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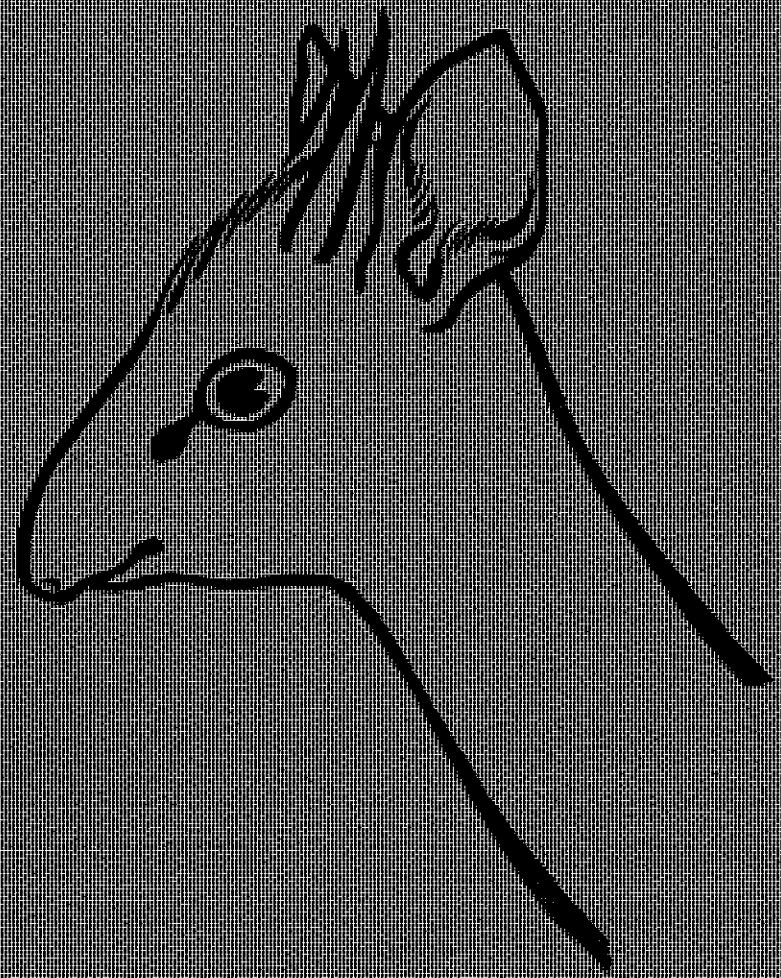

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SHORT NOTES

Leaf blade epidermal anatomy of 39 monocotyledon species from southern South West Africa

by

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ABSTRACT

To enable microscopic identification of fragments of monocotyledon food plants in stomach content samples during a study of the feeding ecology of the rock hyrax or dassie, *Procavia capensis* (Pallas, 1766) on rangeland in southern South West Africa, a supplementary study of the abaxial leaf epidermis anatomy of 39 monocotyledon species was conducted. Methods of preparing leaf epidermis for microscopic study are described. Results are presented as a series of descriptions and accompanying photomicrographs. A key to the 39 species based on epidermal characters is presented.

1 INTRODUCTION

In the arid mountainous regions of southern South West Africa the rock hyrax or dassie, *Procavia capensis* (Pallas, 1766) (*Hyracoidea: Procaviidae*) is said to increase considerably in numbers at certain times and to compete with Karakul sheep for forage in the sparse vegetation characteristic of these areas. The species is a declared problem animal in accordance with the provisions of the Nature Conservation Ordinance, no. 4 of 1975.

A study of the feeding ecology of the rock hyrax in rangeland in the Groot Karas Mountains of southern South West Africa was conducted to define and evaluate the hyrax problem. As it was possible to collect a population sample, quantitative analyses of the stomach content of the animals could be carried out. As the amount of grass eaten by hyrax was an important factor in assessing the problem, it was essential that fragments of monocotyledon plants be identified to species level where possible. As these fragments could only be identified microscopically on the basis of the anatomy of the leaf epidermis, a supplementary study of the epidermis of the 39 monocotyledon species encountered in the study areas was conducted. Microscope slides, photomicrographs and descriptions of the epidermis studied were used in the identification of grass fragments during stomach content analyses.

Botanists working in other fields such as physiology and palaeontology played a part in the development of methods of preparing epidermis for study. Methods of replication and maceration have been described by Long and Clements (1934), Bennett and Furmidge (1956), North (1956), Tateoka, Inoue and Kawano (1959), Clarke (1960), Sampson (1961), Sinclair and Dunn (1961), Horanic and Gardiner (1967) and Pohl (1967).

After initial work by Baumgartner and Martin (1939) and Dusi (1949), several researchers attempted feeding habit studies using plant microtechniques. Martin (1955 and 1964) described cuticle fragments used in the analysis of sheep rumen contents and faeces in Scotland. Chapman (1957) used the technique for analysing oesophageal contents of locusts (*Nomadacris septemfaciata*) in East Africa. Croker (1959) and Hercus (formerly Croker) (1960) analysed sheep faeces in New Zealand. Storr (1961 and 1964) worked on quokkas (*Setonix brachyurus*) in Australia, describing methods of preparation of reference material. In Great Britain, Hewson (1962) analysed stomach contents of the mountain hare (*Lepus timidus scoticus*). In East Africa Stewart (1965 and 1967) and Kiley (1966) comprehensively studied faecal analysis in large herbivores.

Stomach content analysis has become a popular technique in feeding habit studies (e.g. Carleton 1966, Hayden 1966, Sparks 1968, Field 1970 and 1972, Liversidge 1970 and 1972, Reichman and Van de Graaff 1974, Turkowsky 1975 and Wilson, Hirst and Ellis 1977). Plant anatomists were the first to realise that the leaf epidermis anatomy of monocotyledons had potential for taxonomic use. Leaf epidermis of grasses therefore received much attention from botanists before ecologists thought of analysing faeces or stomach contents microscopically. Early in the century Günzel (1913 and 1921) published information on the leaf epidermis anatomy of South West African grasses, some of which are included in the present investigation. Early South African workers are Goosens and Theron (1934), Goosens (1938), Fisher (1938 and 1939), Fisher and Schweickerdt (1941), and Schweickerdt (1941).

Davies (1959) described grass leaf epidermis in order to distinguish rapidly between grasses in the vegetative stage. Probably the most comprehensive related modern work is Metcalfe's (1960) in which he refers extensively to the leaf epidermis anatomy of monocotyledons.

More recently in South Africa De Winter (1965) worked on the Aristideae and Stipeae. Kok (1968) described both adaxial and abaxial epidermes of 60 grass species from the Van Riebeeck Nature Reserve near Pretoria, drew up a key based on epidermal characters and simplified and standardised the terminology used in describing epidermal anatomy (see also Kok and Van der Schijff 1973). Kok briefly investigated the possibilities of using his key and descriptions to identify grass fragments from blesbok (*Damaliscus dorcas phillipsi*) faeces.

Ellis (1979) studied grass leaf anatomy for the purpose of standardising descriptions to facilitate their taxonomic use, drawing up a fixed range of variable characters for each cell type and zone on the epidermis. Some of the authors mentioned above who described the methods they used to prepare their collections of reference materials and included descriptions of the epidermis or cuticle of plants expected in the diets of the animals they studied, are Martin (1955 and 1964), Croker (1959), Storr (1961) and Liversidge (1970). Other authors published papers devoted entirely to this aspect, for example Williams (1962), Stewart (1965) and Williams (1969).

The present paper describes the preparation of the reference collection of monocotyledon species used in the rock hyrax stomach content analyses and provides descriptions of the abaxial leaf epidermis anatomy of the species encountered.

2 STUDY AREAS AND METHODS

2.1 Study areas

Farmers reported that high intensity hyrax problems occurred in the Groot and Klein Karas Mountains south of Keetmanshoop in southern South West Africa. Attention was focussed on the Groot Karas Mountains and the farm Sandmodder no. 73 (26°57'S;

18°55'E) in the Keetmanshoop District was chosen as being representative of the mountain itself. The farm Warmfontein no. 280 (27°7'S; 19°15'E), also in the Keetmanshoop District, is typical of the transition zone between the mountain complex and the southern Kalahari.

Optimum rock hyrax habitat has the deep crevices and ledges found in the stratified layers of the sandstone cliffs and ridges typical of the Groot Karas Mountains. At Sandmodder the research was conducted along the Leeu River which traverses the farm in a ravine before emerging on to the plain north of the mountains. At Warmfontein a dry sandy watercourse meanders between the low rocky ridges typical of the transition zone. The ridges on both sides of this stream were selected for study purposes.

Giess (1971) drew up a preliminary vegetation map of South West Africa. According to this map both study areas fall within what he described as the Dwarf Shrub Savanna (Vegetation Type 9), which is dominated by Karroo shrubs and grasses.

2.2 Material and Methods

2.2.1 Collection and identification of samples

Herbarium specimens and material preserved in F.A.A. (Formaline-Acetic Acid—Alcohol) were collected from all areas in the two study areas which showed signs of utilisation by rock hyrax and from which the hyrax population was sampled. The herbarium specimens were identified by the SWA Herbarium in Windhoek. A checklist of the monocotyledon species occurring in the two study areas is presented in Table 1.

TABLE 1: Checklist of the monocotyledon species occurring in rock hyrax habitat on the farms Sandmodder no. 73 and Warmfontein no. 280, Keetmanshoop District, South West Africa. Genera are numbered according to the system used by Dyer (1975—1976).

SPECIES	COLLECTION NUMBERS
GRAMINEAE	
K 64 *Dichanthium* Willemet	
D. papillosum (Hochst. ex A. Richard) Stapf	A26/76
K 80 *Heteropogon* Pers.	
H. contortus (L.) Beauv. ex Roemer & Schultes	J 38/76
K 89 *Digitaria* Haller	
D. eriantha Steudel	A159/75
K103 *Chloris* Swartz	
C. virgata Swartz	A107/75
K103 *Leucophrys* Rendle	
L. mesocoma (Nees) Rendle	O 4/75
K116 *Panicum* L.	
P. arbusculum Mez	A 76/75; A152/75
K128 *Setaria* Beauv.	
S. appendiculata (Hackel) Stapf	A175/75
S. verticillata (L.) Beauv.	A119/75; A172/75; J 34/76
K132a *Rhynchelytrum* Nees	
R. villosum (Parl. ex Hooker) Chiov.	A166/75
K138 *Anthephora* Schreber	
A. pubescens Nees	A 73/75; A112/75; A157/75
K140 *Cenchrus* L.	
C. ciliaris L.	A158/75
K203 *Asthenatherum* Nevski	
A. glaucum (Nees) Nevski	A 85/75; J3/76
K261a *Stipagrostis* Nees	
S. ciliata (Desf.) De Winter	A 84/75; J4/76
S. hirtigluma (Steudel ex Trin. & Rupr.) De Winter ssp. *patula* (Hackel) De Winter	A177/75
S. Hochstetterana (Beck ex Hackel) De Winter	A116/75
S. namaquensis (Nees) De Winter	J 6/76
S. uniplumis (Licht. ex Roemer & Schultes) De Winter	A 75/75; A149/75
K262 *Aristida* L.	
A. adscensionis L.	A 74/75; A106/75; A165/75
A. congesta Roemer & Schultes	A 83/75; J34/76
A. engleri Mez	Ma 1/76
K274 *Tragus* Haller	
T. berteronianus Schultes	A108/75
K286 *Eragrostis* Wolf	
E. biflora Hackel	A 20/76
E. echinochloidea Stapf	A 27/76
E. nindensis Fic. & Hiern	A134/75; A151/75
E. porosa Nees	A104/75
E. rotifer Rendle	A 25/76
E. trichophora Coss. & Dur.	A128/75
K296 *Cynodon* L.C. Richard ex Pers.	
C. dactylon (L.) Pers.	A129/76; J37/76
K320 *Oropetium* Trin.	
O. capense Stapf	A136/75; A 4/76
K332 *Dactyloctenium* Willd.	
D. aegyptium (L.) Beauv.	A 24/76
K350 *Triraphis* R. Br.	
T. ramosissima Hackel	A 77/75; A153/75
K357 *Enneapogon* Desv. ex Beauv.	
E. brachystachyus (Jaub. & Spach) Stapf	A 2/76
E. cenchroides (Roemer & Schultes) C. E. Hubbard	A126/75; A167/75
E. scaber Lehm	A 78/75; A120/75; A150/75
K361 *Schmidtia* Steudel	
S. kalahariensis Stent	A105/75

SPECIES	COLLECTION NUMBERS
CYPERACEAE	
459 *Cyperus* L. *C. longus* L. ssp. *tenuiflorus* (Rottb.) Kükenthal	A 23/76
459c *Mariscus* Gaertner *M. aristatus* (Rottb.) Chermezon	A 12/76
471 *Fimbristylis* Vahl *F. exilis* (Humb., Bonpl. & Kunth) Roemer & Schultes	A135/75
LILIACEAE	
985a *Trachyandra* Kunth *T. arvensis* (Schinz) Oberm.	A 79/75; A153/75

2.2.2 Choice of Material

As leaf fragments could be extracted intact from hyrax stomach content samples and because preliminary examination of stomach contents indicated that hyrax did not eat grass stems and the other more fibrous parts of the grass plant to any appreciable extent, it was decided to investigate only the abaxial leaf epidermis of 39 monocotyledon species.

Intraspecific variation of the anatomy of the grass leaf epidermis is one of the pitfalls of this technique of determining diet. Kok (1968) stated that the epidermis of the grass leaf can vary from one point to another on the leaf itself while leaves from different parts of the plant may also differ. Kok (1968) and Kok and Van der Schijff (1973) described a system whereby preparations were made from various parts of leaves from various parts of the plant. Liversidge (1970), however, stated that "midleaf material predominated in (springbok) rumen samples so that it is possible to reject the extremities without prejudicing the results." He therefore prepared his reference material from midleaf portions only, but did not state from which part of the plant the leaves were obtained.

In this study a similar system to that mentioned by Kok (1968) and Kok and Van der Schijff (1973) was adopted to take intraspecific variation into account. Eight fragments of each species were selected from the F.A.A. samples as follows: Two leaves were selected at random from the upper half of the plant. Each leaf was divided into two equal halves, a proximal half and a distal half. A fragment was then cut from the middle of each of these portions. The same procedure was adopted for two leaves taken from the lower half of the plant.

2.2.3 Microscope slides

Three methods are used to process leaf material for the purpose of obtaining a fragment of epidermis for study namely (i) maceration (Baumgartner and Martin 1939, Dusi 1949, Martin 1955, Chapman 1957, Croker 1959, Clarke 1960, Hercus 1960, Storr 1961, Stewart 1965, Pohl 1967, Kok 1968 and Dilcher 1974), which usually involves boiling the fragments in an acidic solution such as nitric or acetic acid; (ii) film replication (Long and Clements 1934, Sinclair and Dunn 1961, Horanic and Gardner 1967, Miller and Ashby 1968 and Dilcher 1974), which involves painting the epidermis with a chemical solution such as cellulose acetate, cellulose nitrate or silicon rubber which then coagulates and can be removed leaving an impression of the leaf surface; and (iii) scraping, which involves scraping away all leaf material from one side using a razor or scalpel blade until only the required epidermis remains (Fisher 1939, Dusi 1949, Metcalfe 1960, Stewart 1964 and 1965, De Winter 1965, Kok 1968, Liversidge 1970, Field 1972 and Kok and Van der Schijff 1973). This method necessitates the use of a dissection microscope and requires a certain amount of practice before acceptable fragments of epidermis can be obtained.

The following scraping method was used in the present study: A 2 cm fragment was cut from the selected leaf portion and placed on the glass working surface of the stereo microscope with the adaxial surface facing up. A straight-edged scalpel blade was used for scraping whilst the leaf portion was held down with a dissecting needle. Scraping was done under the 12× or 25× lenses of the microscope towards the apical end of the leaf and the material was kept moist with 70 per cent ethanol. After most of the mesophyll had been removed small loose pieces of tissue were removed with a fine jet of water from a wash bottle. A small section of semi-scraped mesophyll was left attached to one end of the fragment to counteract curling during staining. Fragments grouped according to their origin on the plant were then transferred to "Shandon" curetting baskets, two fragments to a basket and then immersed in 70 per cent ethanol where they were stored until staining could be carried out.

The following staining technique using Safranin "O" in ethanol during which fragments were stained in their baskets was developed:

Two per cent ethanol solution of Safranin "O" — 30 seconds
Ninety-six per cent ethanol — 15 seconds
Absolute ethanol — 30 seconds or longer
1:1 solution of clove oil and xylene — 15 seconds
Xylene containing one drop of absolute ethanol — 30 seconds
Xylene — 10 seconds.

The epidermal fragments were mounted in "D.P.X." under the stereo microscope and then placed on a hotplate at 34°C for three to four days.

2.3 Terminology

For descriptive purposes the epidermis is viewed with the long axis of the leaf horizontal in the field of the

microscope (Kok 1968, Kok and Van der Schijff 1973). Epidermal fragments were therefore mounted in this manner. All the directions parallel to the long axis are then termed "horizontal" and those perpendicular are termed "vertical". Kok (1968) succeeded in simplifying and standardising the terminology used in describing leaf epidermis. With the following exceptions this terminology was applied in the present study:

(1) Kok (1968) classified the "cork cells" described by some authors (De Winter 1965) as short cells but he did not differentiate between suberised and non-suberised short cells in his descriptions. In the present study a differentiation between the two types was made wherever possible.

(2) Kok classified only unicellular hairs as macrohairs. In this study long bicellular hairs such as described by Metcalfe (1960) and Ellis (1979) as bicellular glandular macrohairs for the *Pappophoreae* were encountered in the genera *Enneapogon* and *Schmidtia*. They were classified as macrohairs. Both unicellular and bicellular macrohairs are therefore recognised here.

2.4 Descriptions

Except for counts of the numbers of cell files in the costal and intercostal zones the descriptions are entirely qualitative. However, the various species can be distinguished from one another on qualitative characteristics alone.

In descriptions of the alternation of cells in specific cell files, appendages such as microhairs and prickle hairs were excluded. For example, although prickle hairs occur in a file with silica cells, only the number of short or long cells alternating with the silica cells are mentioned.

Prickle hairs usually occur in files with silica cells in the costal zones and in files with long cells in the intercostal zones. The cell files in which they occur are only mentioned in the event of an exception to the above. The same applies to microhairs which do not occur in the costal zones and usually only occur in long cell files in the intercostal zones.

Both interstomatal long and short cells normally have concave end walls when they are adjacent to stomata. In all other respects they can be described according to Kok's (1968) terminology for long and short cells. Interstomatal cells are only described when they differ from the other long or short cells in the intercostal zones. The end walls of the interstomatal cells are only mentioned when they are not concave as in the epidermis of *Trachyandra arvensis*.

2.5 Illustrations

A photomicrograph of the most representative fragment of each species was taken using "Kodak Plus X Pan" 120 roll film in a Zeiss Universal Photomicroscope. A stage micrometer was photographed on the same film at all possible magnifications to provide each print with a scale.

An acceptable photomicrograph of the epidermis of *Eragrostis biflora* could not be produced. A line drawing was therefore made by tracing from the image produced by placing the negative in the enlarger.

The photomicrograph(s) for each species were only labelled in respect of cell types which are obscure or of particular importance with the exceptions of Plates 1 and 2 in which all the cell types visible are labelled for the convenience of the reader. The following code was used to label the photomicrographs:

b	—	Bicellular microhair
Cz	—	Costal zone
C	—	Silica cell
Icz	—	Intercostal zone
i	—	Interstomatal cell
l	—	Long cell
o	—	Unicellular microhair
p	—	Papilla
r	—	Prickle hair
s	—	Short cell
x	—	Stoma
y	—	Subsidiary cell
z	—	Macrohair

3 RESULTS

3.1 Key

A key to the species listed in Table 1 based on epidermal characters is presented as an Appendix. Kok (1968) stated that it would be difficult to draw up a phylogenetic key based on epidermal characters alone. However, in studies of food preferences a key is simply an aid in the identification of monocotyledon fragments from the stomach contents or faeces of an animal. In the present study no attempt was made to select characters of taxonomic significance in the construction of the key.

3.2 Family Gramineae (Poaceae)

Anthephora pubescens Nees
(Plates 1 and 2)

Costal zones:

Three to 23 cell files wide. Files with silica cells alternate with one to three files with long cells. Within the files with silica cells, silica cells alternate with one long and/or one short cell.

Silica cells:	Short dumbell-shaped but may also be cross-shaped.
Short cells:	Rectangular but may also be square. Walls smooth or wavy

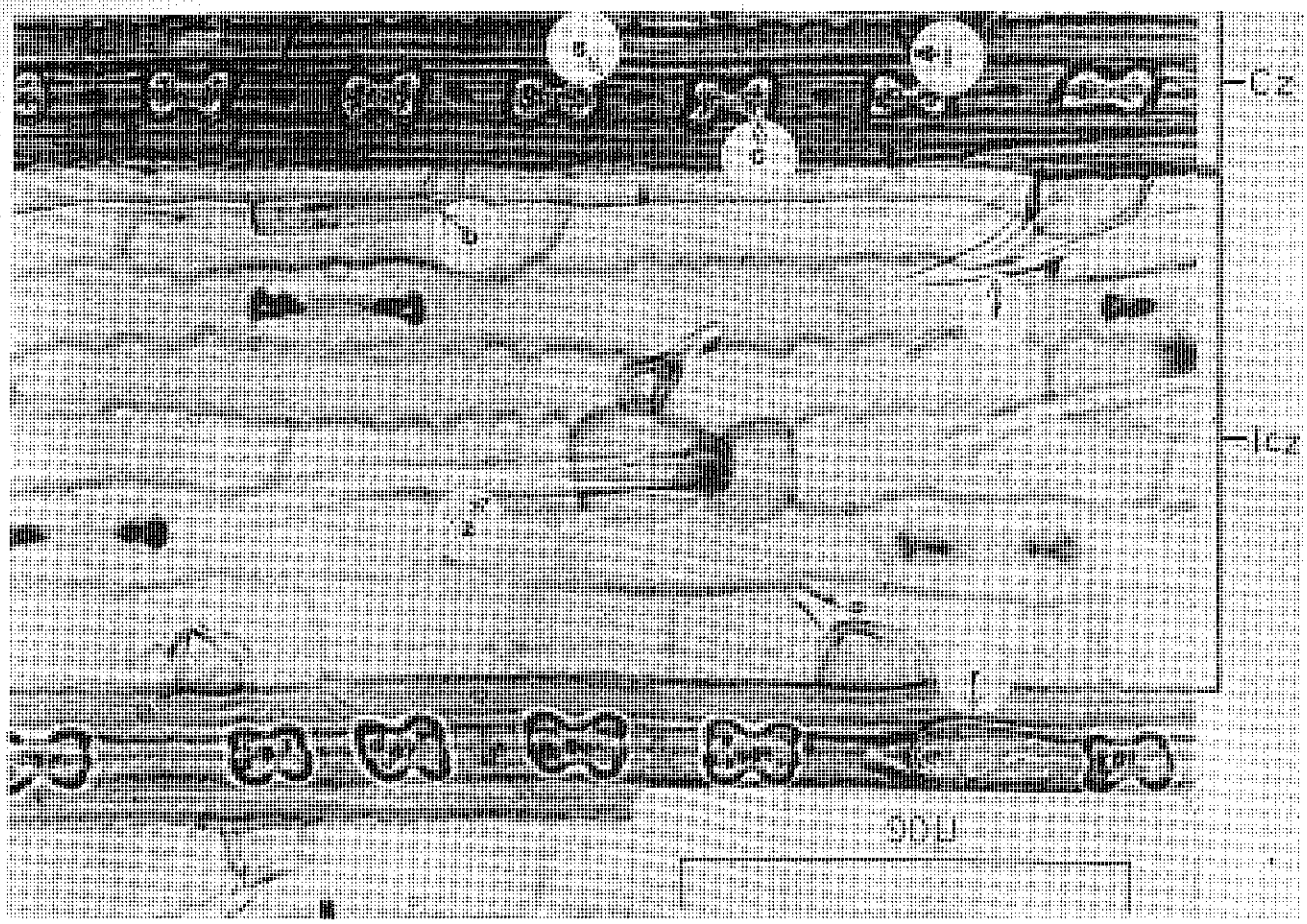


PLATE 1: Surface view of the abaxial epidermis of *Anthephora pubescens* Nees – focus on the costal zone.

