. Achenes of *P. macrostachyos* and *P. polystachyos* are with very similar microstructure on achene surface, but both have mesa-shaped silica bodies at the centre of epidermal cells. These two can be separated based on achene size. *P. macrostacyos* have larger achene (1.5-2 x 0.6-1.37 mm) than *P. polystachyos* (1-1.5 x 0.4-0.5 mm). The two varieties of *P. pumilus* i.e. *P. pumilus* var. *membranaceus* and *P. pumilus* var. *pumilus* are very similar in their achene microstructure and both have silica bodies in the epidermal cells. So, these varieties cannot be separated using micromorphological characters of the achenes, but mainly by the arrangement of the glumes on the rachilla. Another very closely related species of *Pycreus* are *P. malabaricus* and *P. stramineus* which are separated mainly by colour of the spikelets, but shows similarity in achene size, shape and epidermal microstructure. In both the species silica bodies are absent and have distinct epidermal pattern than other species of *Pycreus*. Both possess linear or longitudinally oblong epidermal cells with transversally ridged, sinnulate and longitudinally

straight, sritullate anticlinal walls in the epidermal cells.

In *P. sanguinolentus* silica bodies are absent on achene surface. Achene in this species is distinct from other taxa, being obovate-orbicular and by the presence of a notch at posterior region of the achene. Thus in *Pycreus* both macromorphology and micromorphlogy of the achene is very useful for identifying, and delimiting different taxa.

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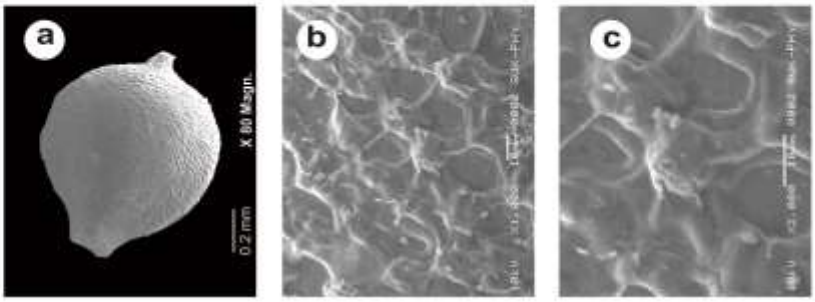
Table 1. Macro- and micro-morphology of achenes in the genus *Pycreus*

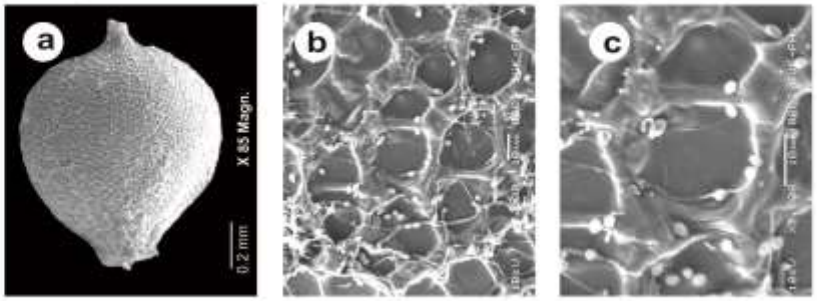
Sr. No.	Plant name and voucher specimen	Macromorphology	Micromorphology (interpretation of SEM images)
1.	*Pycreus diaphanus* (Schrad. ex Roem. & Schult.) S. Hooper & T. Koyama Bastora, Ucassaim, near St. Elizabeth's church, Bardez Taluk, North Goa, 20.9.2007, *R.T. Patil* 192641 (BSI) PLATE 1	Biconvex, laterally sub-compressed, obovate to obovate-elliptic, shortly apiculate at apex, narrowed at base, 0.94 x 0.85 mm.	Epidermal cells transversely oblong, irregularly hexagonal; anticlinal wall thick, straight, raised; periclinal wall smooth, flat, with inconspicuous smaller silica bodies, without elevation at the centre of each cell. Prominent nodular projections were found at the junction of antclinal walls of nearby cells.
2.	*Pycreus flavidus* (Retz.) T. Koyama Parra, Bardez Taluk, North Goa, 17.10.2006, *R.T. Patil* 192510 (BSI). PLATE 1	Biconvex, laterally compressed, obovate to oblong-elliptic, shortly apiculate at apex, narrowed at base, 1.06 x 0.87 mm.	Epidermal cells isodiametric, hexagonal; anticlinal wall thick, straight, raised; periclinal wall smooth, flat, with minute silica bodies without much elevation at the centre of each cell. Inconspicuous nodular projections were found at the junction of 4 anticlinal walls of nearby cells.
3.	*Pycreus macrostachyos* (Lam.) J. Raynal Dona Paula-Miramar road, Tiswadi Taluk, North Goa, 24.11.2006, *R.T. Patil* 192518 (BSI). PLATE 1	Biconvex, laterally compressed, oblong-obovate, concave on one surface, apiculate at the obtuse apex, slightly stipitate, 1.84 x 1.37 mm.	Epidermal cells sub-isodiametric, hexagonal; anticlinal wall straight but indistinct; periclinal wall convex with mesa-shaped silica bodies at the centre of each cell. Buttresses not prominent.
4.	*Pycreus malabaricus* C.B. Clarke Tivim,Bardez Taluk, North Goa, 9.9.2007, *R.T. Patil* 192608 (BSI). PLATE 1	Biconvex, slightly laterally compressed, ovate to obovate-elliptic, asymmetric, minutely apiculate at the obtuse apex, 0.91 x 0.65 mm.	Epidermal cells linear or longitudinally oblong; anticlinal wall transversally ridged and sinnulate while longitudinally straight stritullate; periclinal wall smooth, flat, without silica bodies.
5.	*Pycreus polystachyos* (Rottb.) P. Beauv. Quepem, near court, Quepem Taluk, South Goa, 22.4.2007, *R.T. Patil* 192564 (BSI). PLATE 2	Biconvex, laterally compressed, narrowly oblong or oblong-obovate, sub-truncate and minutely apiculate at apex, stipitate. 1.12 x 0.5 mm.	Epidermal cells sub-isodiametric, hexagonal; anticlinal wall straight but inconspicuous; periclinal wall convex with mesa-shaped single silica body in each cell; buttresses not prominent.