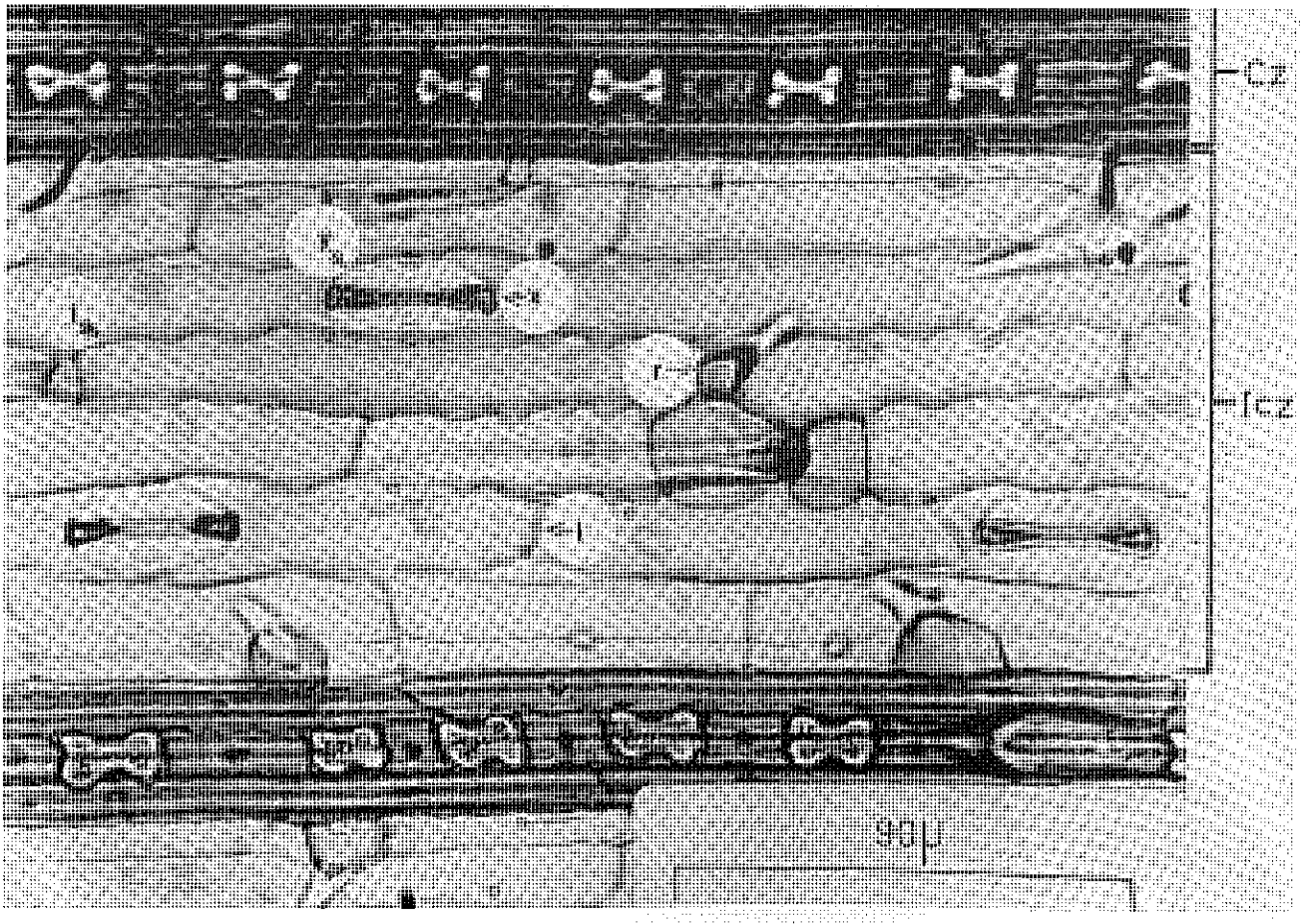


PLATE 2: Surface view of the abaxial epidermis of *Anthephora pubescens* Nees – focus on the intercostal zone.

but slightly sinuous in exceptional cases.

Long cells: Rectangular with slightly sinuous, sometimes wavy walls.

Prickle hairs: Common in some fragments; Bases oval and broader than the adjacent cells.

Intercostal zones:

Four to nine cell files wide. One or two files with stomata alternate with two or more files with long cells. The arrangement of the files with stomata is, however, not always regular. Within the files with stomata, stomata alternate with one long or one short cell.

Subsidiary cells: Usually triangular.

Long cells: Rectangular or coffin-shaped. Walls wavy but may also be sinuous. Near the centre of the zone are one or two files with inflated long cells which protrude from the surface and overlie the adjacent cells. At the zone margins one or two files with narrow long cells occur which do not conform to the same level as the rest of the zone and therefore also overlie the adjacent cells.

Short cells: Square or rectangular with smooth or wavy walls.

Prickle hairs: A variety occurs. Near the zone margins their bases are broader than the adjacent cells while near the centre of the zone they are narrower than the adjacent cells. Bases are rectangular or square and vertically or horizontally oriented. At the zone margins the bases have one convex wall. The barbs of prickle hairs in the centre of the zone are longer than those of the prickle hairs at the zone margins.

Microhairs: Common in the outer two rows. Basal cells narrowed at the proximal end and typically sharply angled to one side from the base. Apical cells as long as the basal cells.

Macrohairs: Occur near the centre of the zone. Supported by two specialised epidermal cells.

Aristida adscensionis L.
(Plate 3)

Costal zones:

One to 14 cell files wide. Broad zones occur at the leaf margins and in the middle of the lamina. Files with silica cells alternate with one or two files with long cells. Within the files with silica cells, silica cells alternate with one short cell but may also alternate with more than one short or long cell.

Silica cells: Short or long dumbell-shaped.

Short cells: Nodular but may also be cross-shaped or rectangular. Walls sinuous.

Long cells: Rectangular with sinuous walls.

Prickle Hairs: Occur in the narrower costal zones and on the edges of the broad costal zones. Horizontally oriented with oval bases broader than adjacent cells.

Intercostal zones:

Three to nine cell files wide, including one or two files with stomata. Within the latter, stomata alternate with one or more long cells.

Subsidiary cells: Usually dome-shaped. Stewart (1965) states that the subsidiary cells of this species are markedly triangular.

Long cells: Rectangular with sinuous walls.

Short cells: Rare. Irregularly shaped with sinuous walls.

Microhairs: Common in some files. Basal cells narrowed at the proximal end. Apical cells as long as, but more often longer than the basal cells. In his description, Stewart (1965) states that microhairs occur occasionally.

Aristida congesta Roemer & Schultes
(Plate 4)

Costal zones:

One to seven cell files wide. Files with silica cells alternate with one file with long cells and within the files with silica cells, silica cells alternate with one or two short cells and/or long cells.

Silica cells: Short dumbell-shaped but may also be long dumbell-shaped.

Short cells: Cross-shaped but may also be long dumbell-shaped or rectangular. The latter have sinuous walls giving them a nodular appearance.

Long cells: Rectangular with sinuous walls.

Prickle hairs: Observed on some of the fragments examined. Bases oval and broader than the adjacent cells. De Winter (1965) mentions "unicellular very sharp-pointed retrorse hairs projecting obliquely over the stomatal zones".

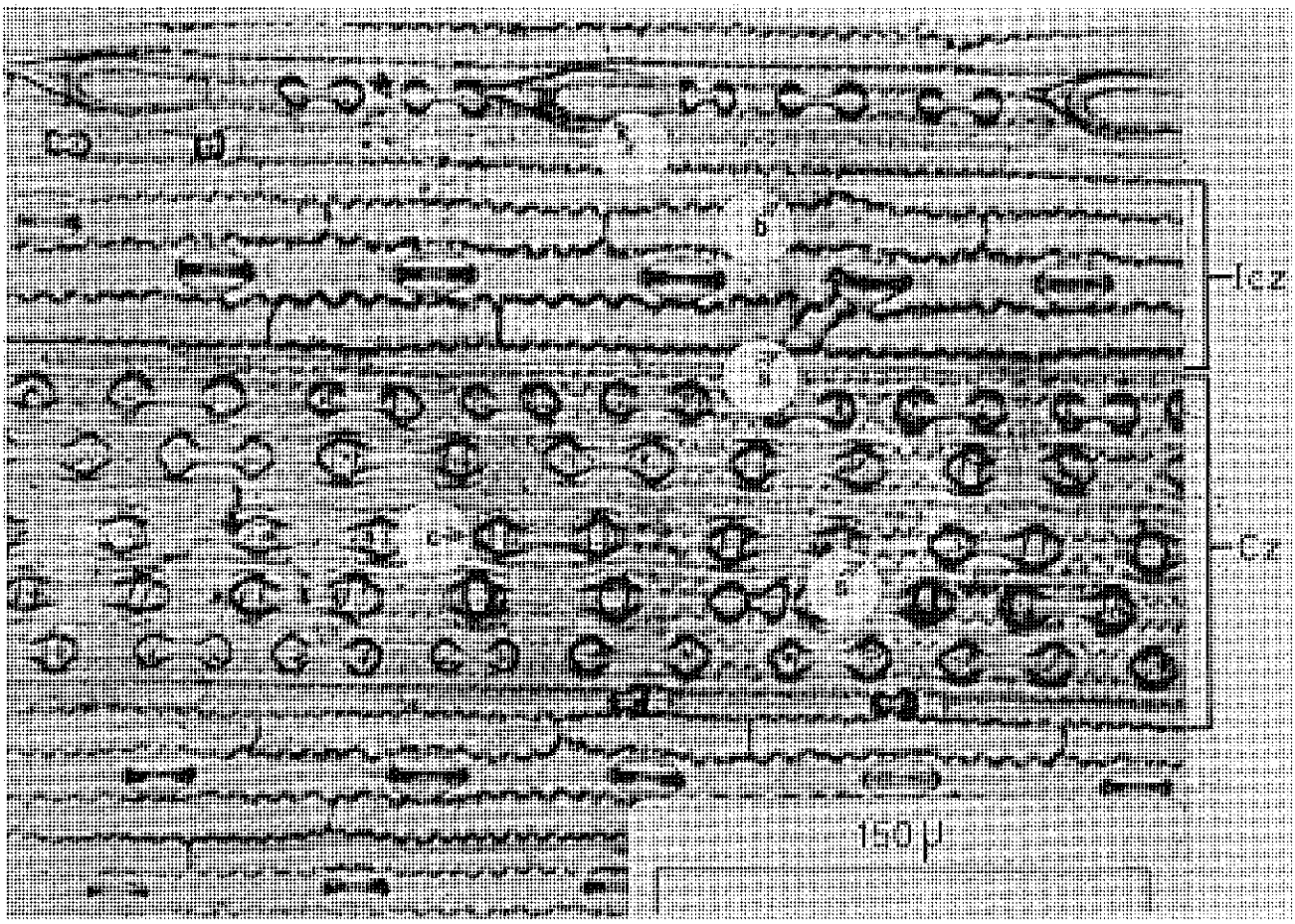


PLATE 3: Surface view of the abaxial epidermis of *Aristida adscensionis* L.

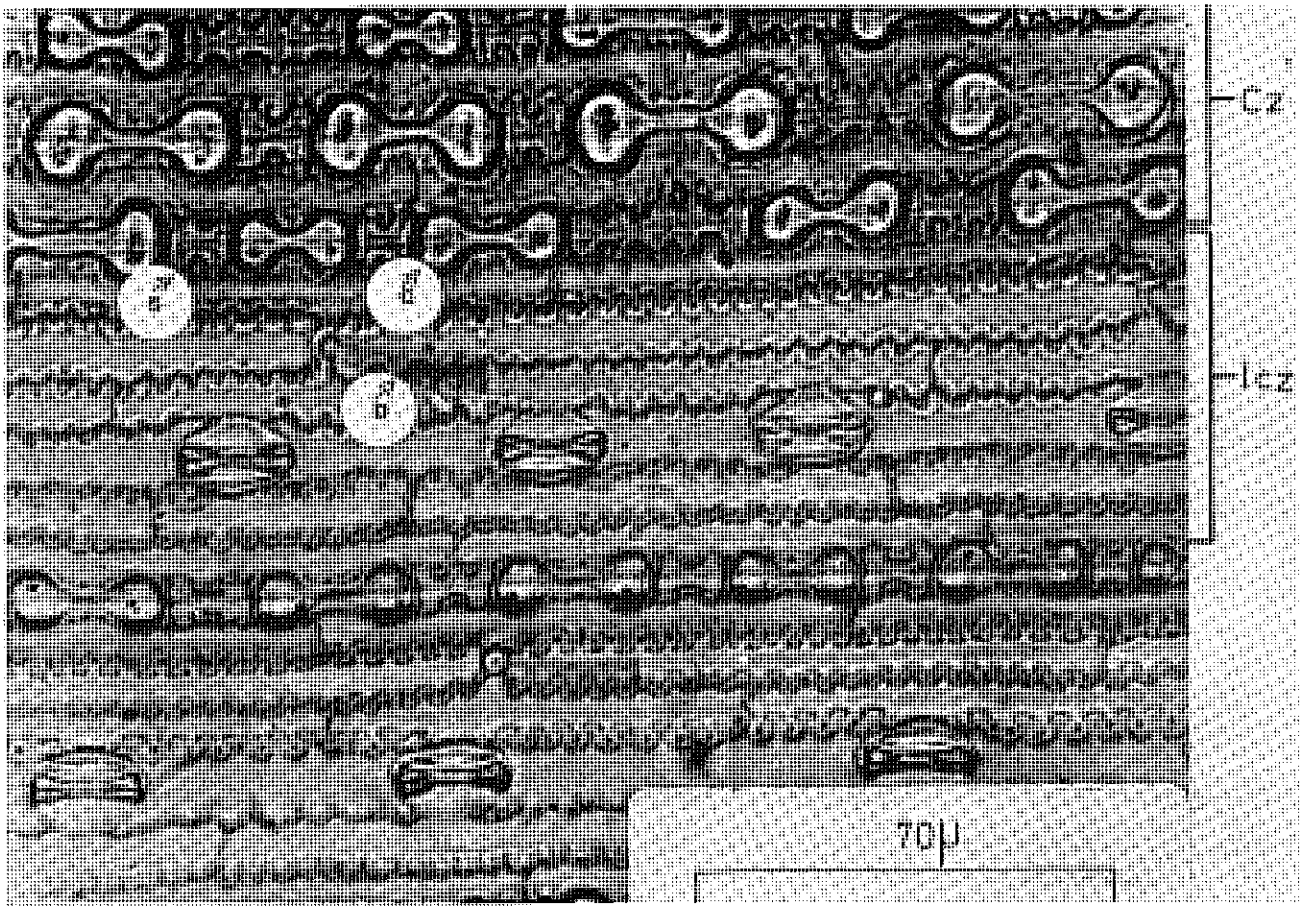


PLATE 4: Surface view of the abaxial epidermis of *Aristida congesta* Roemer & Schultes

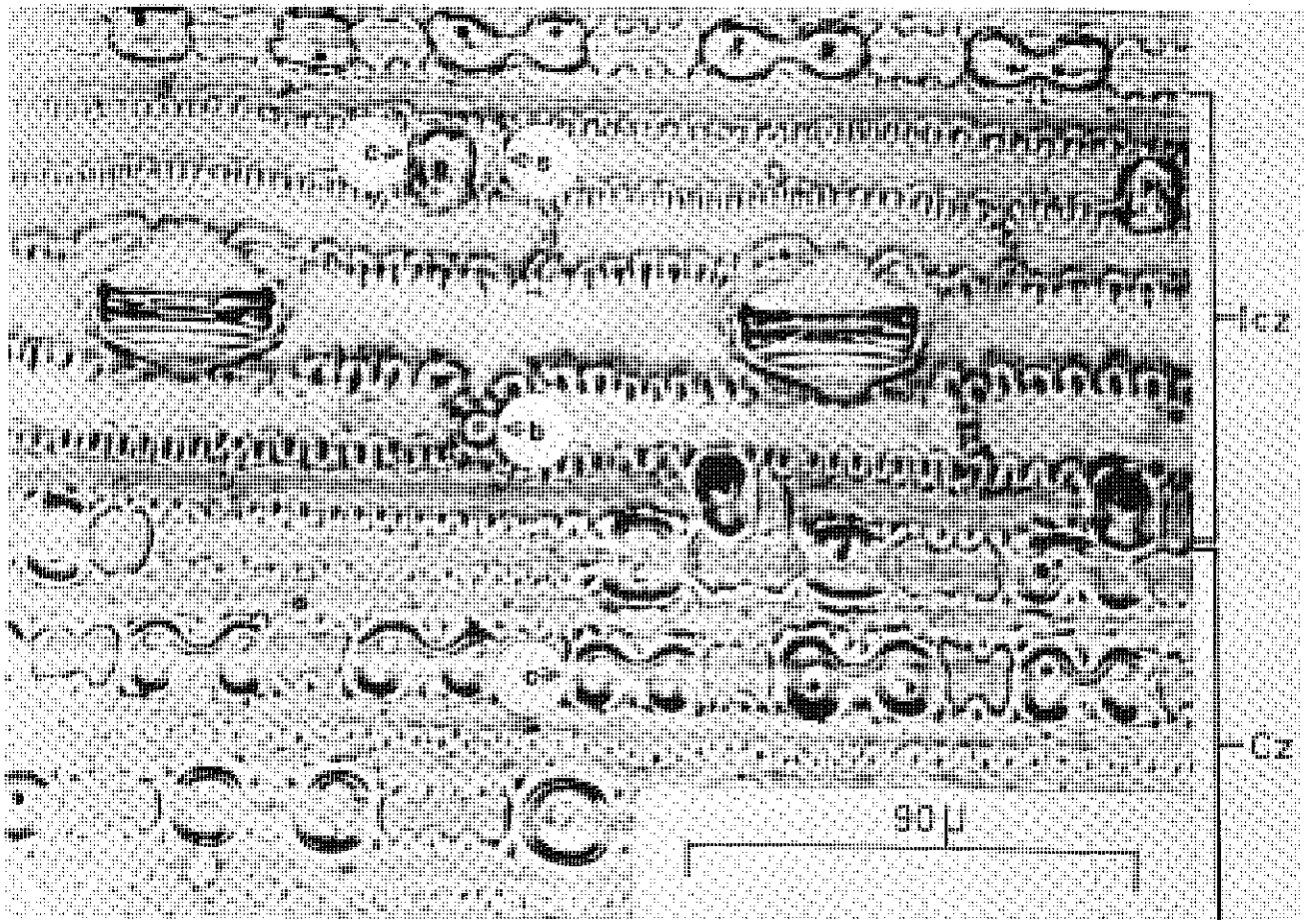


PLATE 5: Surface view of the abaxial epidermis of *Aristida engleri* Mez

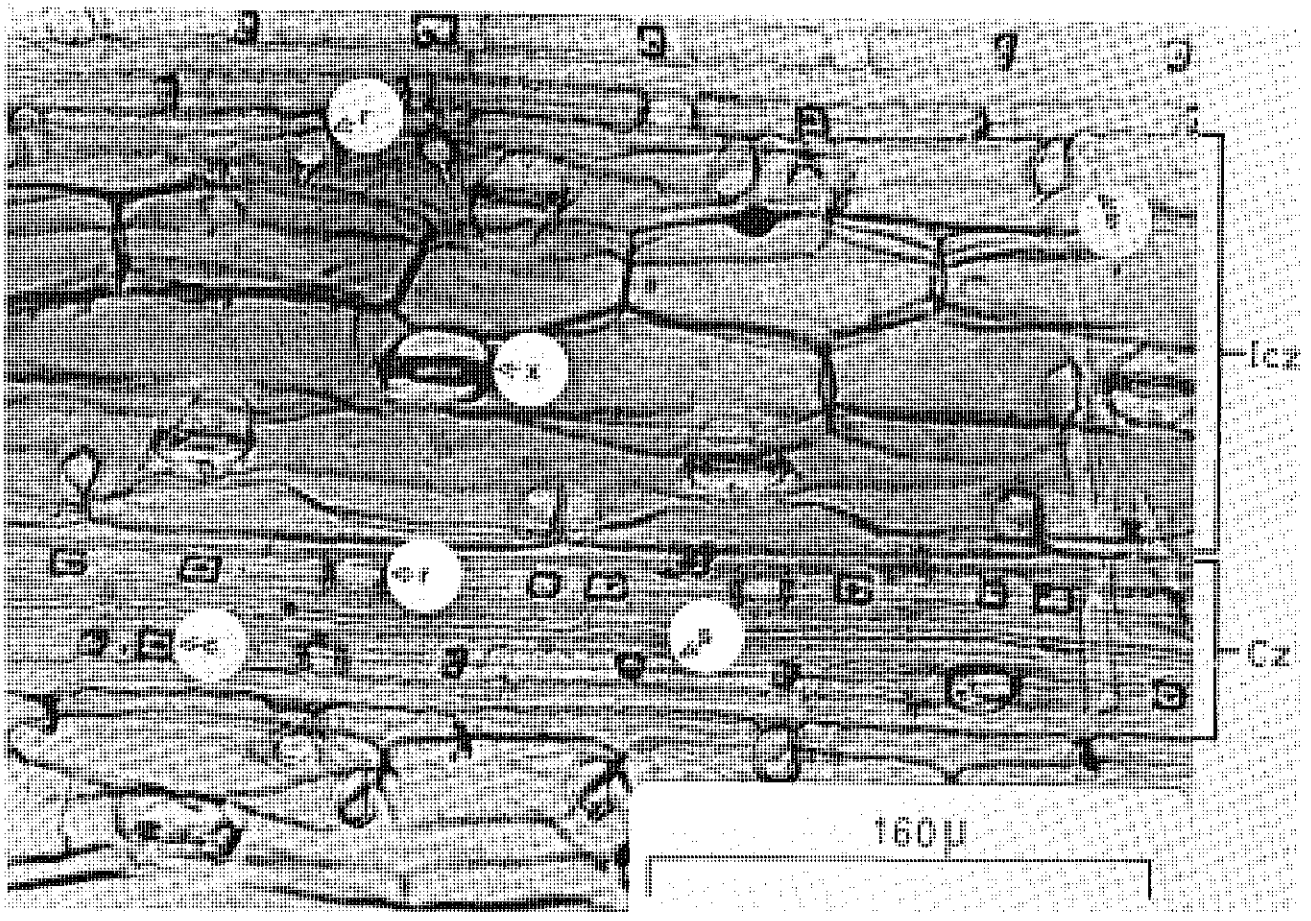


PLATE 6: Surface view of the abaxial epidermis of *Asthenatherum glaucum* (Nees) Nevski

Intercostal zones:

Five to eight cell files wide including one or two files with stomata which are not always regularly arranged. Stomata alternate with a single long cell.

Subsidiary cells:	Usually dome-shaped.
Long cells:	Rectangular with sinuous walls.
Short cells:	Vertically flattened but may also be rectangular or irregularly shaped.
Silica cells:	May occur near the zone margins. Short dumbell-shaped.
Microhairs:	Common. Basal cells narrowed at the proximal end and apical cells as long as or longer than the basal cells.

Aristida engleri Mez
(Plate 5)

Costal zones:

One to twelve cells files wide. Files with silica cells alternate with one or two files with long cells. Within the files with silica cells, silica cells usually alternate with one short cell but may alternate with one long cell or more than one short cell.

Silica cells:	Short dumbell-shaped but may also be vertically flattened, square, rectangular or irregularly shaped.
Short cells:	Rectangular but may also be square, vertically flattened or irregularly shaped. Walls sinuous or wavy.
Long cells:	Rectangular with sinuous walls.
Prickle hairs:	None observed but De Winter (1965) mentions a few "unicellular sharp-pointed hairs".

Intercostal zones:

Four to seven cell files wide including one or two files with stomata. When two files with stomata occur, they are usually separated by two files with long cells. Stomata alternate with one long cell.

Subsidiary cells:	Dome-shaped but may also be triangular with constricted apices.
Long cells:	Rectangular with sinuous walls.
Short cells:	Irregularly shaped but may also be vertically flattened, square or rectangular (the latter two with sinuous walls).
Silica cells:	Usually paired with a short cell. More common near zone margins. Vertically flattened but may also be square or irregularly shaped.
Microhairs:	Basal cells narrowed at the proximal end. Apical cells lost or distorted during processing.

Asthenatherum glaucum (Nees) Nevski
(Plate 6)

Costal zones:

Five to twelve cell files wide. Files with silica cells alternate with one or two files with long cells but can also be adjacent. Within the files with silica cells, silica cells alternate with one or more short or long cells.

Silica cells:	Scattered. Rectangular but may also be square, vertically flattened or irregularly shaped. Square or rectangular cells have slightly protruding rounded corners approximating the shape of cross-shaped cells.
Short cells:	Square and rectangular cells most common but short dumbell-shaped, vertically flattened and irregularly shaped cells also occur. Walls smooth or wavy.
Long cells:	Roughly rectangular with sinuous walls.
Prickle hairs:	Bases square or rectangular with thickened walls, broader than adjacent cells. Barbs are either rudimentary or absent and invisible in Plate 6.

Intercostal zones:

It was impossible to count the number of cell rows in the intercostal zones due to overlapping of cell rows near the zone margins. There are normally two files with stomata in the intercostal zones. The arrangement and shapes of cells in the intercostal zones are irregular and peculiar to this species (see "Long cells" below).

Subsidiary cells:	Dome-shaped, often horizontally flattened.
Long cells:	Those in the centre of the zone are either rectangular or coffin-shaped with smooth walls and protrude from the surface. The outer cell files overlap one another and consist of irregularly rectangular cells with sinuous walls.
Interstomatal cells:	Irregularly shaped forms of the above with sinuous, wavy or smooth walls. Near the leaf apex these files overlap less and the cells are more regularly shaped with smooth walls.

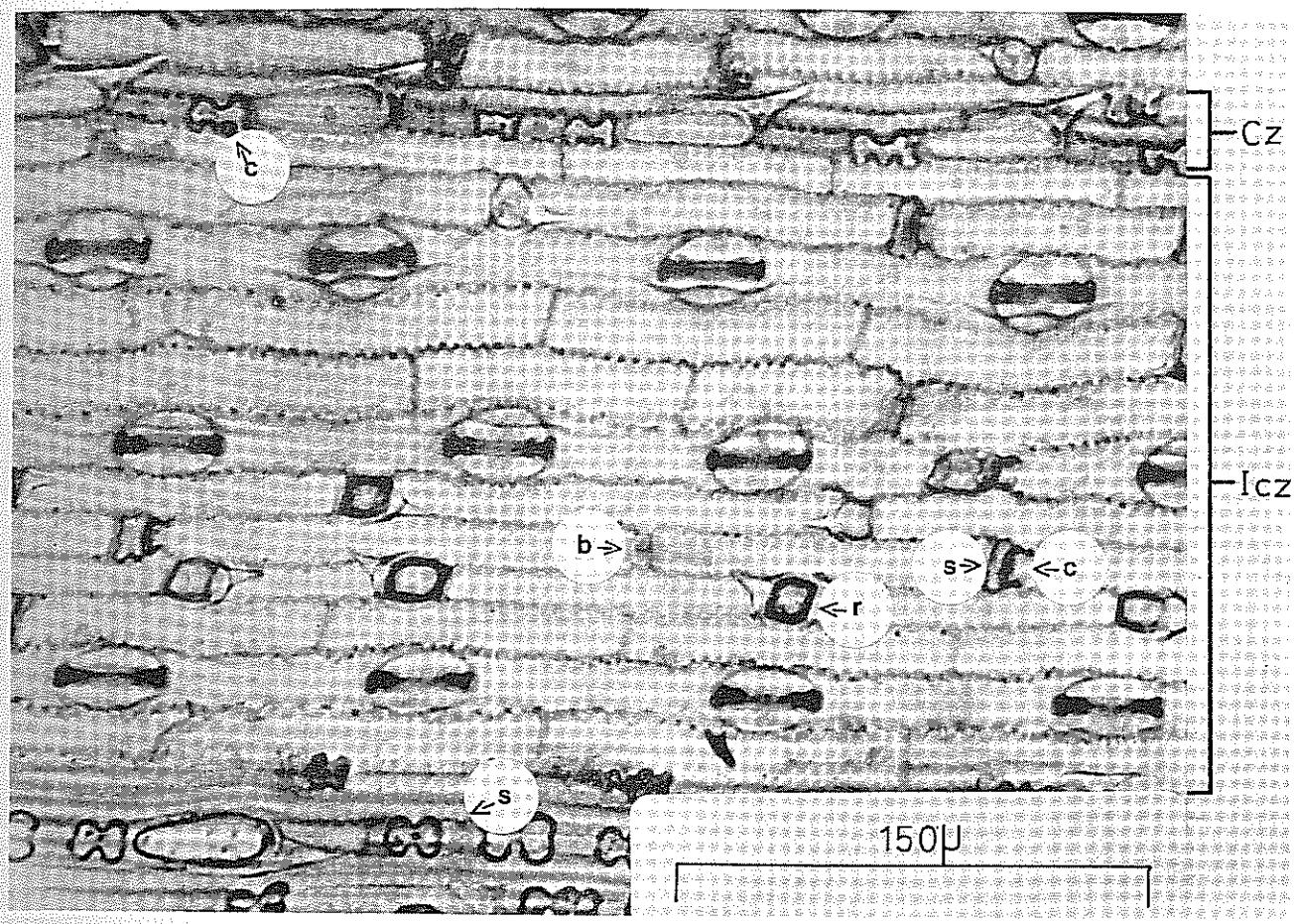


PLATE 7: Surface view of the abaxial epidermis of *Cenchrus ciliaris* L.

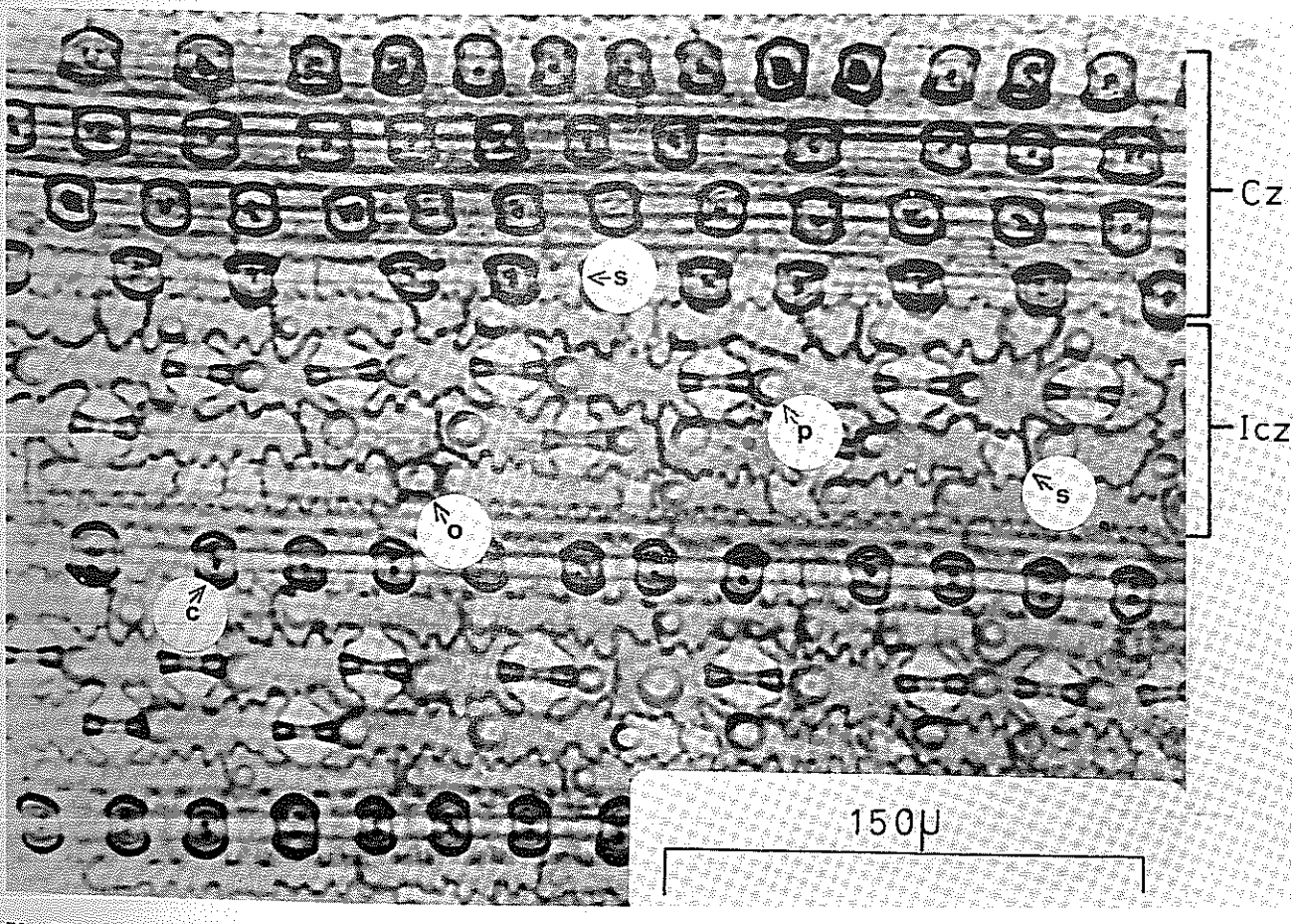


PLATE 8: Surface view of the abaxial epidermis of *Chloris virgata* Swartz

Short cells: Occur near zone margins, usually paired with a prickle hair. Irregularly shaped.

Silica cells: Occur near zone margins. Irregularly shaped.

Prickle hairs: Common at zone margins. Bases triangular, broader than adjacent cells and vertically oriented. Barbs are longer than those of the prickle hairs in the costal zones.

Cenchrus ciliaris L.
(Plate 7)

Costal zones:

One to five cell files wide. Files with silica cells usually alternate with one or two files with long cells. Within the files with silica cells, silica cells alternate with one or two short cells. At the zone margins, silica cells may alternate with long cells.

Silica cells: Short dumbell-shaped but may also be cross-shaped, vertically flattened or irregularly shaped.

Short cells: Rectangular but may also be cross-shaped, vertically flattened or square. Walls sinuous.

Long cells: Rectangular with sinuous walls.

Prickle hairs: Prominent. Bases oval and broader than adjacent cells.

Intercostal zones:

Four to 15 cell files wide including one to four files with stomata which alternate with two or more files with long cells. Stomata alternate with one or more long or short cells. Silica cells may occur in the files with stomata.

Subsidiary cells: Dome-shaped.

Long cells: Rectangular with sinuous walls.

Short cells: The same types as in the costal zones but in this case the most common type is vertically flattened.

Silica cells: Irregularly shaped but may also be vertically flattened.

Prickle hairs: Common. Bases rectangular, square or irregularly shaped and as broad as or narrower than adjacent cells. Barbs short or rudimentary often having the appearance of papillae.

Microhairs: Scattered throughout the zone. Basal cells slightly narrowed at the proximal end, although occasional cells with equidistant walls occur. Apical cells as long as or longer than basal cells and appear to have a pointed apex.

Macrohairs: None observed but Stewart (1965) stated that occasional macrohairs occur.

This species is probably subject to considerable regional variation. A specimen from the Windhoek district had broader, more prominent costal zones with large numbers of prickle hairs. Intercostal zones were narrow and cell walls were wavy instead of sinuous. Microhairs were less common and cell shapes were more irregular. Fewer silica cells were present in the costal zones.

Chloris virgata Swartz
(Plate 8)

Costal zones:

One to seven cell files wide. Files with silica cells usually alternate with one or two files with long cells. Within the files with silica cells, silica cells alternate with a single long or short cell.

Silica cells: Typically saddle-shaped (vertically oriented) but may also be vertically flattened.

Short cells: Cross-shaped or rectangular, the latter with sinuous walls.

Long cells: Rectangular with sinuous walls.

Prickle hairs: Occur in zones more than one cell file wide (but are rare). Bases oval, broader than adjacent cells. Both Metcalfe (1960) and Kok (1968) observed prickle hairs in fairly large numbers, while Fisher (1939) and Stewart (1965) found only occasional prickle hairs.

Intercostal zones:

Five to 10 cell files wide including one or two files with stomata which are often adjacent. Within the files with stomata, stomata alternate with one or more long and/or short cells.

Subsidiary cells: Usually triangular with constricted apices.

Long cells: Roughly rectangular with sinuous walls.

Short cells: Irregularly shaped or vertically flattened. Walls sinuous.

Papillae: A single acentric papilla occurs on almost every cell on some fragments. On other fragments papillae are less common or absent. It appears that where papillae are frequent short cells and microhairs are infrequent and vice versa.

Microhairs: Common on some of the material examined. Unicellular, bulbous short and erect. Fisher

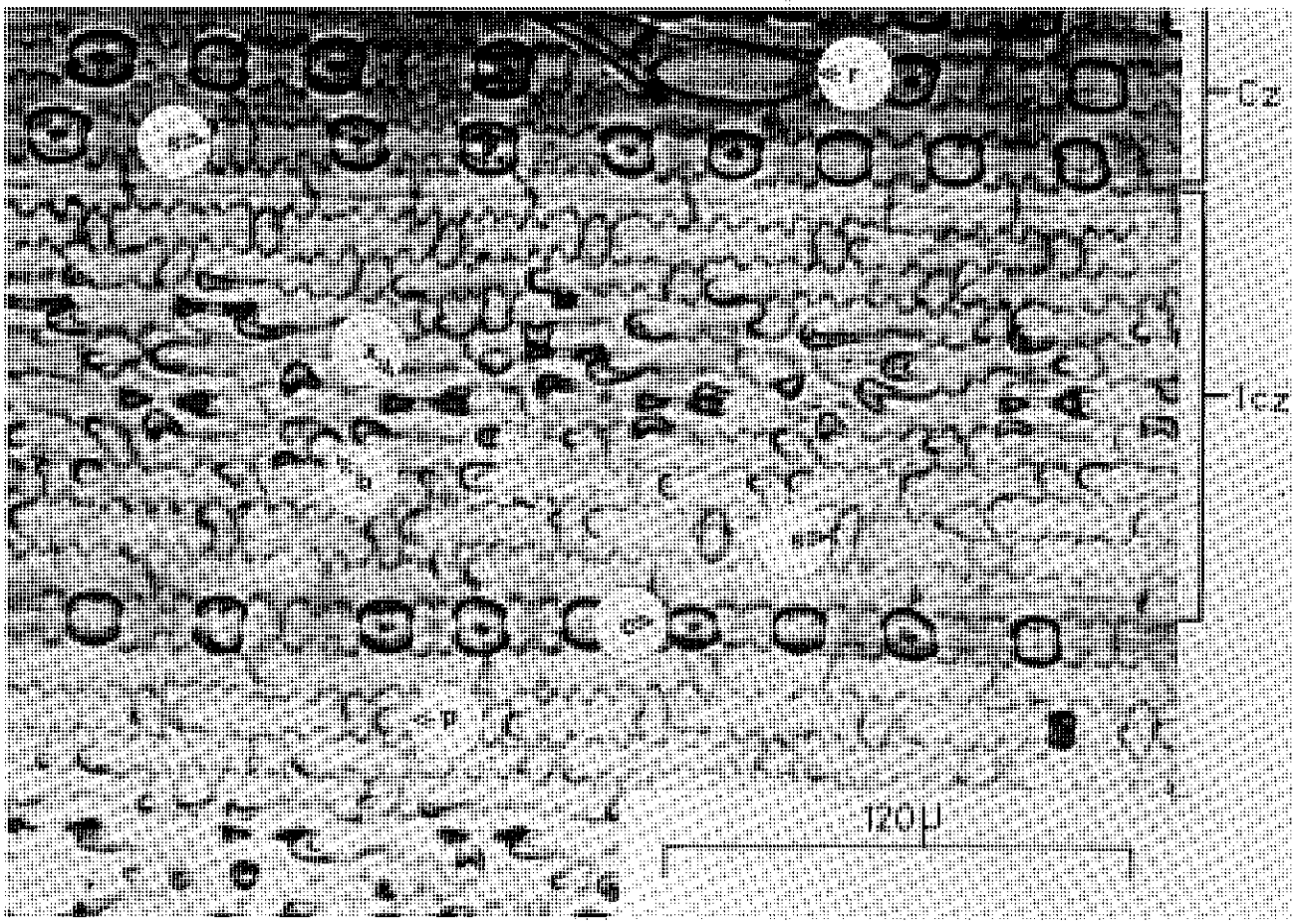


PLATE 9: Surface view of the abaxial epidermis of *Cynodon dactylon* (L.) Pers.

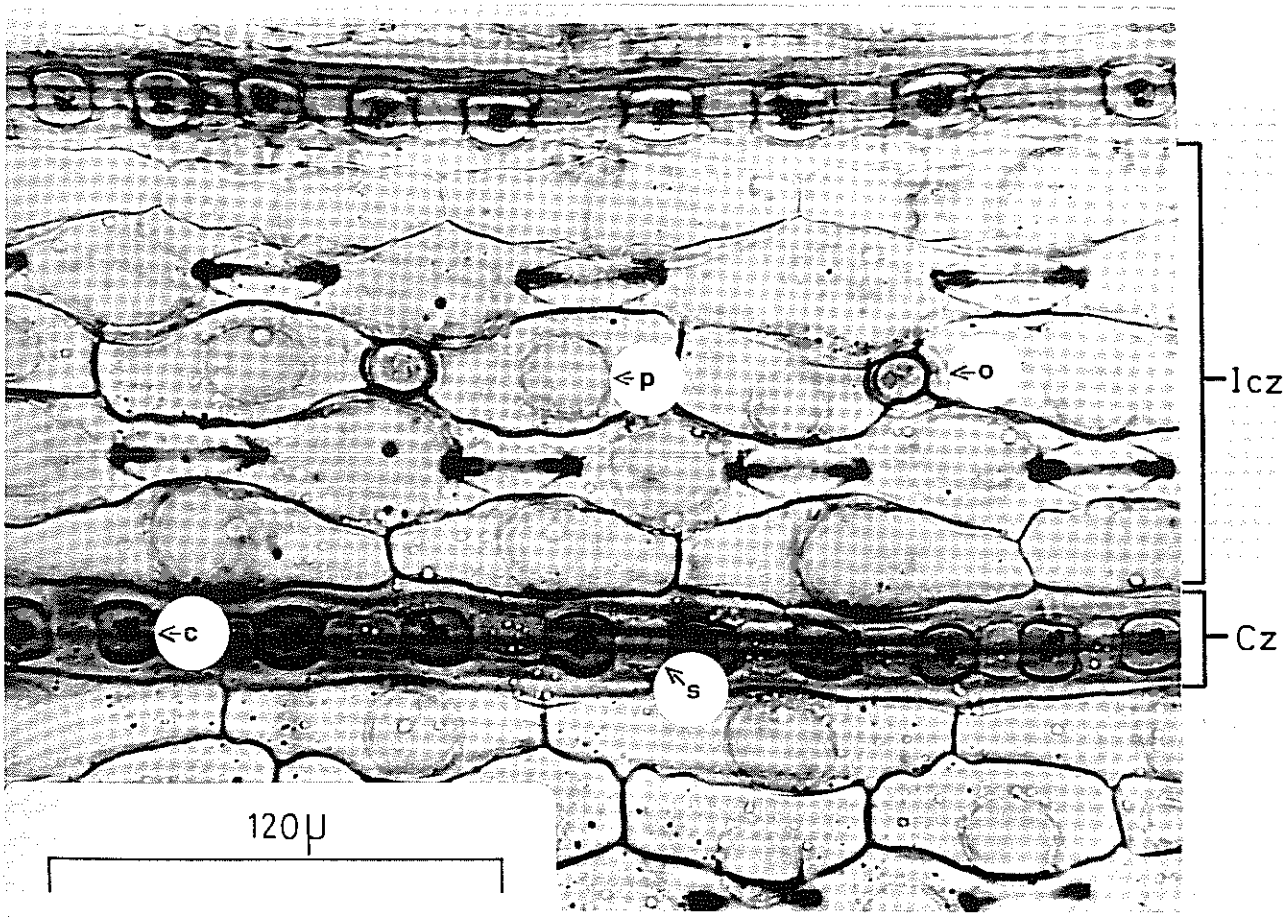


PLATE 10: Surface view of the abaxial epidermis of *Dactyloctenium aegyptium* (L.) Beauv.

(1939), Metcalfe (1960), Stewart (1965) and Kok (1968) described the microhairs of this species as unicellular.

Macrohairs: None observed. Stewart (1965) and Kok (1968) observed macrohairs whereas Fisher (1939) and Metcalfe (1960) found no macrohairs.

Cynodon dactylon (L.) Pers.
(Plate 9)

Costal zones:

One to 11 cell files wide. Files with silica cells alternate with one or two files with long cells. Within the files with silica cells, silica cells alternate with one or two short and/or long cells.

Silica cells: Saddle-shaped (vertically or horizontally oriented), but may also be semilunar (vertically oriented), rectangular, or irregularly shaped.

Short cells: Rectangular with sinuous walls, but may also be cross-shaped, vertically flattened or irregularly shaped.

Long cells: Rectangular with sinuous walls.

Prickle hairs: May occur in broader costal zones. Bases oval (sometimes rectangular), horizontally oriented and broader than adjacent cells. Barbs relatively long. Stewart (1965) states that prickle hairs were abundant in both costal and intercostal zones in the material which he examined. Metcalfe (1960) and Kok (1968), as in this study, found that prickle hairs were rare. Günzel (1913) also mentions prickle hairs in the epidermis of this species.

Intercostal zones:

Seven to 12 cell files wide, including one to four files with stomata. The files with stomata are adjacent or alternate with one or two long cell rows. Stomata alternate with one or more long or short cells. The central parts of the intercostal zones, in which stomata occur, appear to be sunken. In the files with long cells, most of the long cells are paired with a short cell.

Subsidiary cells: Dome-shaped.

Long cells: Rectangular with sinuous walls.

Interstomatal cells: Roughly rectangular but may also be irregularly shaped. Walls sinuous.

Short cells: Common. Irregularly shaped with sinuous walls.

Silica cells: Rare. Vertically flattened or irregularly shaped.

Papillae: A single acentric papilla occurs on almost every cell, even short cells in the central parts of the intercostal zones, but are less common near the zone margins.

Microhairs: Basal cells minute, narrowed at the proximal end and sometimes obscured by apical cells which are bulbous and longer than the former. This is in agreement with what other authors found (Günzel 1913, Metcalfe 1960, Stewart 1965 and Kok 1968).

Macrohairs: Contrary to what Metcalfe (1960) and Stewart (1965) found, no macrohairs were seen in the material examined. Kok (1968) also did not observe macrohairs.

Dactyloctenium aegyptium (L.) Beauv.
(Plate 10)

Costal zones:

One to five cell files wide. Where the zones are more than three files wide, files with silica cells alternate with a file with long cells. In zones which are three cell files wide, there is a single file with silica cells flanked by two files with long cells. Within the files with silica cells, silica cells alternate with one or two short cells.

Silica cells: Saddle-shaped (vertically or horizontally oriented) but may also be vertically flattened or square.

Short cells: Square but may also be saddle-shaped, vertically flattened, rectangular or irregularly shaped. Walls smooth.

Long cells: Roughly rectangular with smooth or wavy walls.

Papillae: Occur on some short cells but not always easily visible.

Macrohairs: May occur at leaf margins. Unicellular. Bases surrounded by more than two specialised epidermal cells. Protrude laterally over the edge of the lamina. Günzel (1913) mentions these hairs and so does Stewart (1965), but Metcalfe (1960) found that they are common in the intercostal zones of material from Mauritius and Sri-Lanka which he examined.

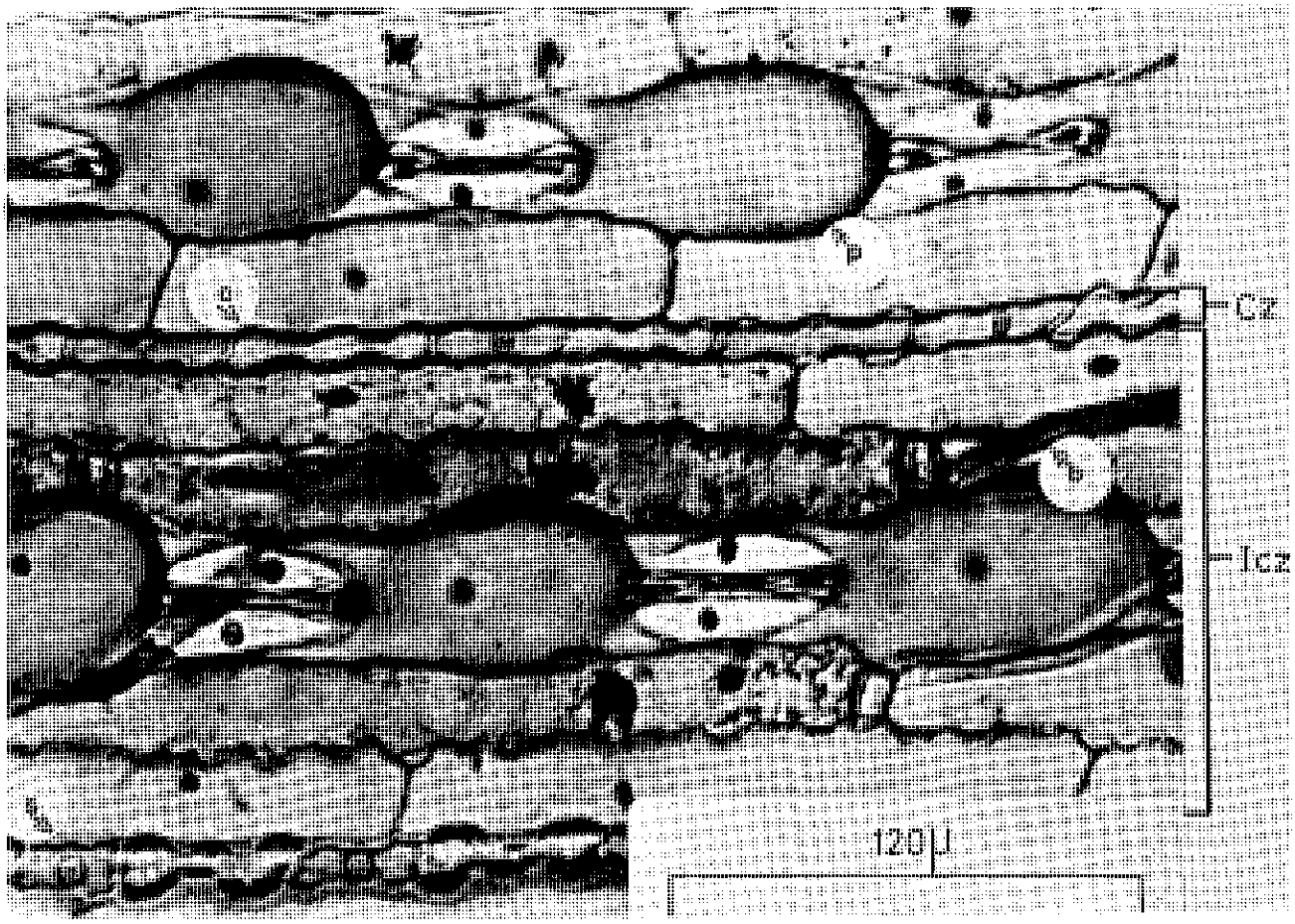


PLATE 11: Surface view of the abaxial epidermis of *Dichanthium papillosum* (Hochst. ex A. Richard) Stapf

Intercostal zones:

Six to 32 cell files wide including one to six files with stomata which alternate with one or more files with long cells. Within the files with stomata, stomata alternate with a single long or short cell. The shapes of cells in the intercostal zones can be irregular.