6.	*Pycreus pumilus* (L.) Nees var. *pumilus* Valpoi, Sattari Taluk, North Goa, 22.9.2007, *R.T. Patil* 192673(BSI). PLATE 2	Biconvex, laterally compressed, oblong-obovoid, minutely apiculate at the obtuse apex, minutely stipitate, 0.65 x 0.37mm.	Epidermal cells isodiametric, hexagonal; anticlinal wall straight, weakly depressed; periclinal wall smooth, convex, with mesa-shaped silica bodies arranged in longitudinal rows; buttresses not prominent.
7.	*Pycreus pumilus* var. *membranaceus* (Vahl) Karthik. Mulgaon, Shirodwadi, Bicholim Taluk, North Goa, 9.9.2007, *R.T. Patil* 192614 (BSI). PLATE 2	Biconvex, laterally compressed, obovoid-oblong, minutely apiculate at the obtuse apex, minutely stipitate, 0.55 x 0.41 mm.	Epidermal cells isodiametric, hexagonal; anticlinal wall straight, weakly depressed; periclinal wall smooth, convex, with mesa-shaped silica bodies arranged in longitudinal rows; buttresses not prominent.
8.	*Pycreus sanguinolentus* (Vahl) Nees) Valpoi, Koparde Fata, Sattari Taluk, North Goa, 22.9.2007, *R.T. Patil* 192670 (BSI). PLATE 2	Biconvex, laterally compressed, obovate-orbicular, minutely apiculate at the obtuse apex, notched at the posterior region, 1.18 x 1.21 mm.	Epidermal cells irregular hexagonal-polygonal; anticlinal wall thick, straight, raised; periclinal wall smooth, flattened; silica bodies absent. Achene surface wavy at low resolution, wrinkled.
9.	*Pycreus stramineus* C.B. Clarke Mulgaon, Shirodwadi, Bicholim Taluk, North Goa, 9.9.2007, *R.T. Patil* 192612 (BSI). PLATE 2	Biconvex, laterally compressed, ovate to obovate-elliptic, asymmetric, minutely apiculate at the obtuse apex, 0.92 x 0.75 mm.	Epidermal cells linear or longitudinally oblong; anticlinal wall transversally ridged and sinnulate while longitudinally straight stritullate; periclinal wall smooth, flat, without silica bodies.

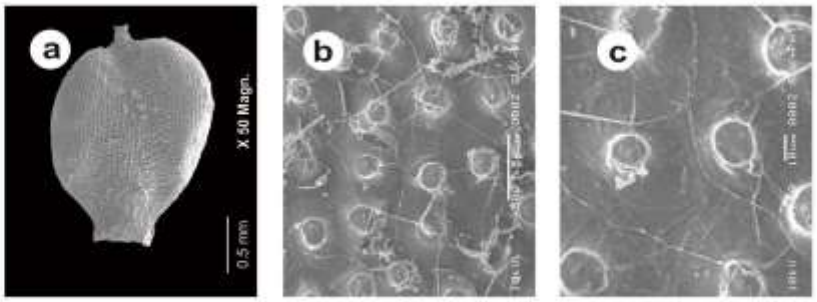
SEM MICROGRAPHS OF PYCREUS P. Beauv. ACHENES
PLATE 1



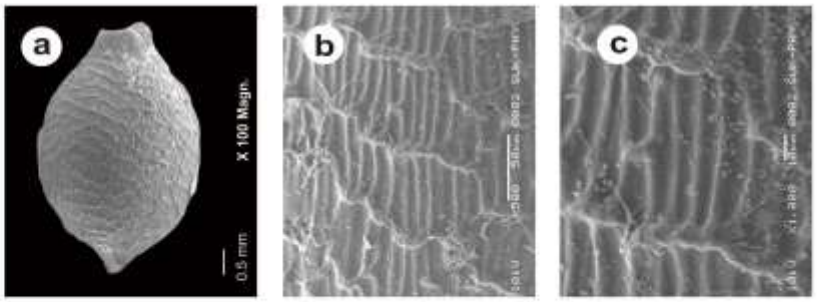
Pycreus diaphanus (Schrad. ex Roem. & Schult.) S.S. Hooper & T. Koyama - a. Achene, b & c. Epidermal cells