Subsidiary cells: Triangular (horizontally flattened).

Long cells: Roughly coffin-shaped with smooth walls but walls may also be wavy.

Interstomatal cells: Interstomatal long and short cells as for long cells.

Short cells: Square but may also be vertically flattened, rectangular or irregularly shaped. Walls smooth or wavy.

Papillae: Single large papillae occur on all cells except stomata and subsidiary cells. Three previous authors (Günzel 1913, Metcalfe 1960 and Stewart 1965) stated that the papillae are prominent and thickened and that they often overlie the stomata. In the material examined in the present study they do not overlie the stomata.

Microhairs: Common. Unicellular, bulbous, short and erect.

Dichanthium papillosum (Hochst ex A. Richard) Stapf (Plate 11)

Costal zones:

One to 12 cell files wide, all of them files with silica cells. Long cells are uncommon and occur mainly in the costal zones at the leaf margin. Silica cells alternate with a single long or short cell.

Silica cells: Nodular (four to six nodes) but may also be long dumbell-shaped. In the broader costal zones (which only occur near the leaf margins) silica cells are mostly cross-shaped but may also be short dumbell-shaped. Stewart (1965) described the silica cells as dumbell-shaped, but found that cross-shaped silica cells occurred near the leaf margins.

Short cells: Rectangular but may also be square. Walls smooth or wavy.

Long cells: Rectangular with wavy walls, but with sinuous walls in the broader costal zones.

Prickle hairs: Occur in the narrow costal zones. Bases oval (but may also be round), broader than adjacent cells. Stewart (1965) found abundant prickle hairs.

Intercostal zones:

Four to seven cell files wide including one or two files with stomata. Within the files with stomata, stomata alternate with a single short or long cell.

Subsidiary cells: Dome-shaped (horizontally flattened).

Long cells: Rectangular with smooth or wavy walls.

Interstomatal cells: Irregularly shaped with smooth walls (both long and short cells).

Short cells: Uncommon. Occur either singly or paired with a silica cell. Vertically flattened or irregularly shaped.

Silica cells: Rare. Occur only in some of the material examined. Irregularly shaped or cross-shaped.

Prickle hairs: Rare. Occur only in some of the material examined. Bases irregularly shaped, vertically oriented and narrower than adjacent cells.

Papillae: Single large papillae which sometimes overlie adjacent cells or stomata occur on interstomatal cells. Two or more smaller papillae occur on long cells in some of the material examined.

Digitaria eriantha Steudel
(Plates 12 and 13)

Costal zones:

Three to four cell files wide. When the zones are three cell files wide, a single file with silica cells is flanked by two files with long cells. Otherwise, files with silica cells alternate with one or two files with long cells. In the costal zones near the leaf margins several adjacent files with silica cells may occur. Within the files with silica cells, silica cells alternate with a single short or long cell.

Silica cells: Short dumbell-shaped but may also be long dumbell-shaped or cross-shaped.

Short cells: Rectangular but may also be cross-shaped or square. Walls smooth or slightly wavy.

Long cells: Rectangular with smooth or wavy walls.

Prickle hairs: Occur near leaf margins. Bases oval, broader than adjacent cells. Barbs rudimentary or absent.

Intercostal zones:

Nine to 15 cell files wide. There are two or three files with stomata separated by two to four files with long cells. Within the files with stomata, stomata alternate with one or two short or long cells.

Subsidiary cells: Usually dome-shaped.

Long cells: Roughly coffin-shaped and often inflated, protruding above the surface and slightly overlying adjacent cells. The basal parts of inflated cells are wavy while the walls which protrude are smooth. Long cells near the zone margins are narrower, not inflated and often overlap one another, providing a confusing image in which it is difficult to recognise individual cells or files. Many of the latter have sinuous walls.

Interstomatal cells: Roughly rectangular, otherwise the same as the inflated long cells described above.

Short cells: Rectangular but may also be square. Walls smooth or wavy. Kok (1968) found no short cells.

Silica cells: Scattered. Short dumbell-shaped. Kok (1968) found no silica cells.

Prickle hairs: Common. Can be classified into two types: (1) Prickle hairs with square or rectangular bases (vertically oriented) and with short barbs found at the zone margins and, (2) prickle hairs with irregularly shaped bases narrower than the adjacent cells, with longer barbs than type (1) and occurring less frequently than type (1) nearer the centre of the zones.

Microhairs: Common. Basal cells narrowed at the proximal end. Apical cells have a pointed apex and are shorter than basal cells. Microhairs near zone margins often angled to one side from the base.

Macrohairs: Common. Bases surrounded by one or two specialised epidermal cells. Not to be confused with type (2) prickle hairs described above. Kok (1968) states that

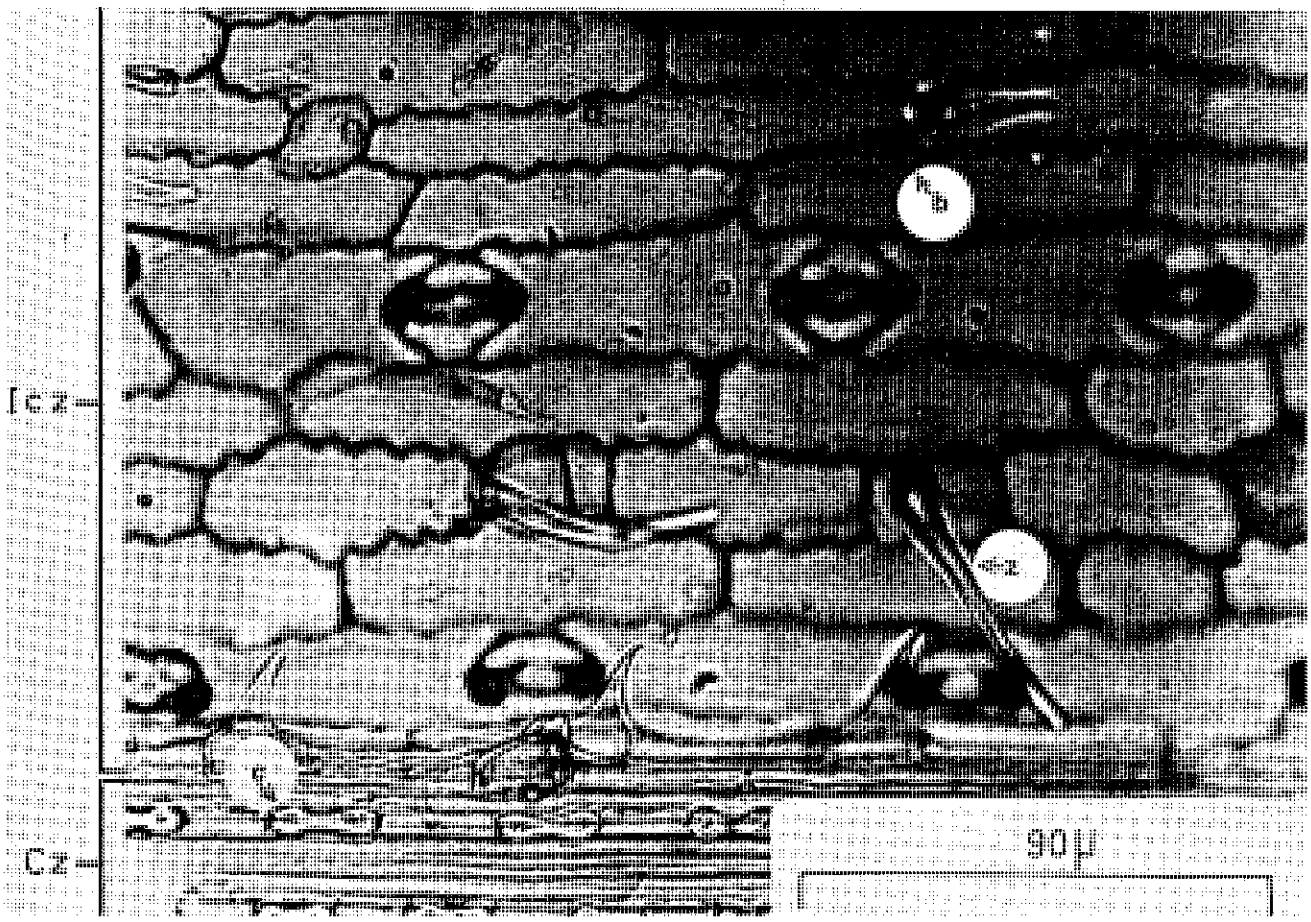


PLATE 12: Surface view of the abaxial epidermis of *Digitaria eriantha* Steudel — focus on the costal zone.

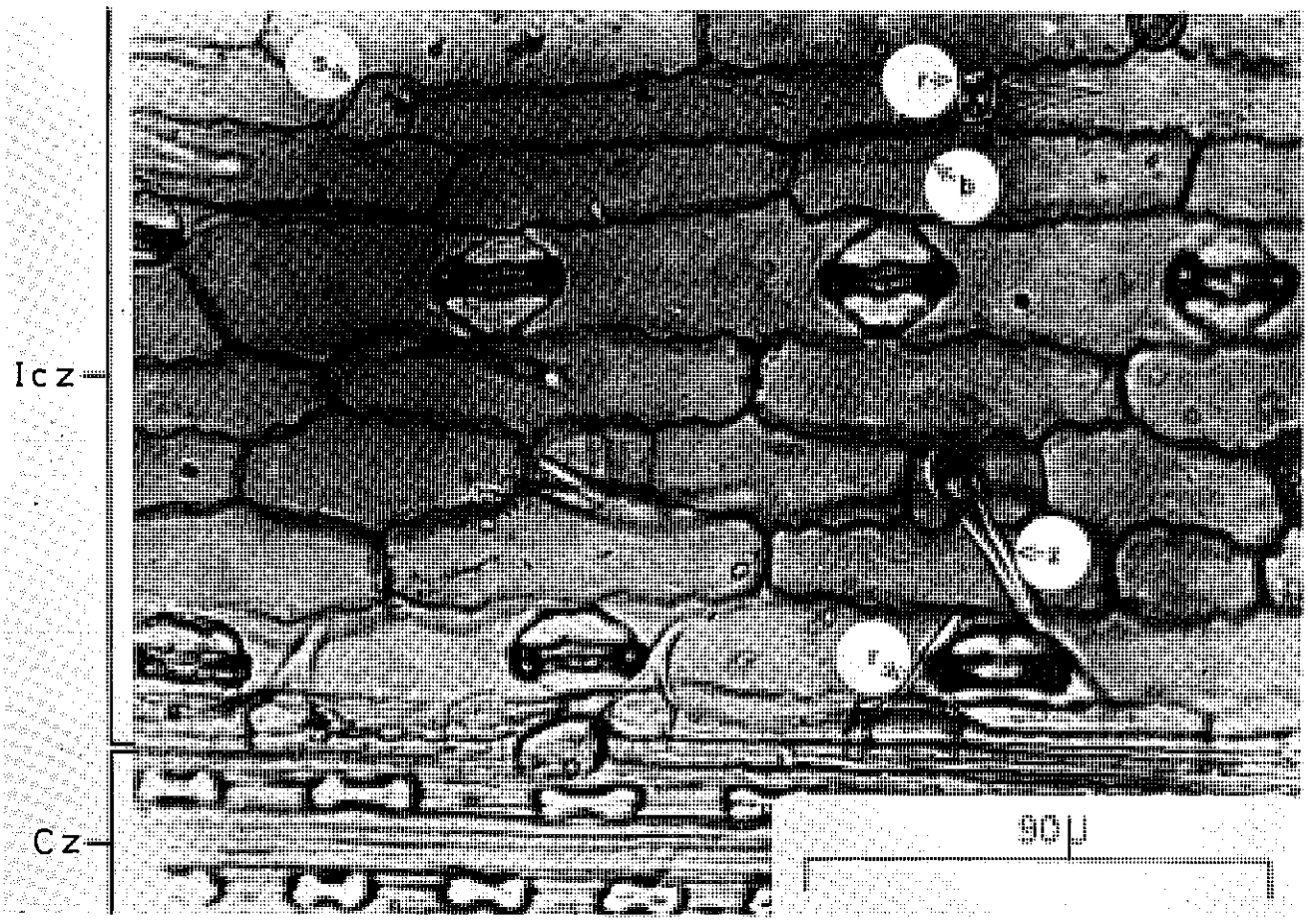


PLATE 13: Surface view of the abaxial epidermis of *Digitaria eriantha* Steudel — focus on the intercostal zone.

he found no macrohairs in the epidermis of this species but mentions prickle hairs with round bases in the intercostal zones.

Enneapogon brachystachyus (Jaub. & Spach) Stapf
(Plates 14, 15 and 16)

This species has a fine and narrow leaf.

Costal zones:

One to 13 cell files wide. Files with silica cells alternate with one file with long cells. When the zones are three cell files wide a single file with silica cells is flanked by two files with long cells. Within the files with silica cells, silica cells can be adjacent but usually alternate with one long or short cell, the latter sometimes with a prickle hair.

Silica cells: Short dumbell-shaped but may also be cross-shaped.
Short cells: Rectangular but may also be vertically flattened or square.
Long cells: Rectangular with sinuous walls.
Prickle hairs: Occur near margins of broader zones but scattered in narrower zones. Bases oval and broader than adjacent cells. Barbs relatively long.

Intercostal zones:

Four to six cell files wide including one or two files with stomata. When there are two files with stomata they are separated by a single file with long cells. Stomata alternate with one or more short or long cells.

Subsidiary cells: Triangular.
Long cells: Rectangular with sinuous walls.
Interstomatal cells: Rectangular with sinuous walls (both long and short).
Short cells: Common and always adjacent to a micro- or macrohair. Round with smooth walls but may also be square, rectangular or irregularly shaped.
Silica cells: May occur near zone margins. Irregularly shaped.
Prickle hairs: May occur along zone margins. Bases square, rectangular or irregular (vertically oriented).
Macrohairs: Two types occur:
(1) Bicellular macrohairs: Basal cells extremely long and slightly narrowed at the proximal end. Apical cells oval, bulbous and wider and shorter than the basal cells. These hairs are always associated with a round short cell at their bases. Stewart (1964 and 1965) described them as glandular and Metcalfe (1960) regards glandular macrohairs as a specific generic character for *Enneapogon*. Tateoka *et al.* (1959) said that the *Pappophoreae* are characterised by a special type of long microhair. It is assumed that they are referring to the hairs described above.
(2) Unicellular macrohairs: Occur only in some of the material examined. Associated with a single round short cell at their bases. Narrow, longer than type (1) and lack the apical cells of type (1).
Microhairs: Common. Sometimes associated with a single short cell which is not always round. Only differ from type (1) macrohairs by virtue of their size (less than one quarter of their length).

Enneapogon cenchroides (Roemer & Schultes) C. E. Hubbard
(Plates 17 and 18)

Costal zones:

One to five cell files wide. Files with silica cells are separated by a single file with long cells. Within the files with silica cells, silica cells usually alternate with a single short or long cell but may alternate with more than one short or long cell.

Silica cells: Long dumbell-shaped but may also be short dumbell-shaped or cross-shaped.
Short cells: Rectangular but may also be square.
Long cells: Rectangular with sinuous walls.
Prickle hairs: Common near leaf apex but occur elsewhere as well. Bases oval and broader than adjacent cells.

Intercostal zones:

Six to 14 cell files wide including two to four files with stomata. Stomata alternate with one or two short or long cells.

Subsidiary cells: Usually triangular (slightly horizontally flattened).
Long cells: Rectangular with sinuous walls.
Short cells: Common. Rectangular or irregularly shaped with sinuous walls but may also be semilunar (vertically oriented) with smooth walls, the latter type almost always paired with a macrohair.

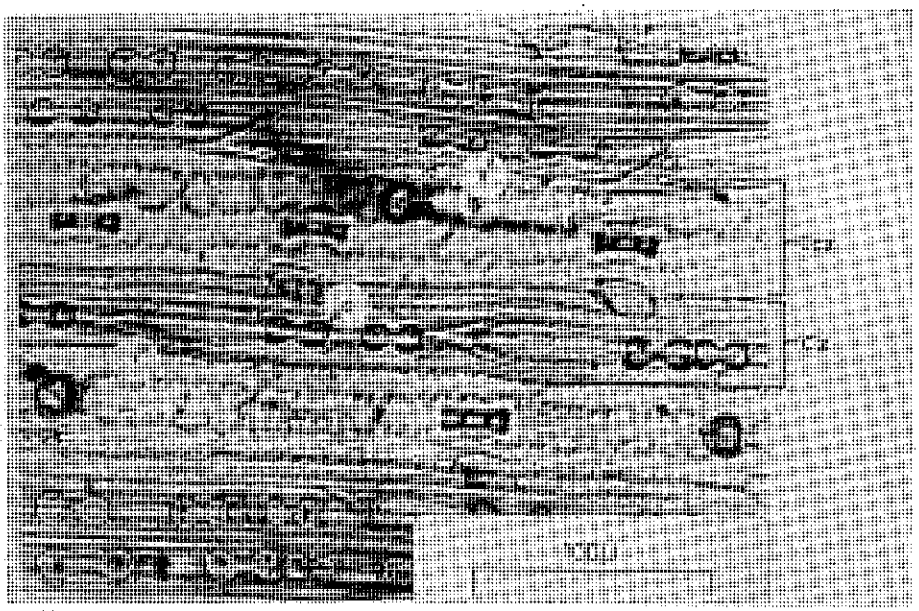


PLATE 14: Surface view of the abaxial epidermis of *Enneapogon brachystachyus* (Jaub. & Spach) Stapf – focus on the costal zone.

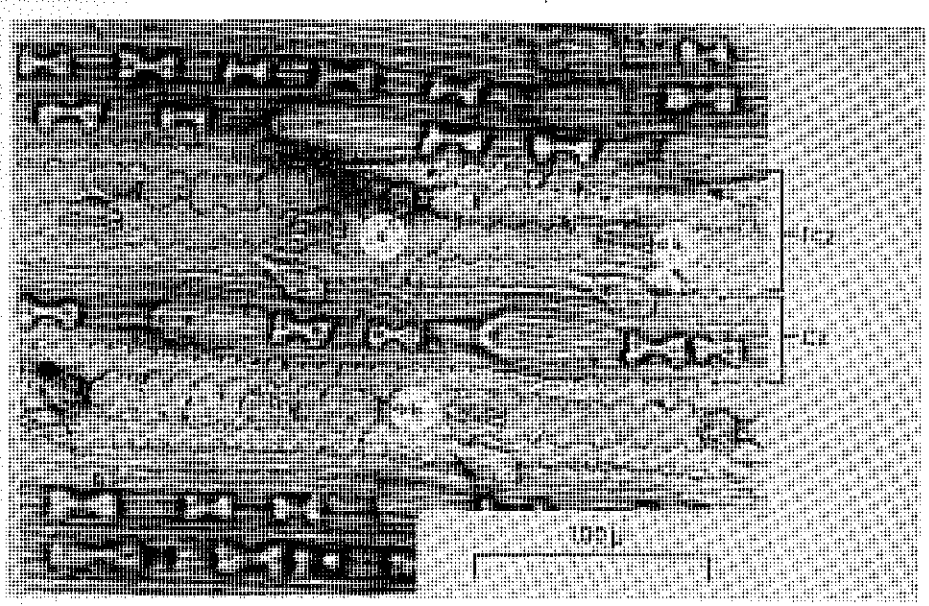


PLATE 15: Surface view of the abaxial epidermis of *Enneapogon brachystachyus* (Jaub. & Spach) Stapf – focus on the intercostal zone.

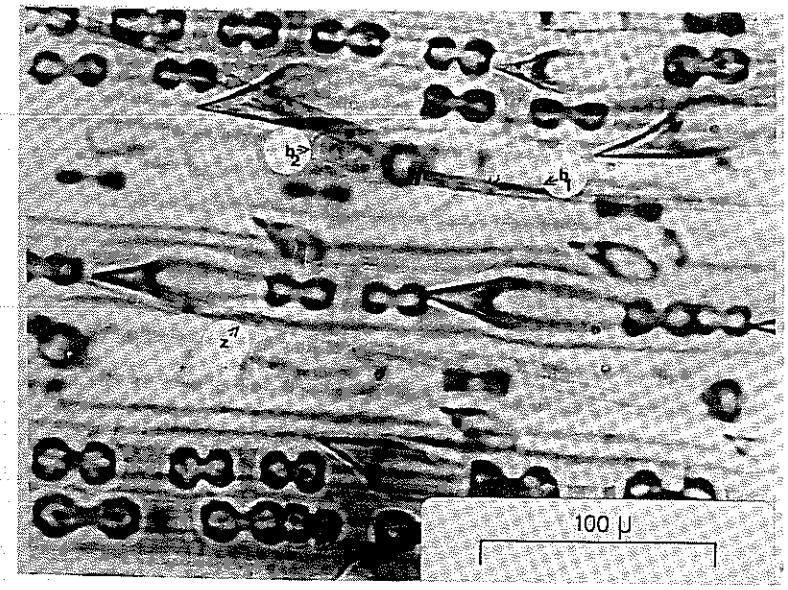


PLATE 16: Surface view of the abaxial epidermis of *Enneapogon brachystachyus* (Jaub. & Spach) Stapf – focus on appendages.

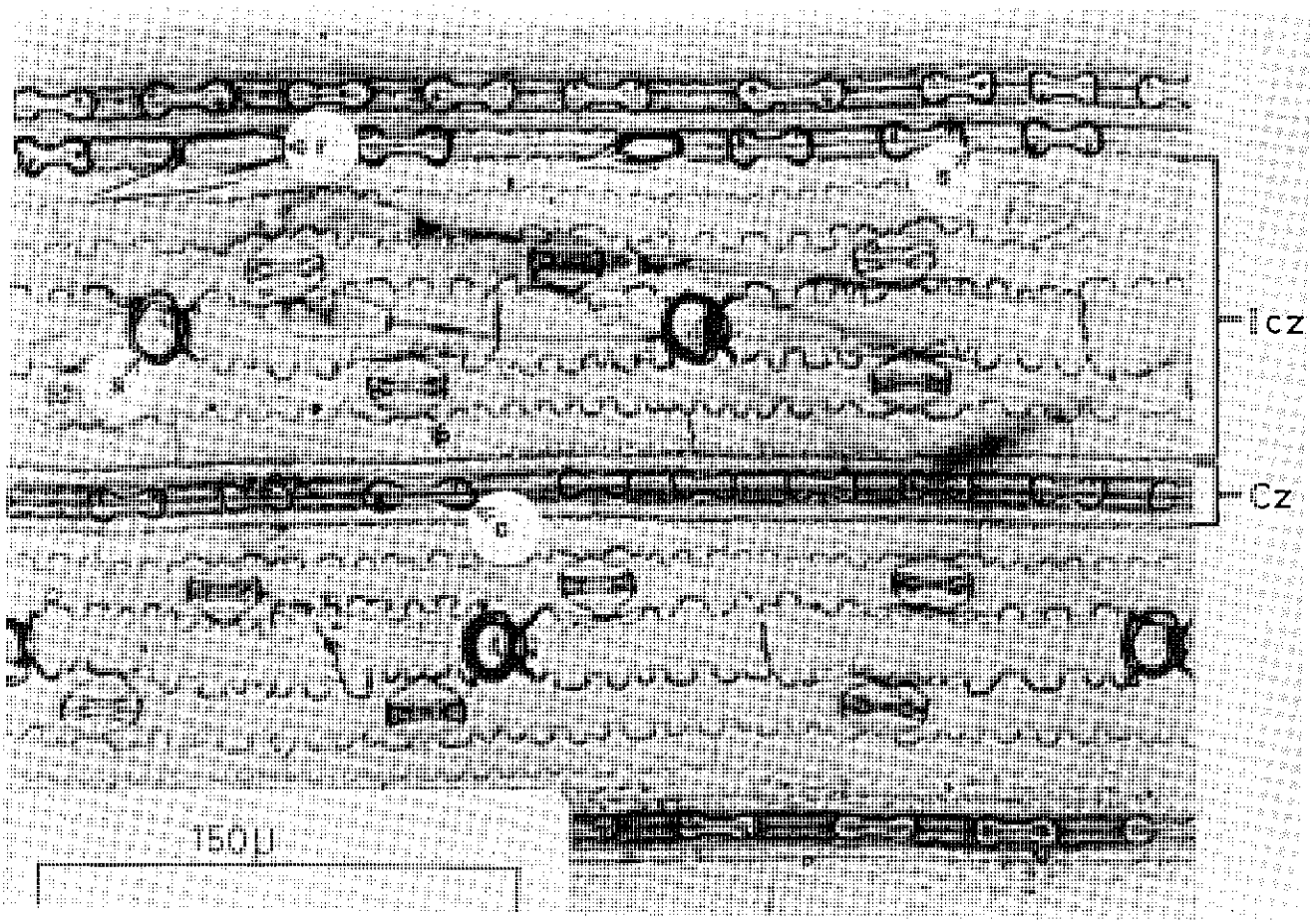


PLATE 17: Surface view of the abaxial epidermis of *Enneapogon cenchroides* (Roemer & Schultes) C. E. Hubbard

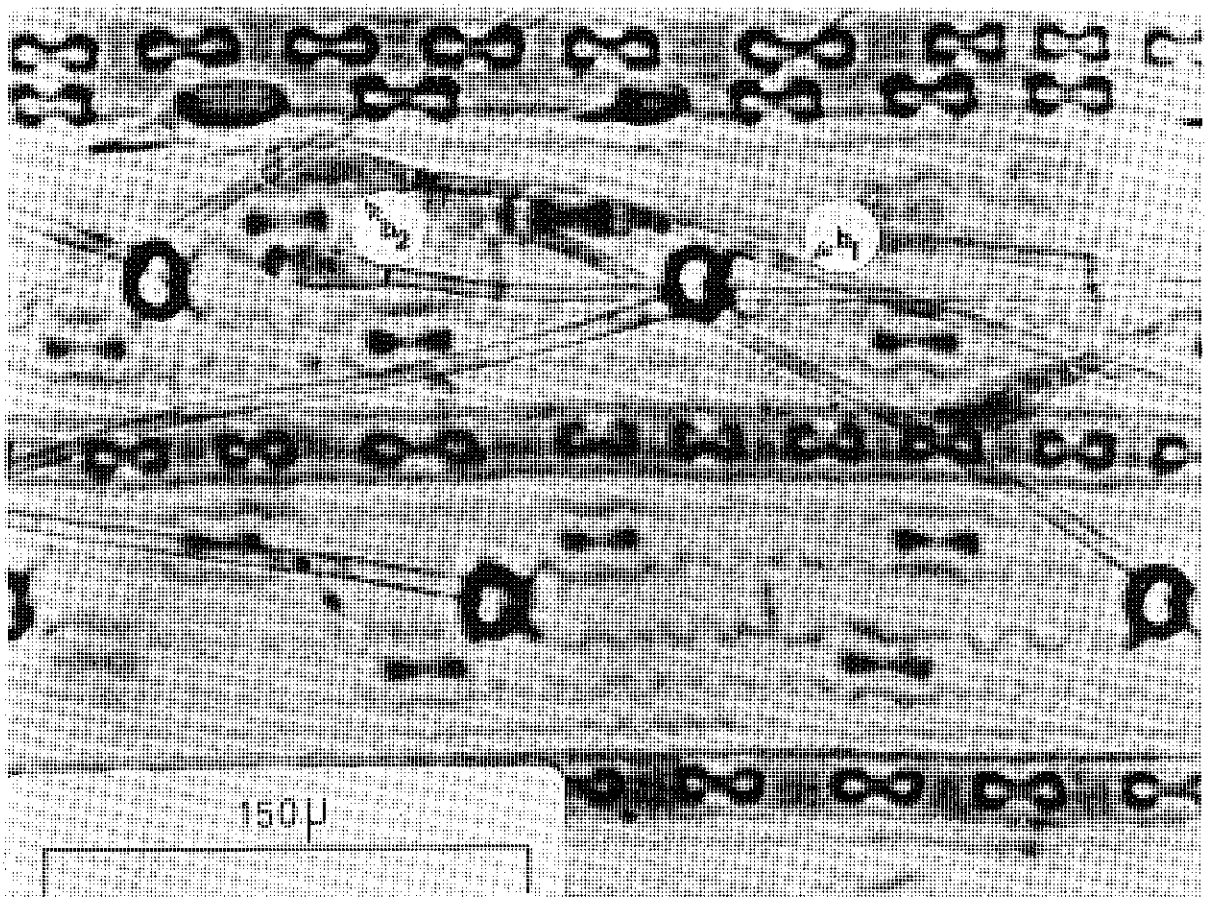


PLATE 18: Surface view of the abaxial epidermis of *Enneapogon cenchroides* (Roemer & Schultes) C. E. Hubbard – focus on appendages.

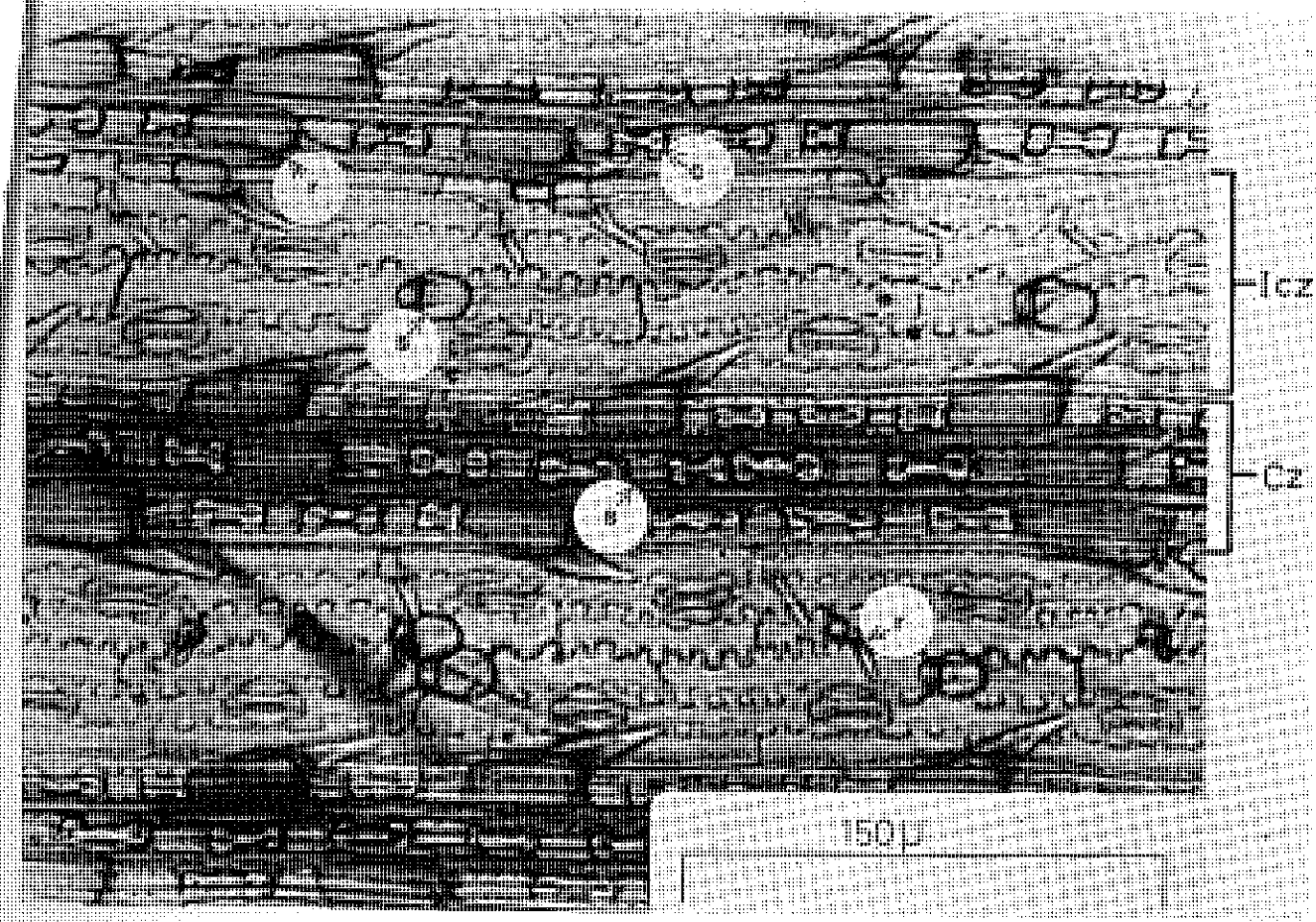


PLATE 19. Surface view of the abaxial epidermis of *Eremopyrum orientale* Lehm.

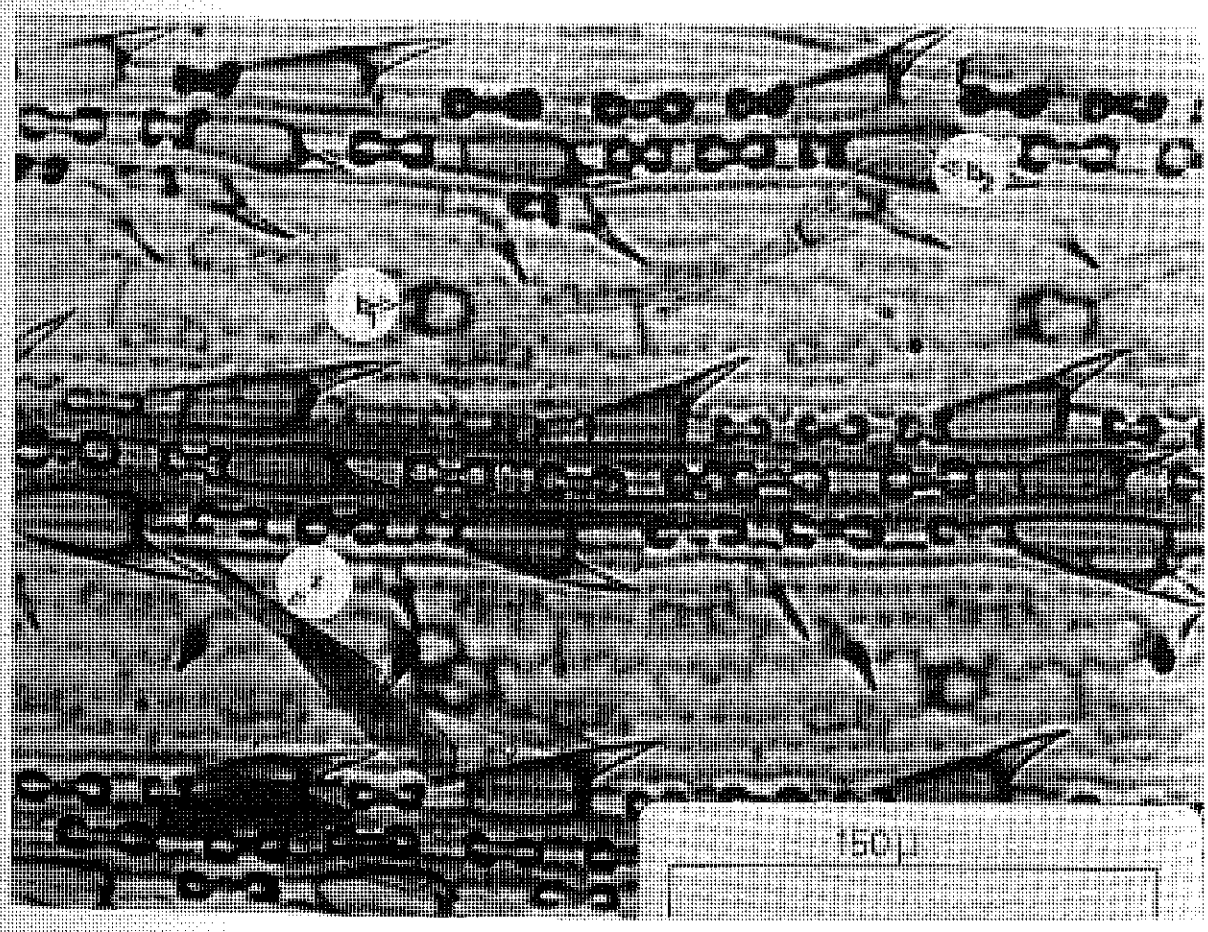


PLATE 20. Surface view of the abaxial epidermis of *Eremopyrum orientale* Lehm. — focus on appendages.

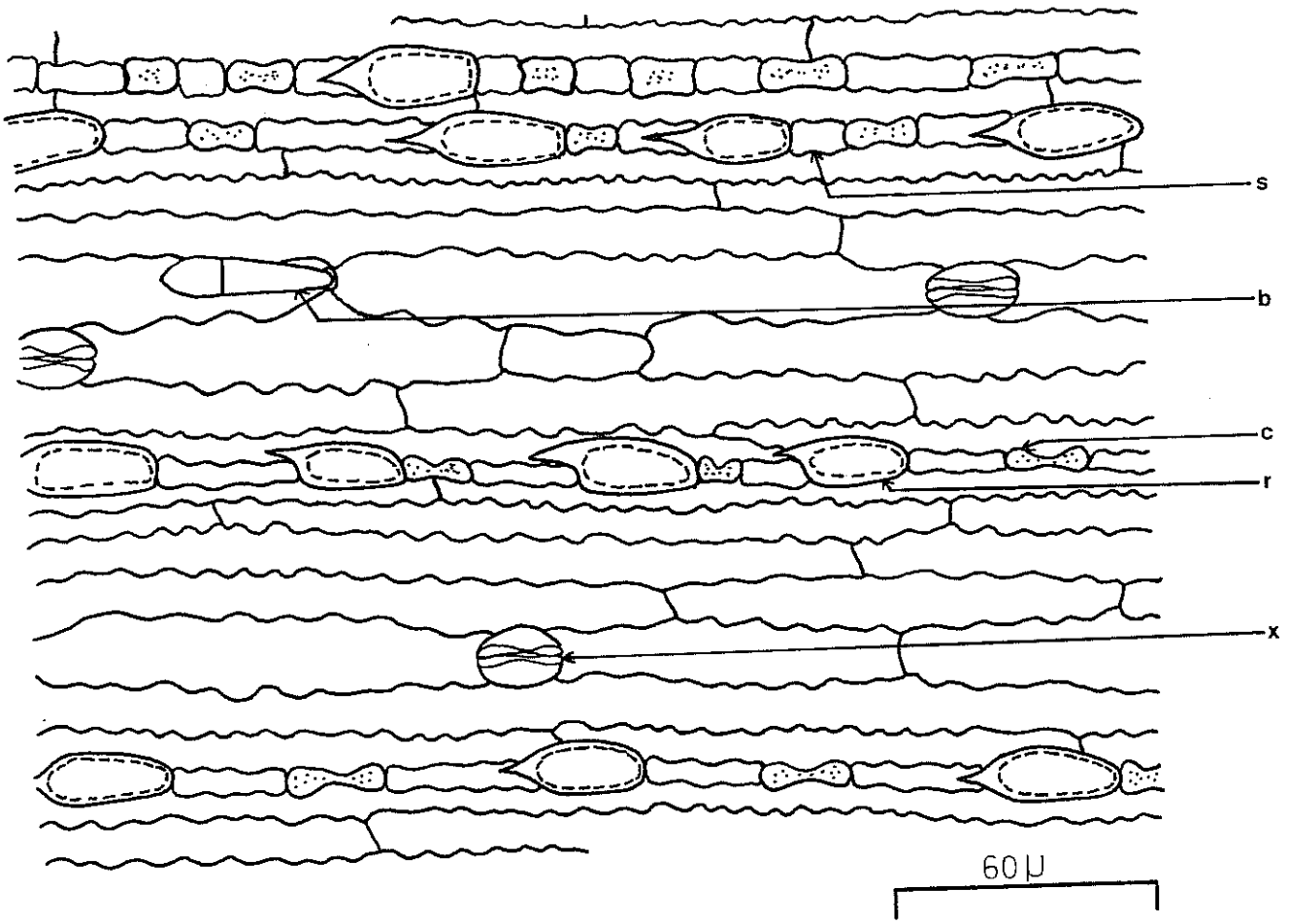


FIGURE 1: Line drawing of a surface view of the abaxial epidermis of *Eragrostis biflora* Hackel

Prickle hairs: None observed. Stewart (1965) mentions "hooks".

Macrohairs: Two types occur:
(1) Bicellular macrohairs: Occur throughout. Always paired with a single, thickened, smooth-walled, semilunar short cell. Basal cells long with approximately equidistant cell walls. Apical cells oval, bulbous and shorter and wider than basal cells.
(2) Unicellular macrohairs: Less numerous than type (1). Also paired with a single, semilunar short cell. Longer than type (1). Apex pointed.

Enneapogon scaber Lehm
(Plates 19 and 20)

Costal zones:

One to nine cell files wide. Files with silica cells alternate with a single file with long cells. Within the files with silica cells, silica cells alternate with one, or sometimes two or three, short or long cells. Silica cells may also be adjacent.

Silica cells: Short dumbell-shaped but may also be long dumbell-shaped or cross-shaped. Nodular silica cells occur but are rare.

Short cells: Rectangular with sinuous walls.

Long cells: Rectangular with sinuous walls.

Prickle hairs: Common. Bases oval or rectangular and broader than adjacent cells.

Intercostal zones:

Four to seven cell files wide including two files with stomata which are separated by one or two files with long cells. Stomata alternate with one or two long cells.

Subsidiary cells: Triangular (horizontally flattened).

Long cells: Rectangular with sinuous walls.

Short cells: Common. Round with smooth walls but may also be irregularly shaped or rectangular with sinuous walls.

Prickle hairs: Smaller than the prickle hairs of the costal zones. Bases vary but are mostly roughly rectangular (vertically oriented) and narrower than the adjacent cells.

Macrohairs: Common. Regularly spaced in the files with long cells. Always paired with a single, round smooth-walled short cell at their bases. Basal cells long with cell walls approximately equidistant. Apical cells oval and shorter and wider than basal cells. Some of the macrohairs are shorter than the rest but as they do not have a specific length they are not classified as microhairs.

Eragrostis biflora Hackel
(Figure 1)

Costal zones:

Usually consist of a single file with silica cells but may sometimes attain a width of 15 cell files, in which case files with silica cells alternate with one or two files with long cells. Within the files with silica cells, silica cells alternate with one or more short or long cells.

Silica cells: Less numerous in the narrower zones than in the broader costal zones. Those in the narrower zones are mostly short dumbell-shaped while those in the broader zones are saddle-shaped (horizontally oriented). Long dumbell-shaped, rectangular and cross-shaped cells may, however, also occur.

Short cells: Rectangular with wavy or slightly sinuous walls.

Prickle hairs: Common in the narrower zones and near the margins of the broader zones. Barbs short and bases oval and broader than the adjacent cells.

Intercostal zones:

Five to nine cell files wide. One or two are files with stomata which are separated by a file with long cells but are sometimes adjacent.

The stomata themselves alternate with one or two long cells.

Subsidiary cells: Dome-shaped.

Long cells: Rectangular with wavy, sometimes slightly sinuous walls. Often slightly tapered at their ends.

Short cells: Rare. Rectangular with smooth or wavy walls but may also be square or irregularly shaped.

Microhairs: Scattered but not common. Basal cells narrowed at the proximal end. Apical cells shorter than basal cells.

Eragrostis echinochloidea Stapf
(Plate 21)

Costal zones:

One to 13 cell files wide. Files with silica cells alternate with a single file with long cells. Within the files with silica cells, silica cells alternate with a long cell and/or a short cell.

Silica cells: Saddle-shaped (vertically or horizontally oriented).

Short cells: Suberised and non-suberised cells occur. Suberised cells are vertically flattened or square with smooth walls. Non-suberised cells are square or rectangular with sinuous walls.

Long cells: Rectangular with sinuous walls.

Prickle hairs: Occur occasionally on some fragments. Bases oval and broader than adjacent cells.

Multicellular epidermal glands consisting of approximately 25 specialised epidermal cells, occur in some of the broader costal zones. They are not equally common on all parts of the epidermis and were only observed on some of the material examined. Günzel (1913) also mentioned these glands.

Intercostal zones:

Six to 10 cell files wide including one or two files with stomata which are separated by one or more files with long cells but may also be adjacent. Within the files with stomata, stomata alternate with one or two long cells but short cells may occur, singly or paired with a silica cell.

Subsidiary cells: Usually triangular.

Long cells: Rectangular with sinuous walls.

Short cells: Two types occur. Firstly, ordinary sinuous-walled rectangular epidermal cells which are simply short versions of the long cells and occur singly. Secondly, smooth-walled short cells which appear to be suberised, are almost always paired with a silica cell and are vertically flattened in shape.

Silica cells: Common. Vertically flattened. Always paired with vertically flattened short cells.

Microhairs: Scattered throughout the zone. Basal cells narrowed at the proximal end and apical cells rounded, shorter than basal cells.

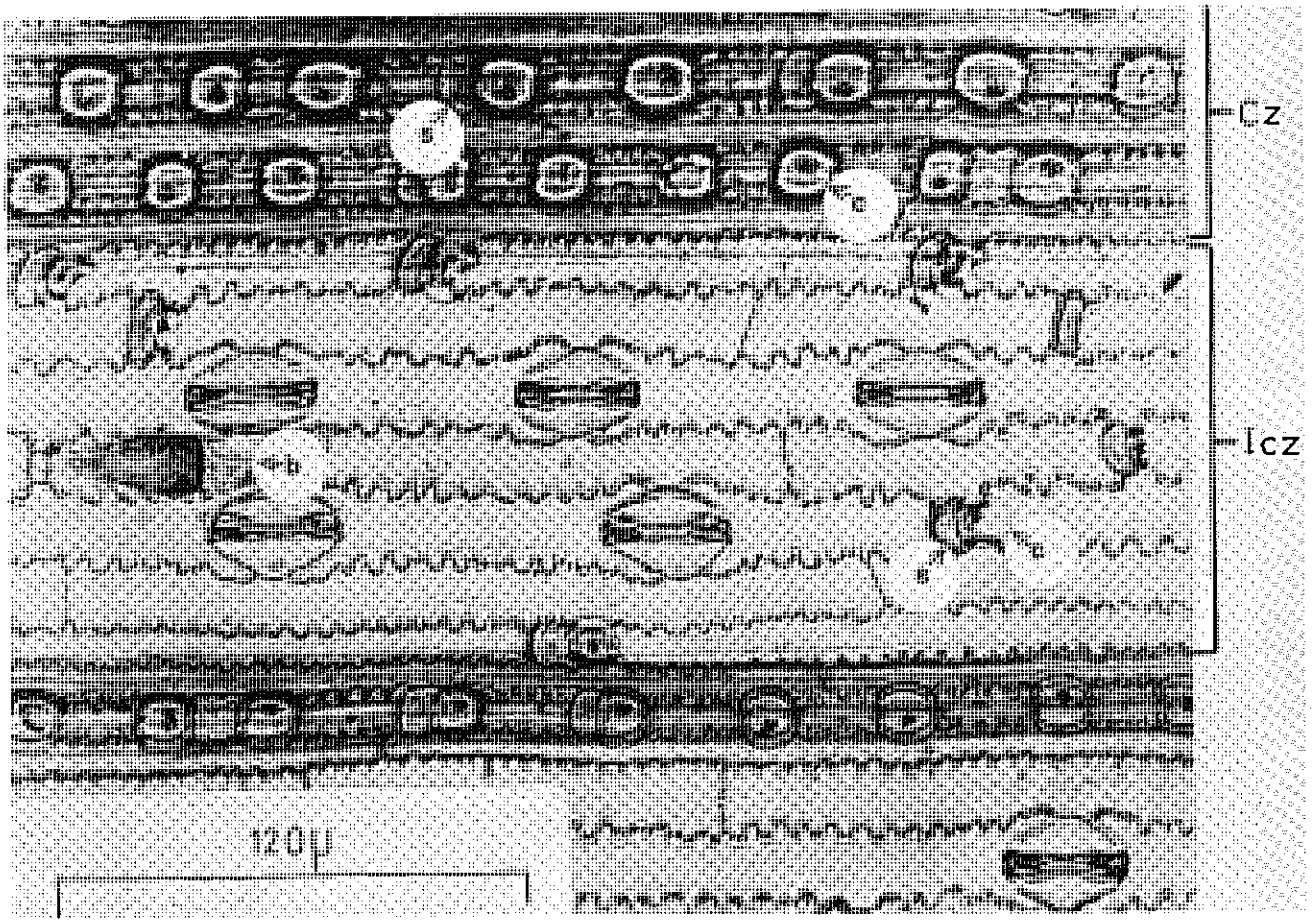


PLATE 21: Surface view of the abaxial epidermis of *Eragrostis echinochloidea* Stapf

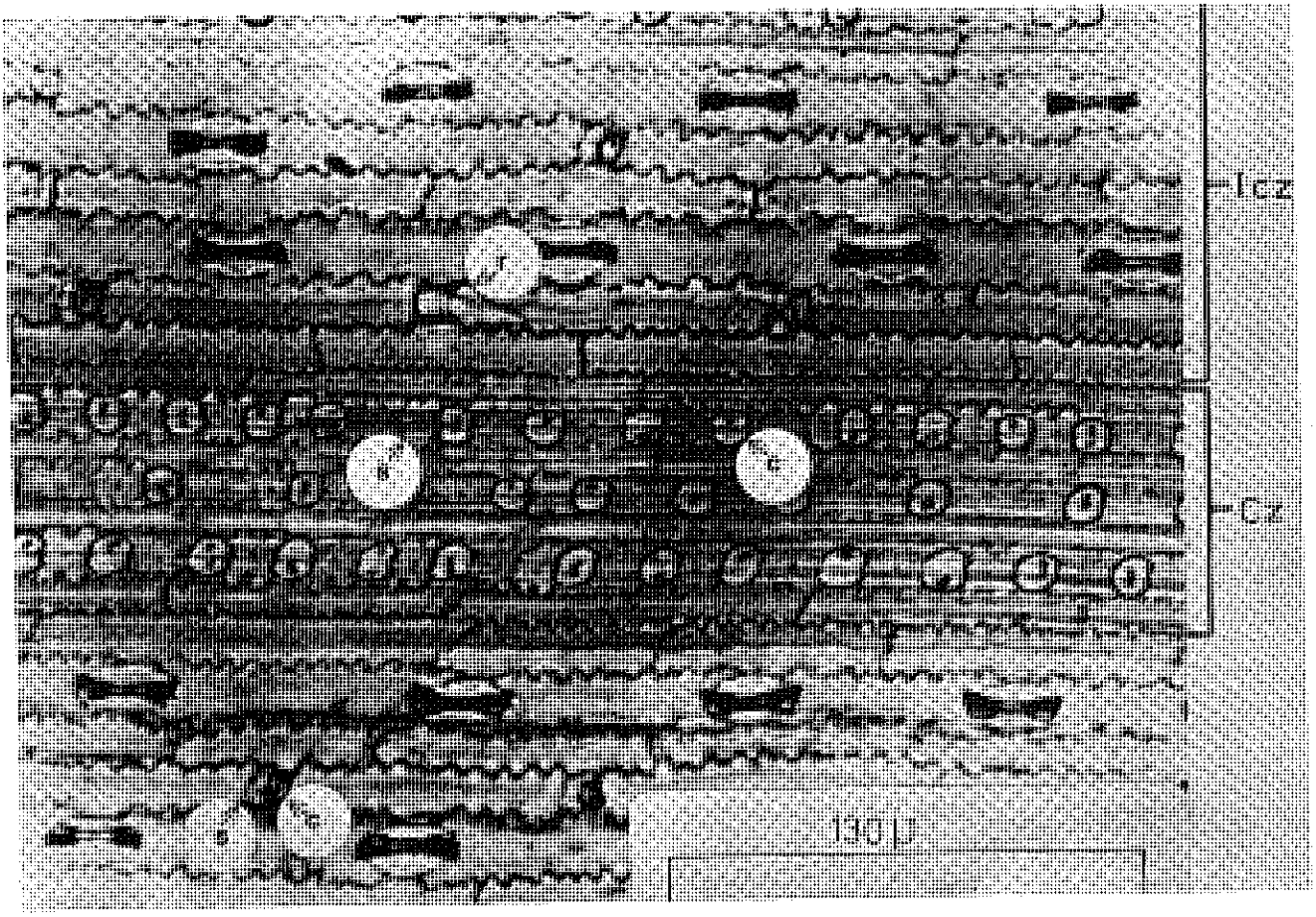


PLATE 22: Surface view of the abaxial epidermis of *Eragrostis nindensis* Fic. & Hiern

Eragrostis nindensis Fic. & Hiern
(Plate 22)

Costal zones:

One to 14 cell files wide. Files with silica cells alternate with one or more files with long cells. Within the files with silica cells, silica cells alternate with one or more short or long cells.