Pycreus flavidus (Retz.) T. Koyama - a. Achene, b & c. Epidermal cells

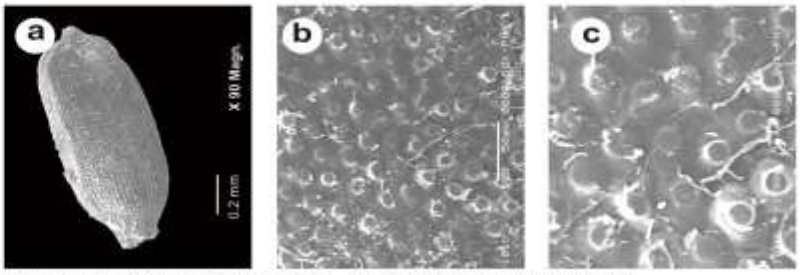


Pycreus macrostachyos (Lam.) J. Raynal - a. Achene, b & c. Epidermal cells

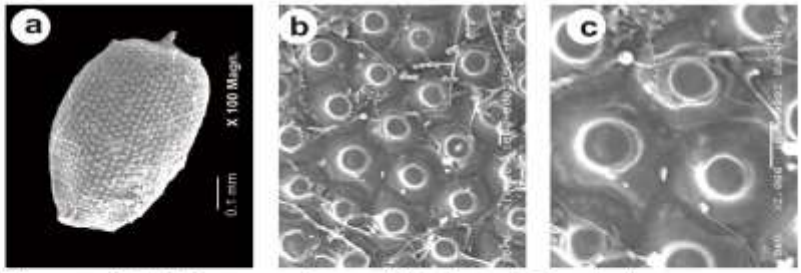


Pycreus malabaricus C.B. Clarke - a. Achene, b & c. Epidermal cells

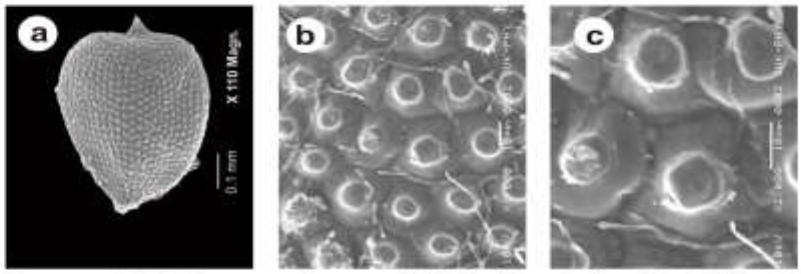
PLATE 2



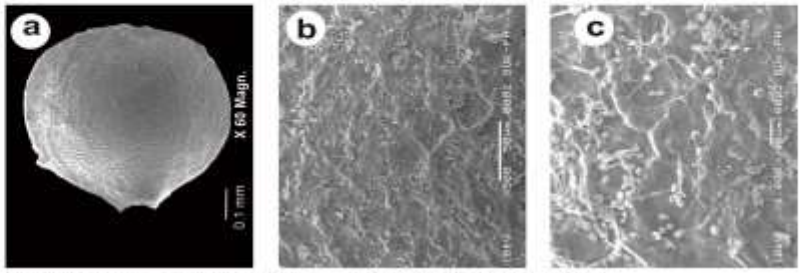
Pycreus polystachyos (Rottb.) P. Beauv. - a. Achene, b & c. Epidermal cells



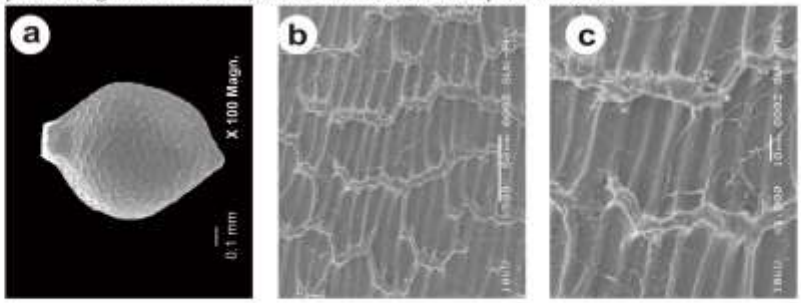
Pycreus pumilus (L.) Nees var. *pumilus* - a. Achene, b & c. Epidermal cells



Pycreus pumilus (L.) Nees var. *membranaceus* (Vahl) Karthik. - a. Achene, b & c. Epidermal cells



Pycreus sanguinolentus (Vahl) Nees - a. Achene, b & c. Epidermal cells



Pycreus stramineus C. B. Clarke - a. Achene, b & c. Epidermal cells