Silica cells: Saddle-shaped (vertically oriented) but may also be vertically flattened or irregular.
Short cells: Square or rectangular with sinuous walls but may also be cross-shaped.
Long cells: Rectangular with sinuous walls.

Intercostal zones:

Five to nine cell files wide including one or two files with stomata, the latter separated by one or two files with long cells. Within the files with stomata, stomata alternate with one long cell almost without exception.

Subsidiary cells: Dome-shaped.
Long cells: Rectangular with sinuous walls.
Short cells: Vertically flattened but may also be rectangular with sinuous walls.
Silica cells: Paired with vertically flattened short cells. Vertically flattened with an irregular shape.
Prickle hairs: Common. Bases rectangular, but may also be oval or square and slightly narrower than adjacent cells.
Microhairs: May occur. Basal cells narrowed at the proximal end and apical cells shorter than basal cells. Apical cells have a rounded apex.
Macrohairs: Not common, only observed on some fragments. Bases surrounded by more than two specialised epidermal cells.

Eragrostis porosa Nees
(Plate 23)

Costal zones:

One to five cell files wide. Files with silica cells alternate with a single file with long cells. Within the files with silica cells, silica cells alternate with one or more short and/or long cells.

Silica cells: Short dumbell-shaped but may also be saddle-shaped, semilunar or irregularly shaped.
Short cells: Rectangular but may also be short dumbell-shaped or saddle-shaped. Walls slightly sinuous.
Long cells: Rectangular with sinuous walls.
Prickle hairs: Common. Bases rectangular and broader than adjacent cells.

Intercostal zones:

Six to 10 cell files wide including two files with stomata which are separated by one to three files with long cells. Within the files with stomata, stomata alternate with one long cell.

Subsidiary cells: Triangular but also often dome-shaped.
Long cells: Rectangular with sinuous walls.
Short cells: Square with sinuous walls but may also be irregularly shaped.
Silica cells: Not common. Irregularly shaped and often paired with a short cell.
Microhairs: Sometimes associated with a short cell. Basal cells narrowed at the proximal end and apical cells rounded and shorter than basal cells. These apical cells seem to be typical of the genus *Eragrostis* in this study.
Macrohairs: May occur near the ligula on some fragments. Surrounded by more than two specialised epidermal cells. Günzel (1913) mentions "cushion hairs", presumably macrohairs, on three specimens from South West Africa which he examined.

Eragrostis rotifer Rendle
(Plate 24)

Costal zones:

One to 13 cell files wide. Files with silica cells may be adjacent, but normally alternate with a single file with long cells. Silica cells are scattered and alternate with one or more short or long cells.

Silica cells: Saddle-shaped but may also be short dumbell-shaped, cross-shaped, vertically flattened or irregularly shaped. In the narrower zones they are mostly short dumbell-shaped and cross-shaped and less numerous than in the costal zones. It also appears that where silica cells are less numerous, prickle hairs are more numerous and vice versa.
Short cells: Vertically flattened but may also be square, rectangular or irregularly shaped with wavy walls. In the narrower zones they are mostly square or rectangular.
Long cells: Rectangular with wavy walls.

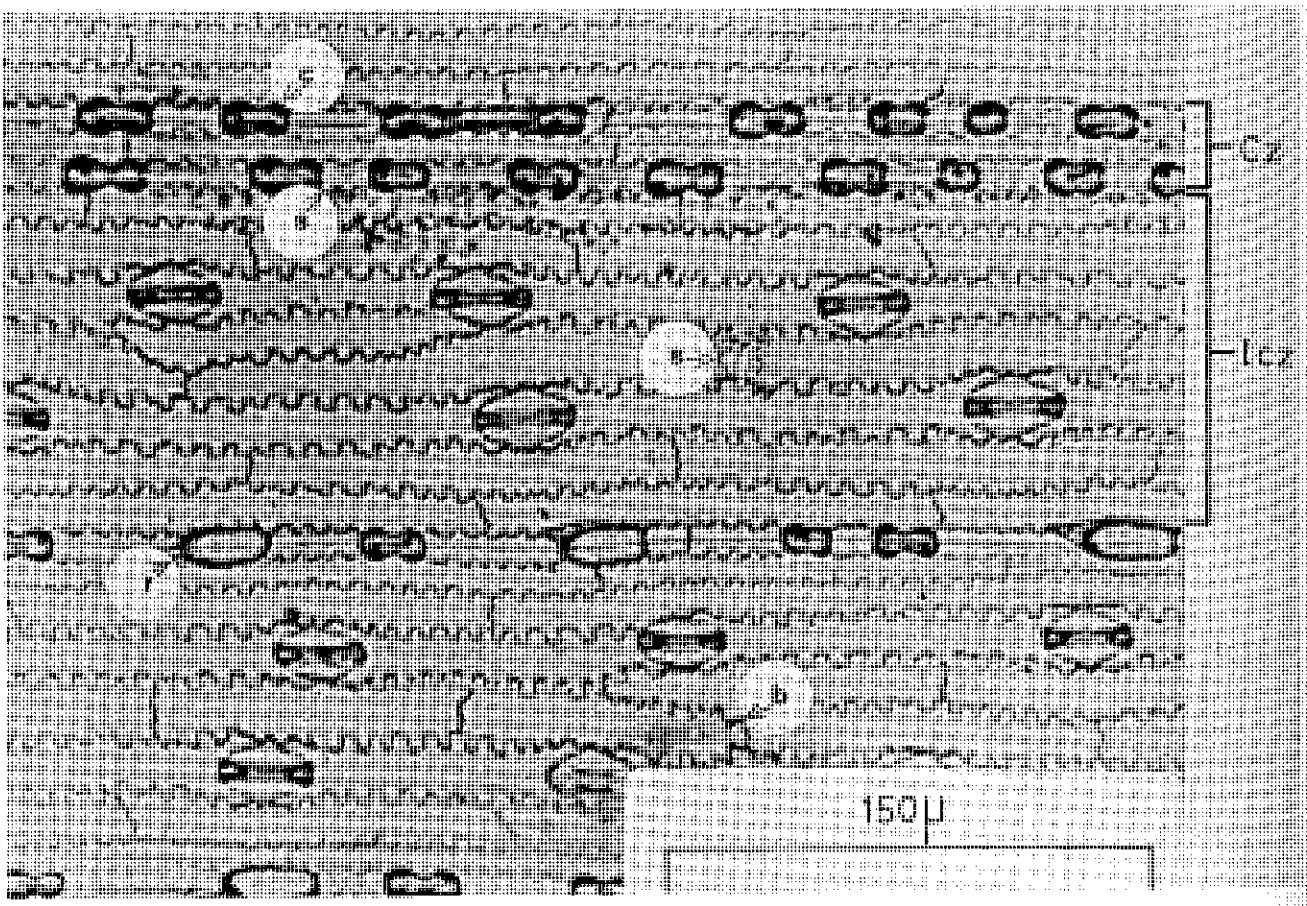


PLATE 33: Surface view of the abaxial epidermis of *Eragrostis perennis* Nees

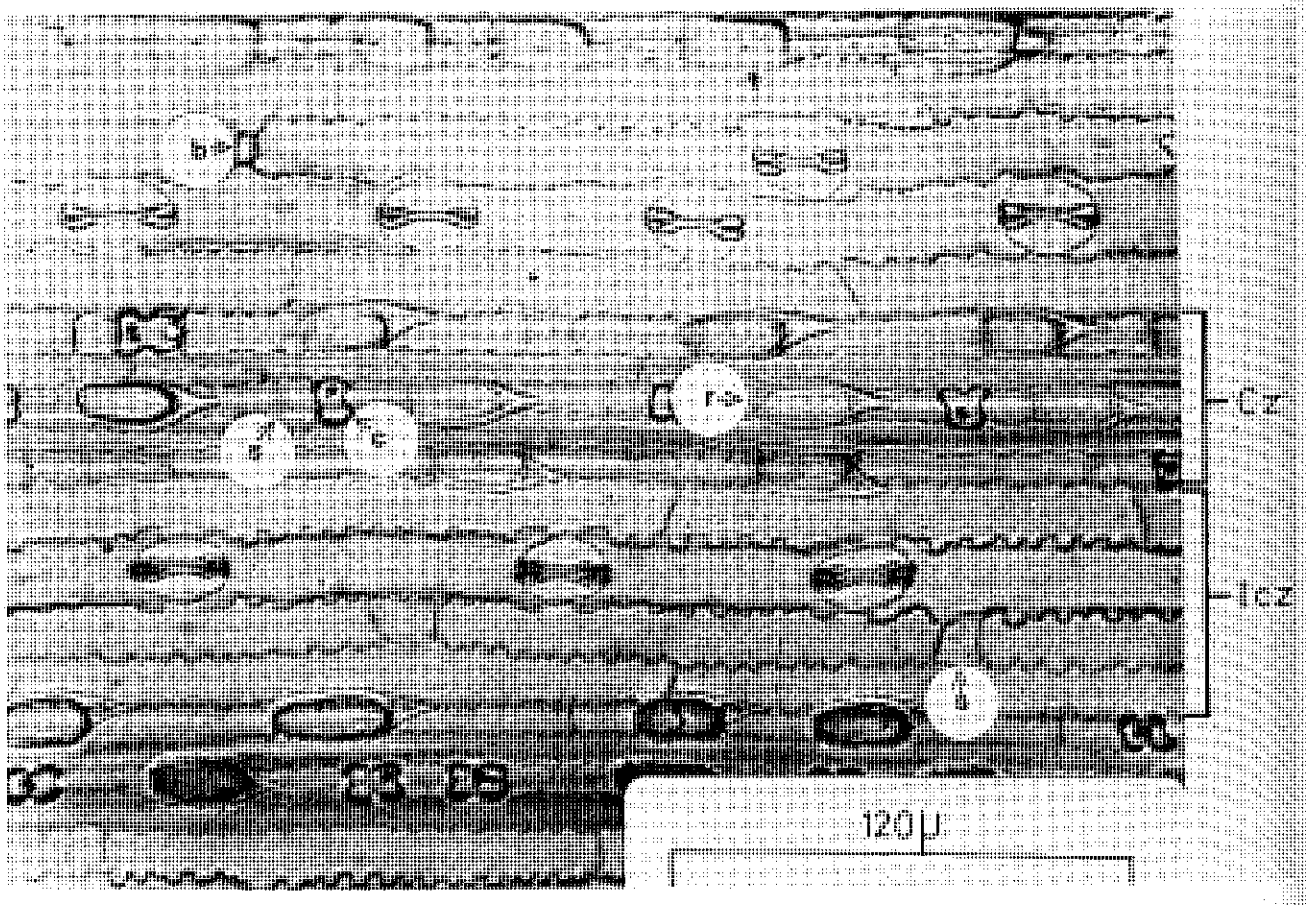


PLATE 34: Surface view of the abaxial epidermis of *Eragrostis rosiflora* Rendle

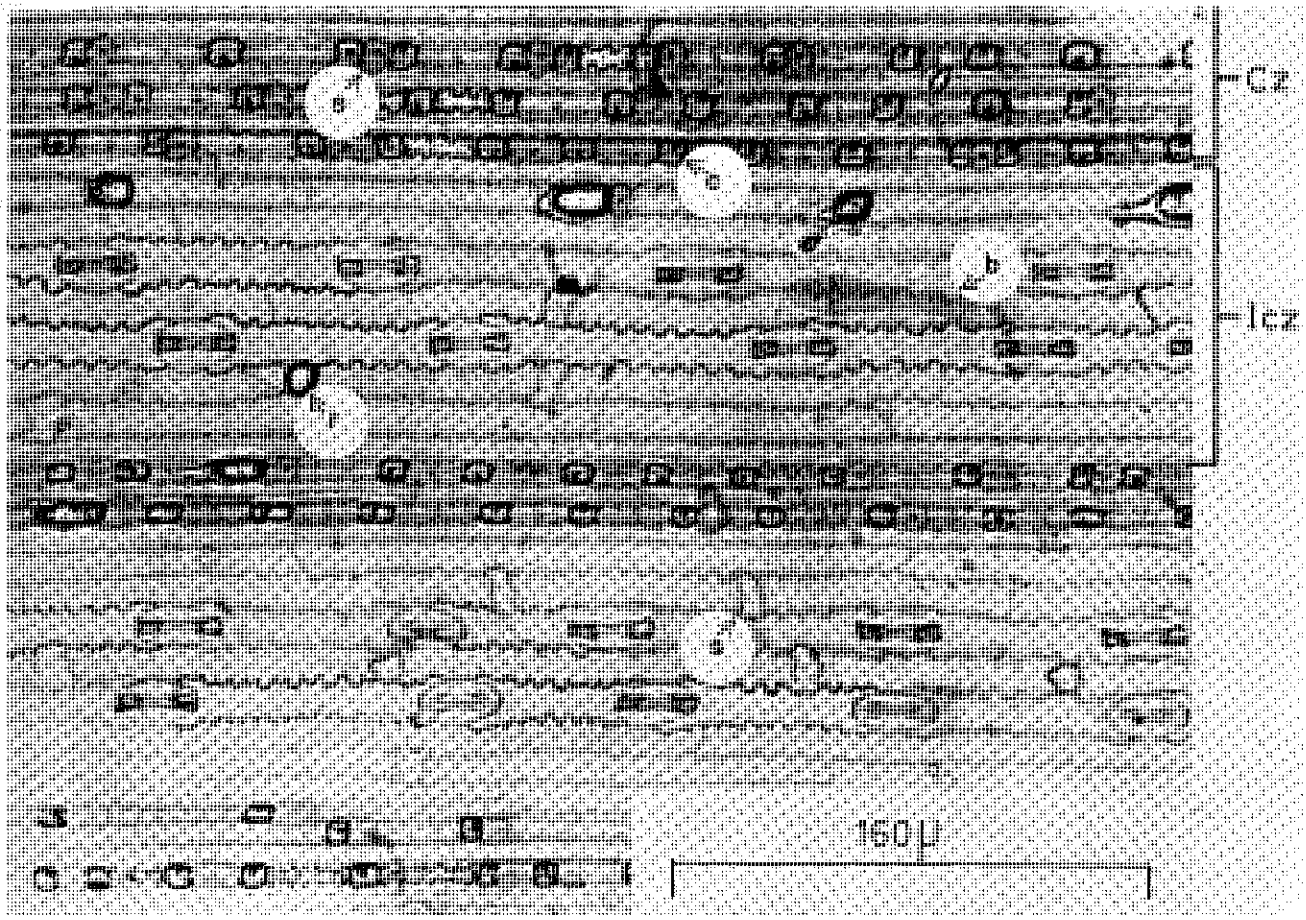


PLATE 25: Surface view of the abaxial epidermis of *Eragrostis trichophora* Coss. & Dur.

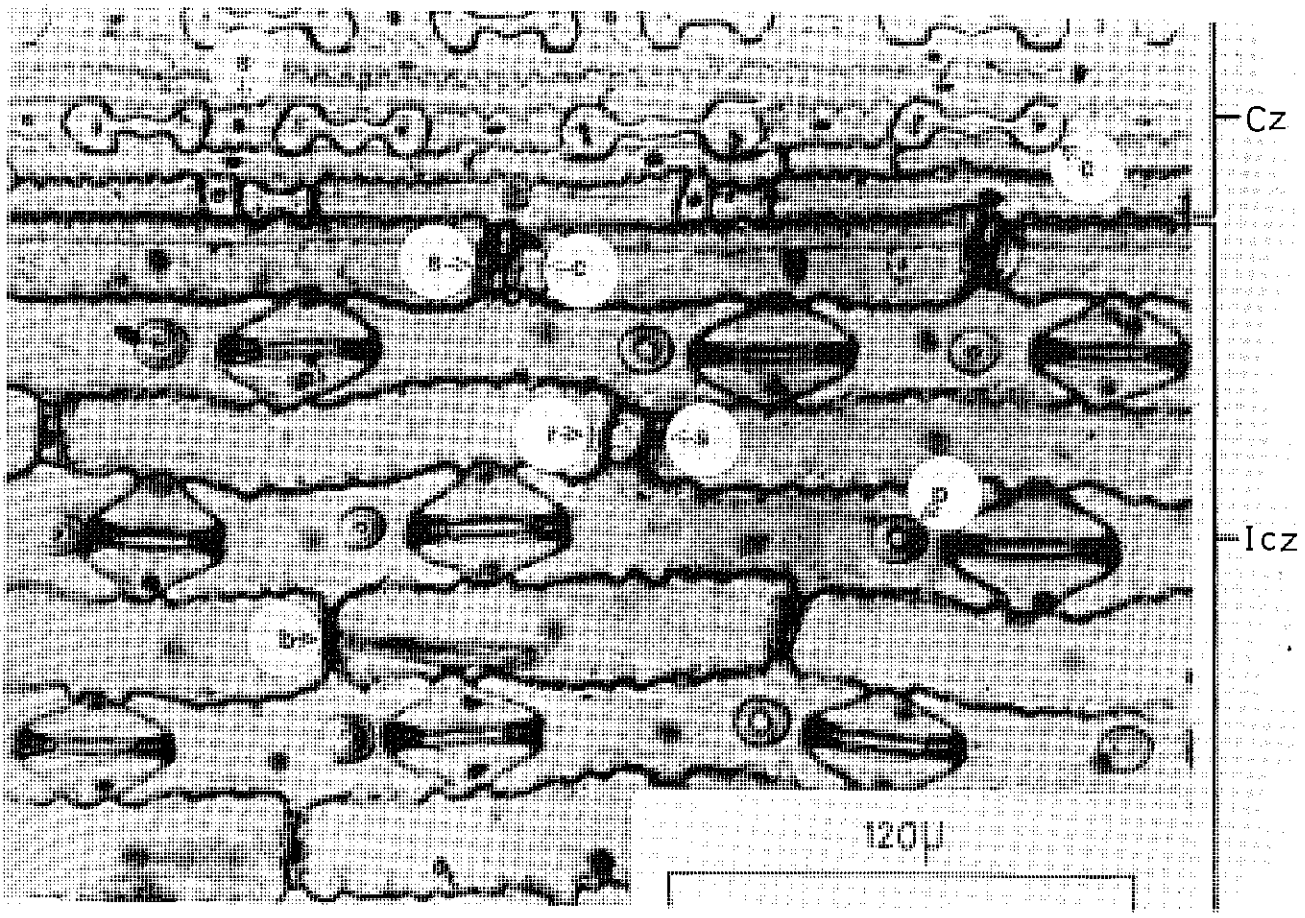


PLATE 26: Surface view of the abaxial epidermis of *Heteropogon contortus* (L.) Beauv. ex Roemer & Schultes

Prickle hairs: More numerous in the narrower zones than in the broader zones. Bases rectangular with rounded corners, or often oval, and slightly broader than adjacent cells. Barbs sharp-pointed.

Multicellular epidermal glands consisting of approximately 60 specialised epidermal cells occur at regular intervals on the costal zone overlying the midvein.

Intercostal zones:

Three to six cell files wide including one or two files with stomata which can be adjacent and are not regularly spaced throughout. Within the files with stomata, stomata alternate with one or two long cells.

Subsidiary cells: Dome-shaped but may also be triangular.
Long cells: Rectangular with sinuous walls.
Short cells: Sometimes protrude from the surface. Vertically flattened but may also be irregularly shaped or round. Walls slightly sinuous.
Silica cells: Not common. Occur near zone margins. Vertically flattened but may also be saddle-shaped.
Prickle hairs: May occur near zone margins. Bases rectangular but may also be square, and are vertically oriented and narrower than adjacent cells.
Microhairs: Common. Basal cells sharply narrowed at the proximal end and rounded apical cells shorter than basal cells. Typical of the genus *Eragrostis* in this study.

Eragrostis trichophora Coss. & Dur.
(Plate 25)

Costal zones:

One to 15 cell files wide. Files with silica cells alternate with one or two files with long cells. Within the files with silica cells, silica cells alternate with one or more short or long cells.

Silica cells: Saddle-shaped but may also be square or vertically flattened. In the narrow zones they are mostly cross-shaped and short dumbell-shaped.
Short cells: Rectangular or square with sinuous walls but may also be vertically flattened, irregularly shaped or round.
Long cells: Rectangular with sinuous walls.
Prickle hairs: Occur in the narrower zones and near the margins of the broader zones. Bases oval and broader than adjacent cells.

Intercostal zones:

Six to 16 cell files wide including one or two files with stomata. The files with stomata are separated by one to five files with long cells. Within the files with stomata, stomata alternate with one or more long or short cells.

Subsidiary cells: Dome-shaped but may also be triangular.
Long cells: Rectangular with sinuous walls.
Short cells: Common. Rectangular but may also be square, vertically flattened or irregularly shaped. Walls sinuous.
Silica cells: Irregularly shaped.
Prickle hairs: Rare. Where present, occur near zone margins. Bases oval, round or square (usually horizontally oriented) and narrower than adjacent cells.
Microhairs: Basal cells narrowed at the proximal end and apical cells hemispherical, shorter than basal cells.

Heteropogon contortus (L.) Beauv. ex Roemer & Schultes
(Plate 26)

Costal zones:

One to five cell files wide. Files with silica cells alternate with one or two files with long cells. Within the files with silica cells, silica cells alternate with a single short and/or long cell but can also be adjacent.

Silica cells: Long dumbell-shaped but may also be short dumbell-shaped, nodular or irregularly shaped.
Short cells: Rectangular but may also be square or cross-shaped. Walls wavy or sinuous.
Long cells: Rectangular with sinuous walls.
Prickle hairs: Occur in some costal zones. Bases oval and broader than adjacent cells. Stewart (1965) found prickle hairs only along the leaf margins.

Intercostal zones:

Four to 12 cell files wide including one to four files with stomata separated by one or two files with long cells. Within the files with stomata, stomata alternate with a single long or short cell.

Subsidiary cells: Triangular but Kok (1968) found the subsidiary cells to be dome-shaped.
Long cells: Rectangular with sinuous walls.

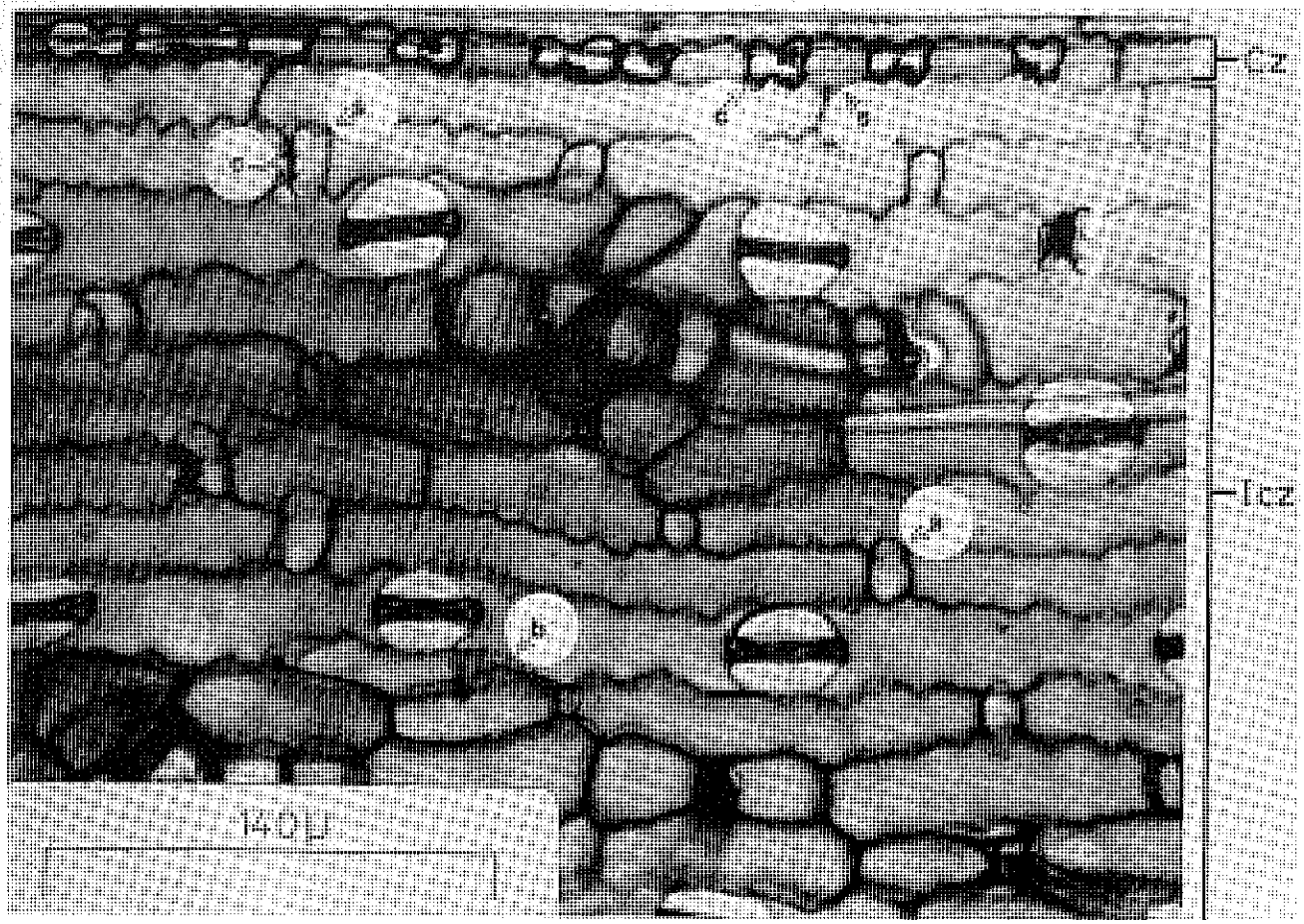


PLATE 27: Surface view of the abaxial epidermis of *Leucophrys mesocoma* (Nees) Rendle

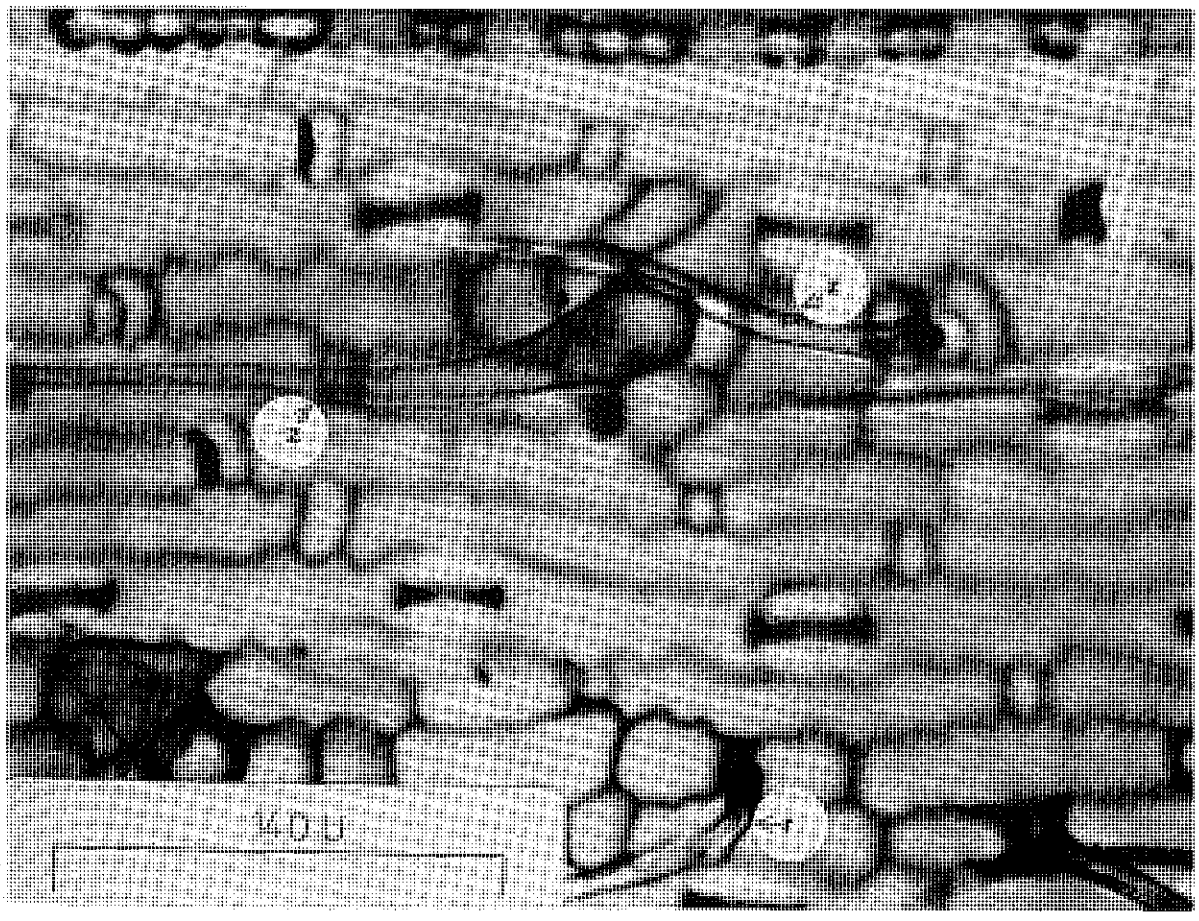


PLATE 28: Surface view of the abaxial epidermis of *Leucophrys mesocoma* (Nees) Rendle – focus on appendages.

Interstomatal cells:	Rectangular with sinuous walls (long and short cells).
Short cells:	Vertically flattened with smooth walls.
Silica cells:	Common. Always accompanied by a short cell. Vertically flattened or irregularly shaped near the centre of the zone but cross-shaped near the zone margins.
Prickle hairs:	Scattered. Always accompanied by a short cell. Bases rectangular, but may also be round, and narrower than adjacent cells.
Papillae:	Single acentric papillae occur on all interstomatal cells and on some of the other long cells as well.
Microhairs:	Common. Basal cells narrowed at the proximal end and apical cells (often lost or distorted during processing) as long as or longer than basal cells.
Macrohairs:	None observed in this study or by Stewart (1965), but Metcalfe (1960) and Kok (1968) observed occasional macrohairs.

Leucophrys mesocoma (Nees) Rendle
(Plates 27 and 28)

Costal zones:

One to three cell files wide. The zones therefore consist of a file with silica cells with or without one or two files with long cells. Silica cells are not regularly spaced and are either adjacent or alternate with several long and/or short cells.

Silica cells:	Short dumbell-shaped but may also be cross-shaped, nodular, vertically flattened, square or rectangular.
Short cells:	Rectangular but may also be short dumbell-shaped, square or irregularly shaped. Walls wavy or smooth.
Long cells:	Rectangular with sinuous walls.

The arrangement of cells in costal zones near the leaf margins differs considerably from the arrangement in other costal zones. Several adjacent files with silica cells occur in which vertically flattened silica cells alternate with a vertically flattened short cell and a long cell.

Intercostal zones:

Thirteen to 29 cell files wide including five to eight files with stomata which alternate with two to four files with long cells but can be irregularly spaced. Within the files with stomata, stomata alternate with one or more long and/or short cells. Long cells are usually paired with a suberised short cell although they also occur singly.

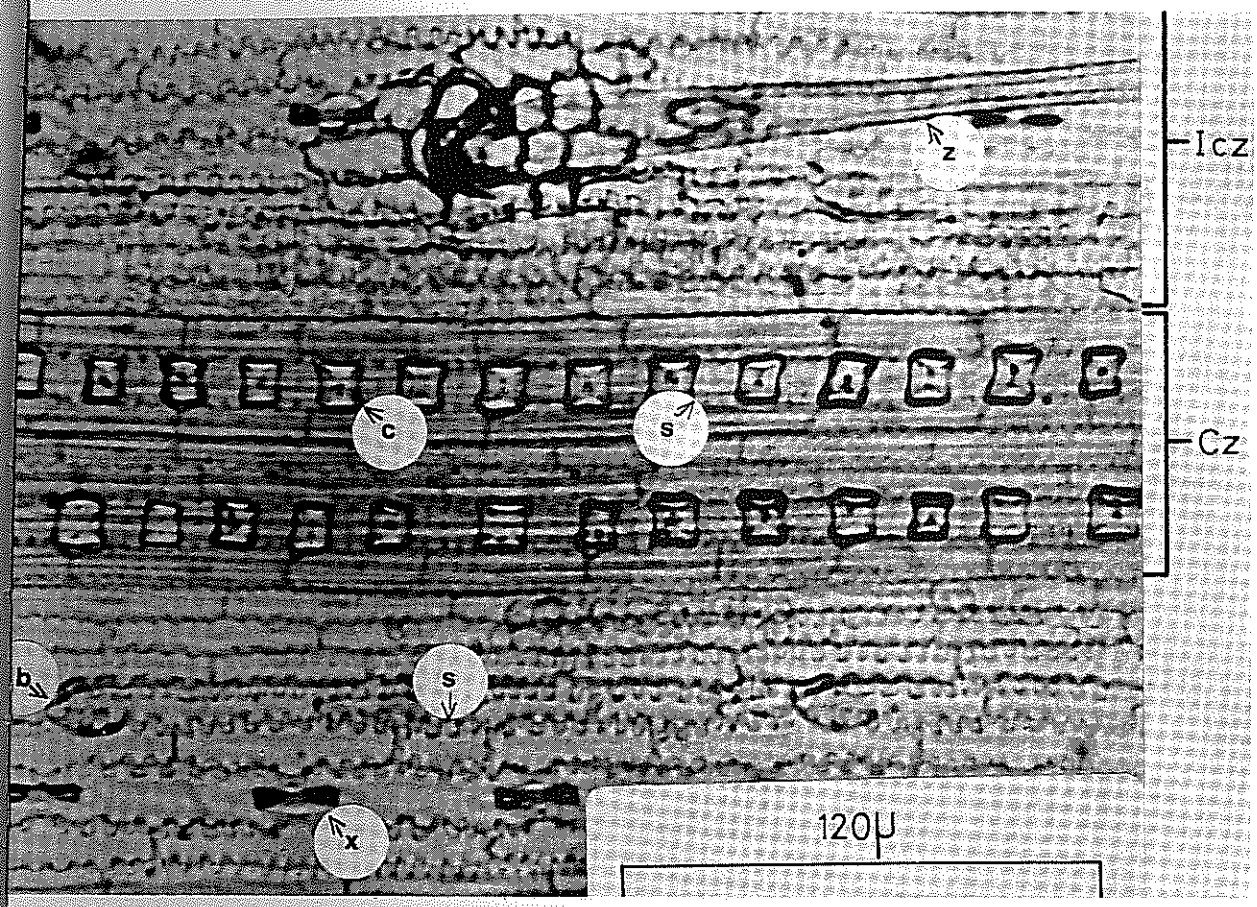
Subsidiary cells:	Dome-shaped.
Long cells:	Rectangular with sinuous walls.
Short cells:	Two types occur, both common. Suberised short cells are paired with silica cells or occur singly and are vertically flattened with more or less smooth walls. Non-suberised short cells occur singly, are rectangular but may also be square, and have sinuous walls.
Silica cells:	Irregularly shaped.
Prickle hairs:	Two types occur: (1) Prickle hairs with short barbs: Not common. Associated with one or two short cells but can occur singly. Bases round or rectangular and narrower than adjacent cells. (2) Prickle hairs with long barbs: The barbs of these hairs approach the length of the macrohairs. Bases smaller than the bases of the type (1) hairs. Not associated with a short cell.
Microhairs:	Not common but scattered. Basal cells narrowed at the proximal end and apical cells (many of which are lost or distorted during processing) longer than basal cells.
Macrohairs:	Bases surrounded by more than two (not more than four) or less than two specialised epidermal cells. Not to be confused with the type (2) prickle hairs.

Oropetium capense Stapf
(Plate 29)

Costal zones:

Five to eight cell files including only two files with silica cells, one near each of the zone margins. Files with silica cells are separated by three to five files with long cells. Silica cells alternate with a single long or short cell.

Silica cells:	Square (sharp-cornered) and relatively symmetrical.
Short cells:	Square but may also be cross-shaped, vertically flattened, rectangular or irregularly shaped.
Long cells:	Rectangular with sinuous walls.
Prickle hairs:	Rare. Bases oval and narrower than adjacent cells.



TE 29: Surface view of the abaxial epidermis of *Oropetium capense* Stapf

rcostal zones:

to 10 cell files wide with only one file with stomata zone. Stomata are regularly spaced and alternate a long cell and/or a short cell.

sidiary cells:	Inflated, with the result that their shape varies with the focus. Basal walls are distinctly triangular and prominently horizontally flattened while the walls which protrude from the surface overlie the adjacent cells to a degree and, if brought into focus, the cells appear dome-shaped.
ng cells:	Rectangular with sinuous walls.
erstomatal cells:	Rectangular with sinuous walls (long and short cells).
ort cells:	Rare. Irregularly shaped but may also be rectangular. Walls sinuous.
crohairs:	Short, bulbous. Basal cells sharply narrowed at the proximal end and apical cells shorter than, but may also be as long as the basal cells.
crohairs:	Occur at regular intervals. Bases surrounded by more than two specialised epidermal cells. Cell walls thickened.

Panicum arbusculum Mez
(Plates 30 and 31)

Costal zones:

Two to nine cell files wide. Files with silica cells alternate with one or two files with long cells but can also be adjacent. In zones with three cell files, a single file with silica cells is flanked by two files with long cells. Silica cells alternate with a single short cell.

Silica cells:	Cross-shaped but may also be short dumbell-shaped, vertically flattened or irregularly shaped.
Short cells:	Vertically flattened but may also be short dumbell-shaped, cross-shaped, rectangular or irregularly shaped. In narrow zones short cells are mostly cross-shaped. Walls wavy or slightly sinuous.
Long cells:	Rectangular with sinuous walls.
Prickle hairs:	Occur only on some fragments in the narrower zones. Bases oval and broader than adjacent cells.

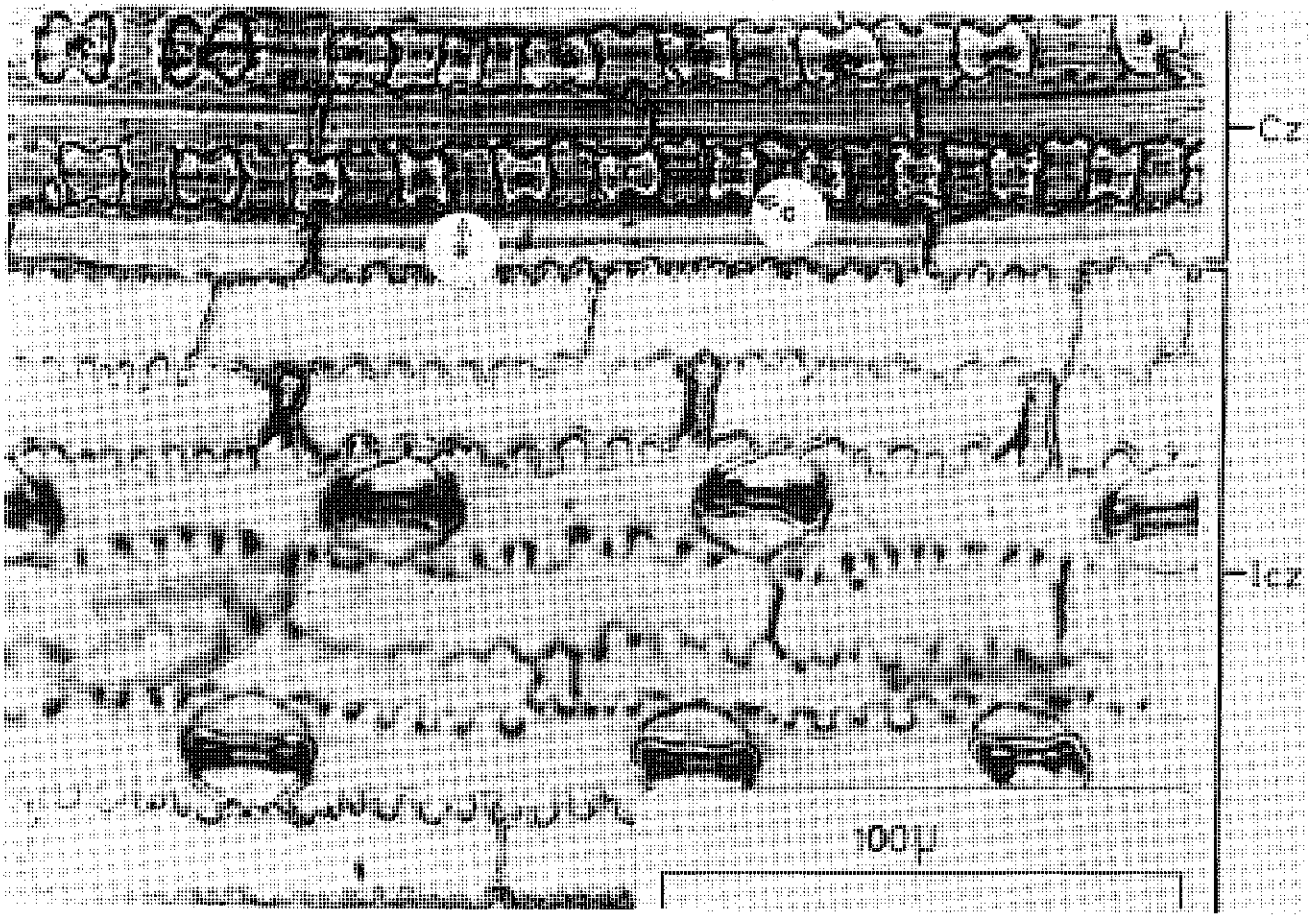


PLATE 30: Surface view of the abaxial epidermis of *Panicum arbusculum* Mez — focus on the costal zone.

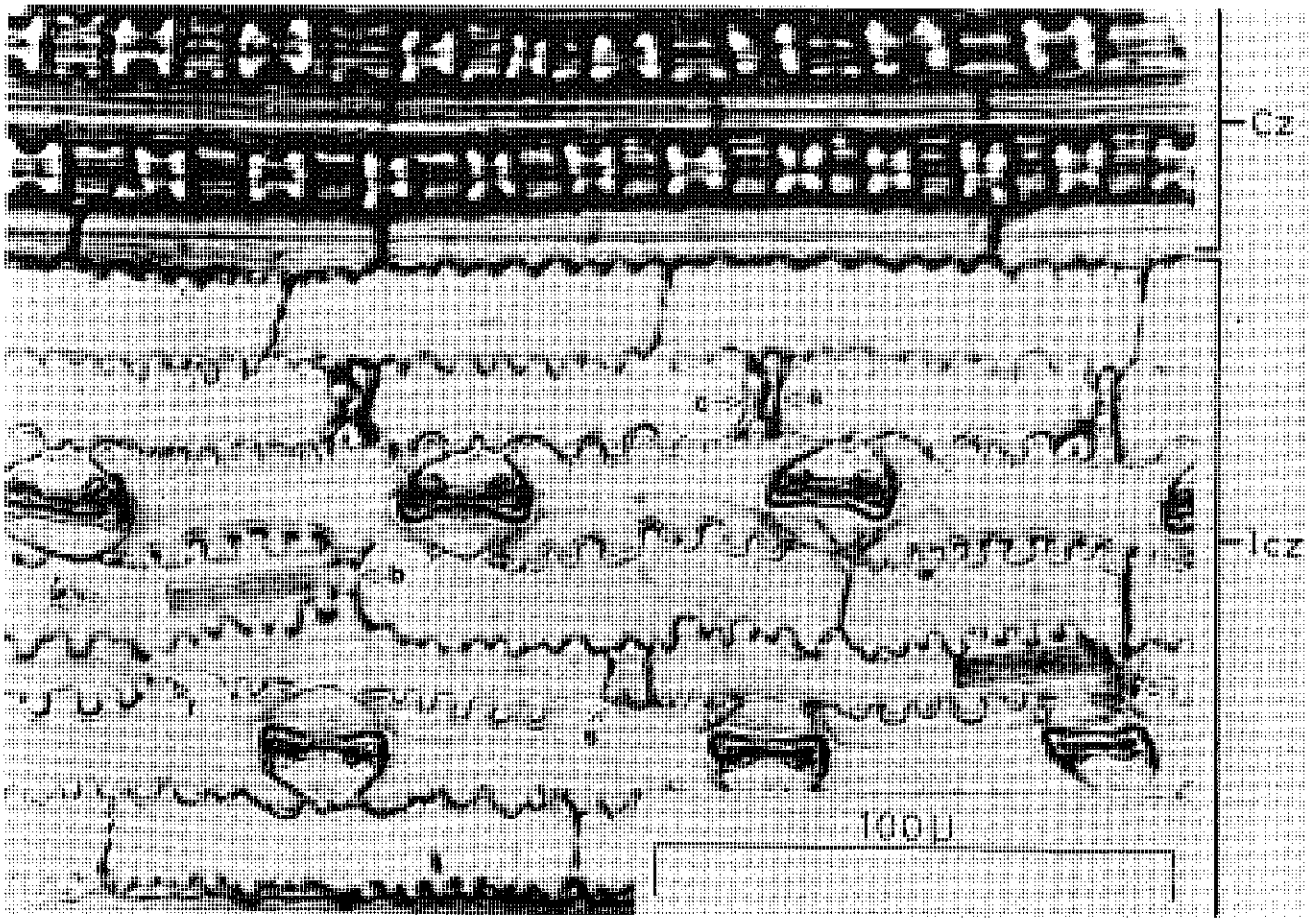


PLATE 31: Surface view of the abaxial epidermis of *Panicum arbusculum* Mez — focus on the intercostal zone.

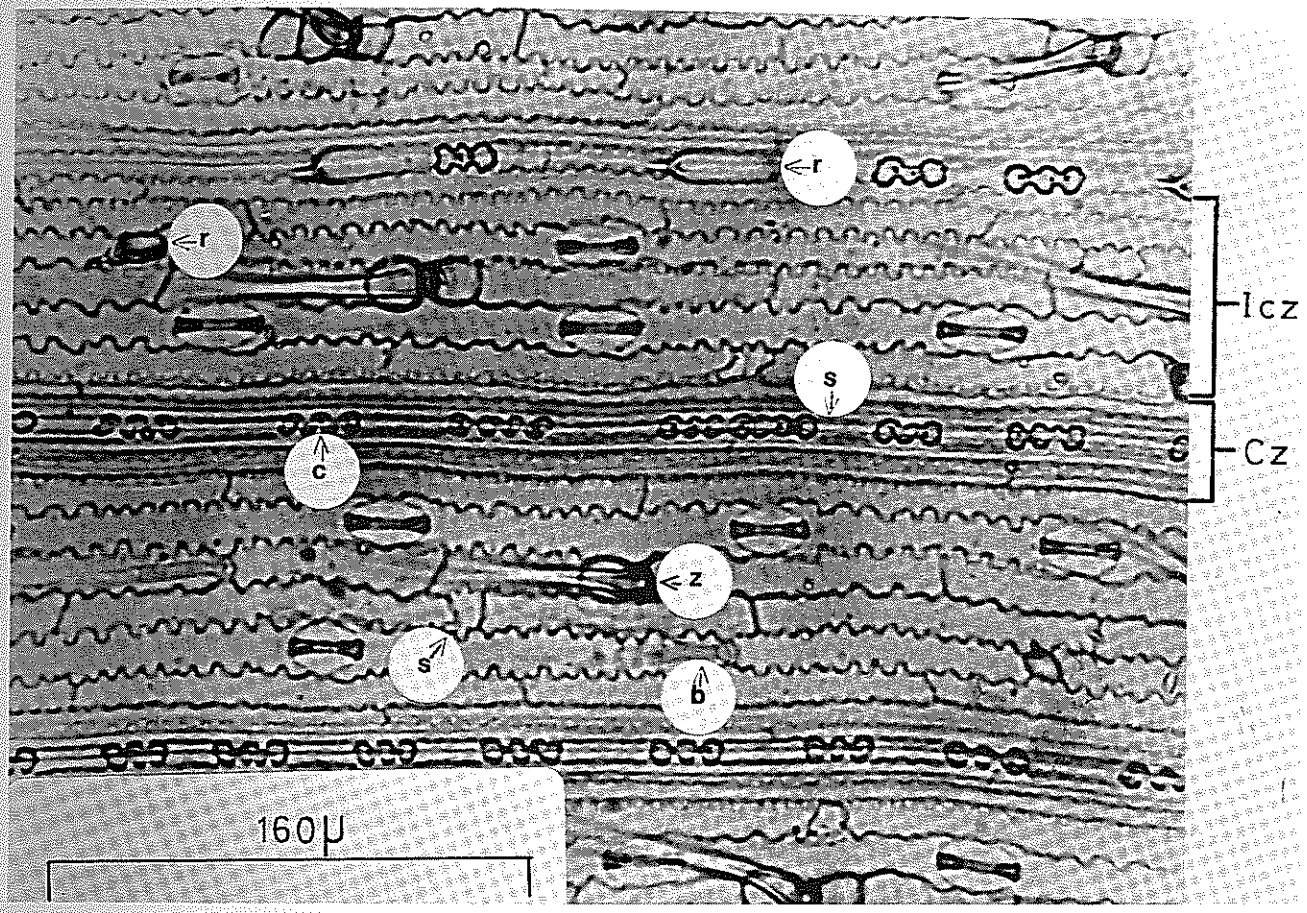


PLATE 32: Surface view of the abaxial epidermis of *Rhynchelytrum villosum* (Parl. ex Hooker) Chiov.

Intercostal zones:

Six to 11 cell files wide including two to three files with stomata which are separated by one or two files with long cells. Within the files with stomata, stomata alternate with a single long cell, but short cells can also occur between the stomata.

Subsidiary cells: Dome-shaped.

Long cells: Rectangular with sinuous walls. Many of the long cells between the files with stomata are inflated and protrude from the surface. The protruding walls are smooth and overlie the adjacent cells.

Short cells: Common. Occur singly or together with a silica cell. Suberised short cells are vertically flattened with smooth walls, whilst non-suberised short cells which are ordinary thin-walled epidermis cells, and interstomatal short cells are rectangular with sinuous walls.

Silica cells: Accompanied by a short cell. Vertically flattened (irregular).

Prickle hairs: Common on some fragments. Bases rectangular (vertically oriented), but may also be irregular, and broader than adjacent cells. Barbs short.

Microhairs: Angled to one side at the base. Basal cells narrowed at the proximal end and apical cells as long as or longer than the basal cells (may be lost during preparation).

Rhynchelytrum villosum (Parl. ex Hooker) Chiov. (Plate 32)

According to Stewart (1965) the epidermis of this species is similar in all respects to that of *Rhynchelytrum repens* (Wild.) C. E. Hubbard. The descriptions given for the latter species by himself, Metcalfe (1960) and Kok (1968) disagree with the description below, although similarities occur.

Costal zones:

One to five cell files wide with a single file with silica cells flanked by one or more files with long cells. Silica cells alternate with one or two short or long cells but may also be adjacent.

Silica cells: Nodular (up to six nodes) but may also be short dumbell-shaped.

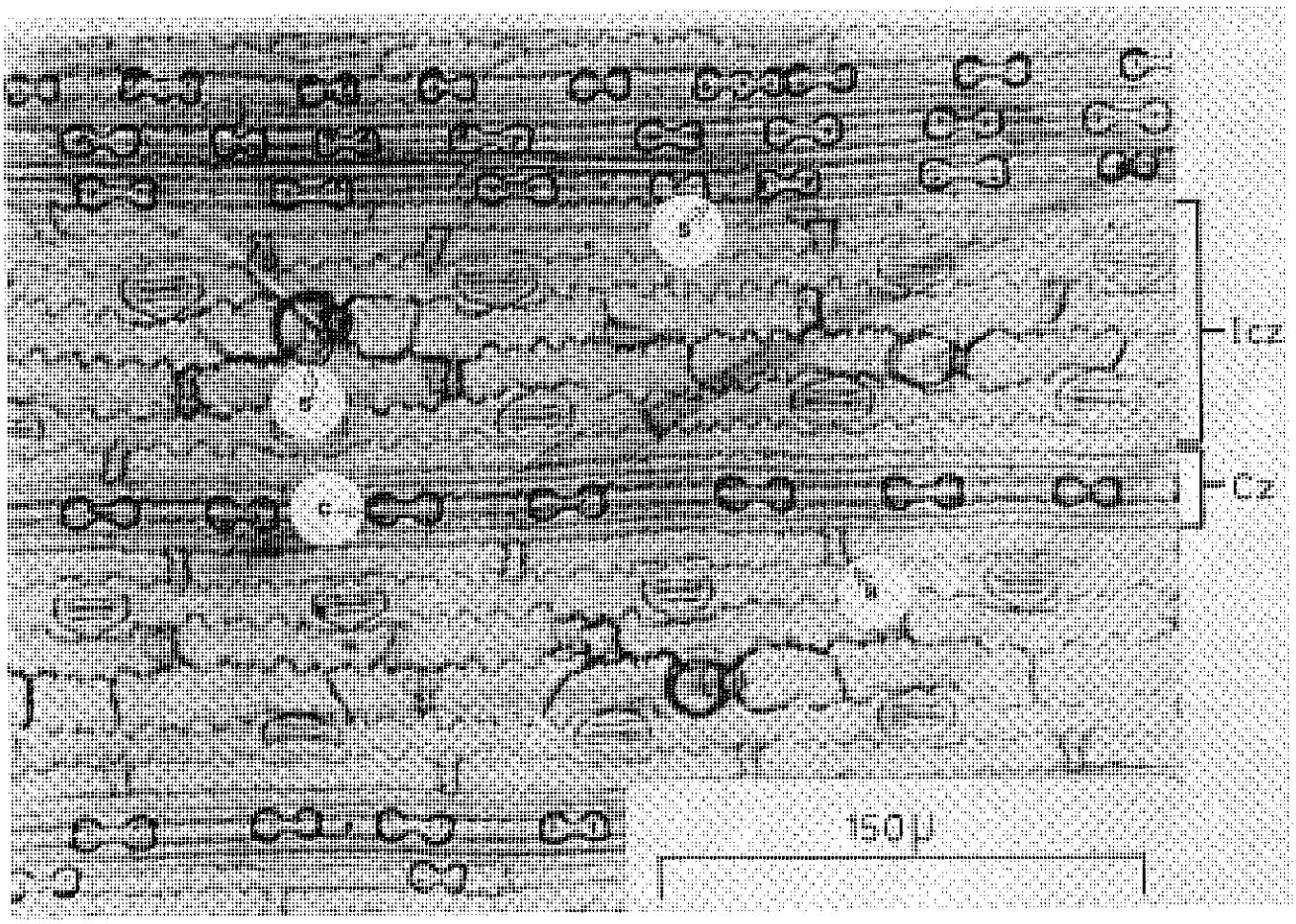


PLATE 33: Surface view of the abaxial epidermis of *Schmidtia kalahariensis* Stent

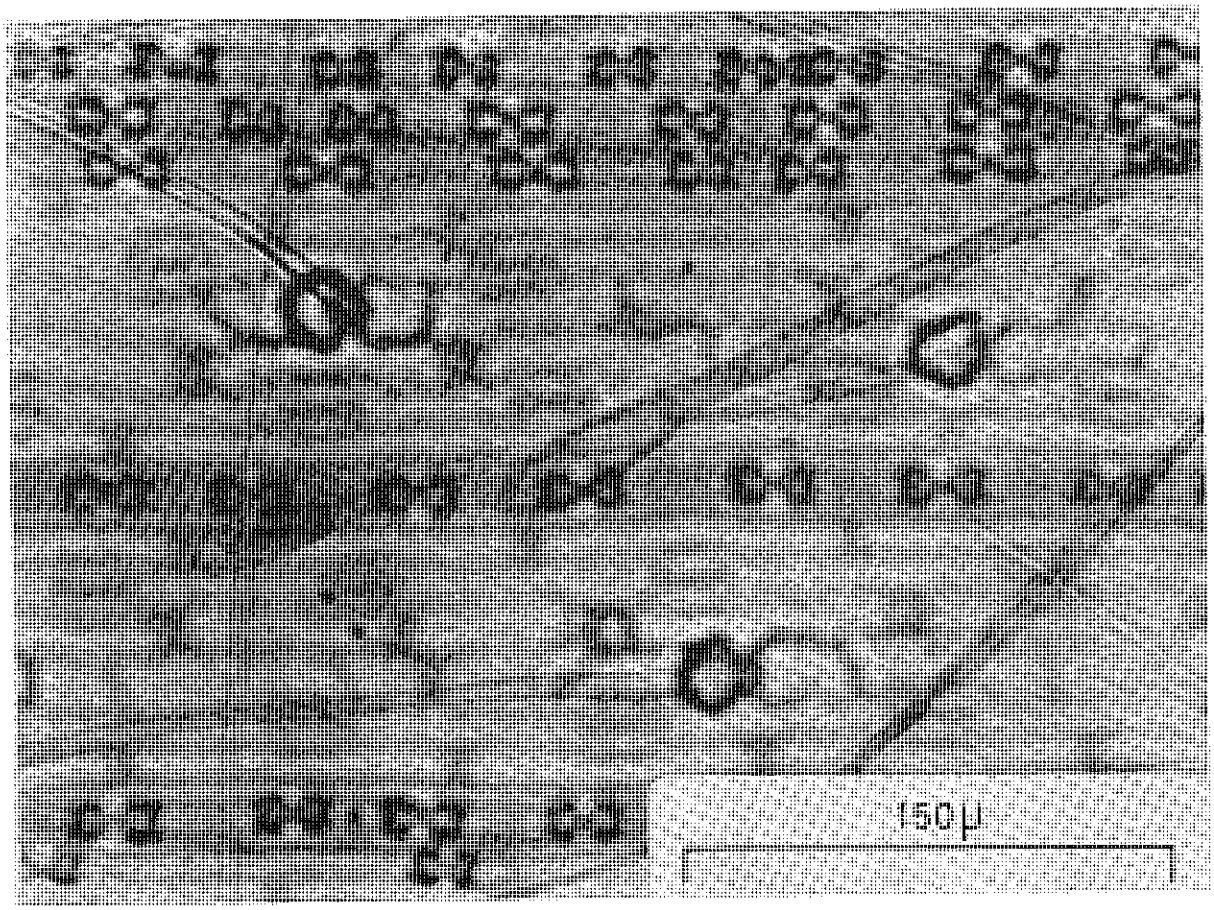


PLATE 34: Surface view of the abaxial epidermis of *Schmidtia kalahariensis* Stent — focus on appendages.

Short cells: Rectangular with sinuous walls.
Long cells: Rectangular with sinuous walls.
Prickle hairs: Occur in some costal zones. Bases oval (elongated) but may also be rectangular and broader than adjacent cells.

Intercostal zones:

Six to 16 cell files wide including one to four files with stomata, the latter separated by two or more files with long cells. Within the files with stomata, stomata alternate with one or more long cells.

Subsidiary cells: Dome-shaped.
Long cells: Rectangular with sinuous walls. Many of the long cells in the centre of the zone are inflated and protrude from the surface, overlying the adjacent cells slightly. The protruding walls are smooth.
Short cells: Common. Irregularly shaped but may also be square or rectangular. Walls sinuous.
Silica cells: Rare. Irregularly shaped.
Prickle hairs: Common. Bases roughly rectangular, (vertically or horizontally oriented) and narrower than adjacent cells. Barbs can be so rudimentary that they are absent or look like papillae.
Microhairs: Scattered. Basal cells approximately parallel-walled and apical cells longer than basal cells.
Macrohairs: Occur in the centre of the zone. Bases surrounded by two specialised epidermal cells.

Schmidtia kalahariensis Stent
(Plates 33 and 34)

Costal zones:

One to five cell files wide. Files with silica cells, in which silica cells alternate with a single long or short cell, alternate with a single file with long cells.

Silica cells: Short dumbell-shaped but may also be long dumbell-shaped, cross-shaped or nodular.
Short cells: Rectangular but may also be square or cross-shaped. Walls sinuous.
Long cells: Rectangular with sinuous walls.
Prickle hairs: Occur on some fragments. Bases rectangular and slightly broader than adjacent cells.

Intercostal zones:

Six to 10 cell files wide including two files with stomata separated by one to three files with long cells. Within the files with stomata, stomata alternate with a single long cell.

Subsidiary cells: Triangular with a slightly constricted apex.
Long cells: Rectangular with sinuous walls.
Short cells: Common. Vertically flattened (irregular) but may also be roughly rectangular or square. Walls sinuous. Rounded smooth-walled short cells occur at the bases of macrohairs.
Macrohairs: Two types occur in the files with long cells between the files with stomata:
(1) Unicellular macrohairs: These hairs are thin and are tapered to a fine-pointed apex.
(2) Bicellular macrohairs: Basal cells long and thin and apical cells are oval, wider and shorter than basal cells. Günzel (1913) found bicellular macrohairs on the epidermis of *Schmidtia bulbosa* Stapf. Stewart (1965) observed "glandular hairs" on the epidermis of *Schmidtia pappophoroides* Steudel (= *S. bulbosa*), but neither of them mentioned unicellular hairs as seen by the present author on *S. kalahariensis*. Tateoka *et al.* (1959) regard the bicellular hairs occurring on the epidermis of the *Pappophoreae* as microhairs whilst Ellis (1979) recognises bicellular glandular macrohairs.

Setaria appendiculata (Hackel) Stapf
(Plate 35)

Costal zones:

One to six cell files wide. Files with silica cells alternate with one or two files with long cells. When there are one to three cell files, only one file with silica cells occurs. Within the files with silica cells, silica cells alternate with a single short cell but can sometimes be adjacent.

Silica cells: Short dumbell-shaped but may also be cross-shaped.
Short cells: Rectangular but may also be square or vertically flattened. Walls sinuous.
Long cells: Rectangular with sinuous walls.

Intercostal zones:

Five to 15 cell files wide including one to three files with stomata (which may be irregularly arranged) sepa-

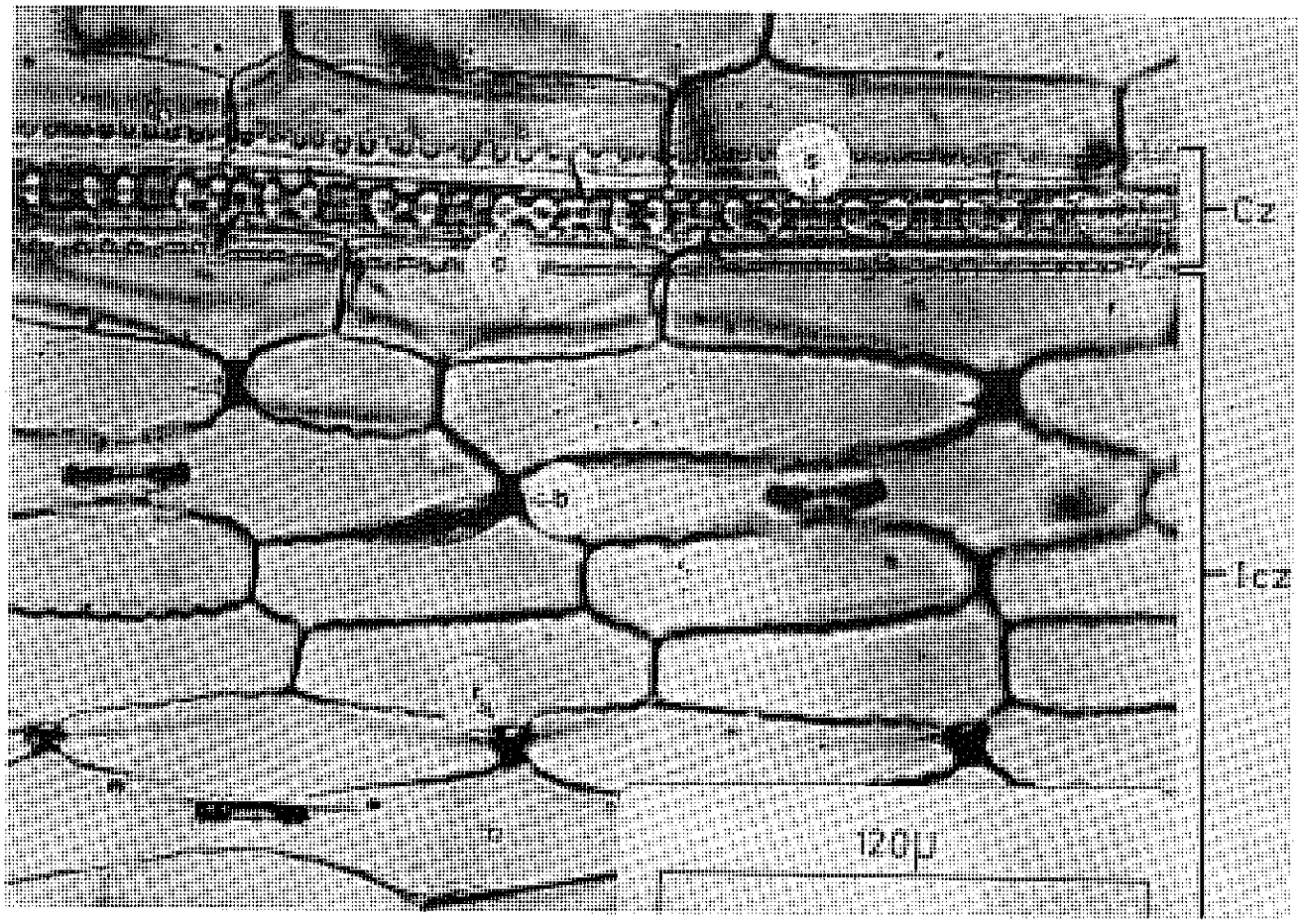


PLATE 35: Surface view of the abaxial epidermis of *Setaria appendiculata* (Hackel) Stapf

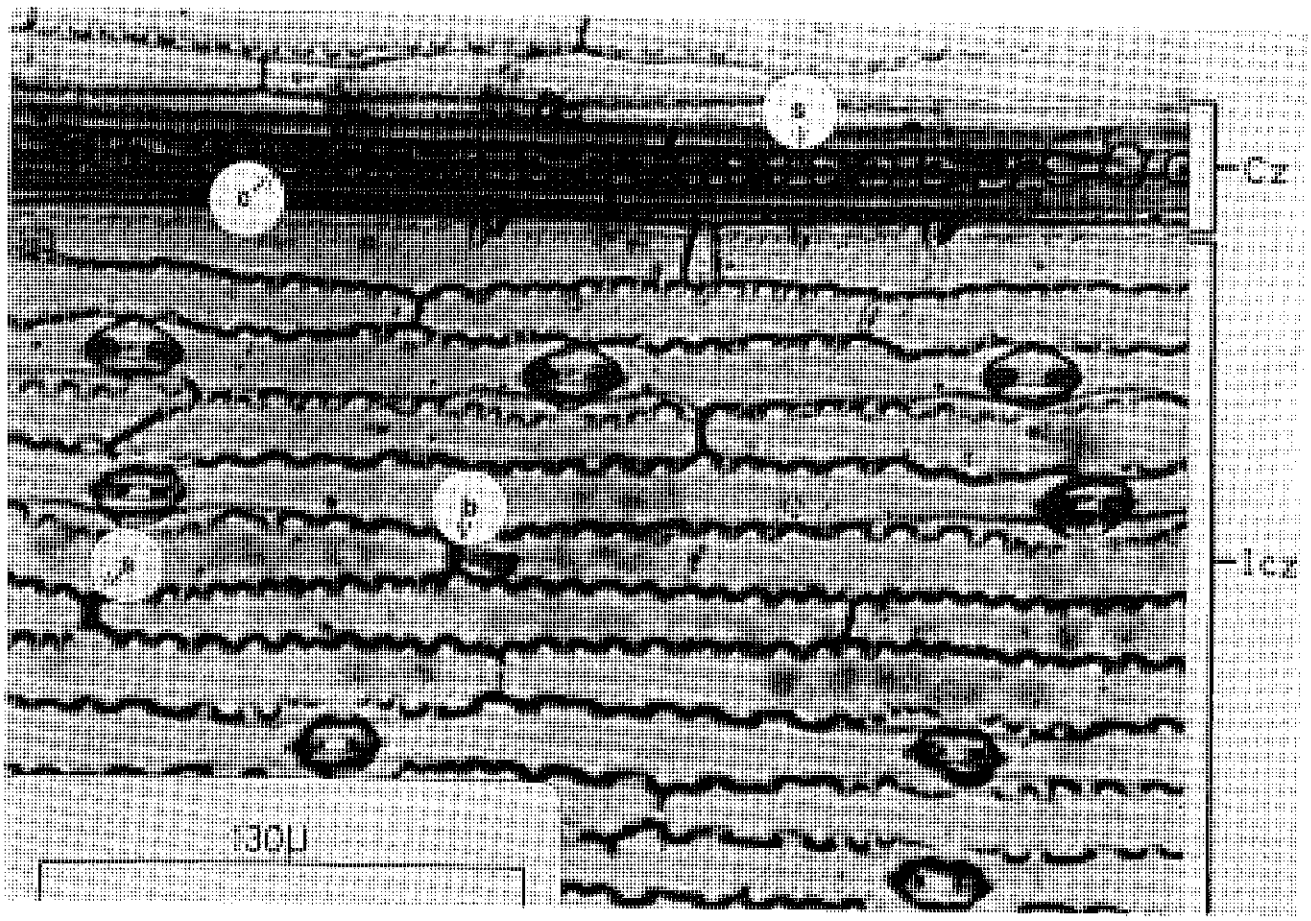


PLATE 36: Surface view of the abaxial epidermis of *Setaria verticillata* (L.) Beauv.

rated by one or more files with long cells. Stomata alternate with one or two long cells.

Subsidiary cells:	Dome-shaped (horizontally flattened).
Long cells:	Roughly coffin-shaped with smooth or wavy walls.
Short cells:	Roughly square with smooth walls but may also be vertically flattened, round or irregularly shaped.
Prickle hairs:	Bases square or round and narrower than adjacent cells. Barbs may be short and rudimentary.
Microhairs:	Scattered. Occur in files with stomata as well. Basal cells narrowed at the proximal end and apical cells longer than basal cells, tapering towards the apex.

Setaria verticillata (L.) Beauv.
(Plate 36)

Costal zones:

One to six cell files wide. Files with silica cells alternate with one to three files with long cells. Within the files with silica cells, silica cells alternate with one or more short and/or long cells but may be irregularly spaced.

Silica cells:	Short dumbell-shaped but may also be cross-shaped, nodular or irregularly shaped.
Short cells:	Vertically flattened but may also be round, square or rectangular. Walls tend to be sinuous.
Long cells:	Rectangular with slightly sinuous walls.
Prickle hairs:	May occur. Bases long, oval and broader than adjacent cells.

Intercostal zones:

Three to 19 cell files wide including one to five files with stomata separated by one to five files with long cells. Stomata alternate with a single long cell.

Subsidiary cells:	Usually triangular. May be horizontally flattened.
Long cells:	Roughly rectangular but may also be coffin-shaped. Walls wavy. Some of the long cells are inflated and protrude from the surface, overlying adjacent cells. The protruding walls are smooth.
Short cells:	Rare. Rectangular but may also be square or vertically flattened. Walls wavy or smooth.
Microhairs:	Basal cells narrowed at the proximal end and apical cells approximately four times the length of the basal cells.
Macrohairs:	Although macrohairs were not actually seen in the material examined, probably due to loss during preparation, evidence of macrohairs in the form of groups of more than two prominent specialised epidermal cells was found near the leaf apex. These groups of cells are rare. Both Günzel (1913) and Stewart (1965) mention macrohairs with specialised basal cells for this species.

Stipagrostis ciliata (Desf.) De Winter
(Plate 37)

Costal zones:

Five to 16 files wide with the files with silica cells alternating with one or two files with long cells. Within the files with silica cells, silica cells alternate with one long cell and/or one or more short cells.

Silica cells:	Square with rounded corners (i.e. subcircular) but may also be vertically flattened or rectangular (vertically oriented).
Short cells:	Two types can be distinguished: (1) Suberised short cells: These cells are paired with a silica cell (or with another suberised short cell) and have smooth walls with a dark outline and are vertically flattened with no fixed shape. (2) Non-suberised short cells: As far as can be ascertained, these cells are shortened forms of the long cells with finely sinuous walls. They are rectangular but may also be square.
Long cells:	Rectangular with finely sinuous walls.
Prickle hairs:	Occur near zone margins. Bases oval (thickened), but may also be irregular, and broader than adjacent cells. Barbs short.

Intercostal zones:

Three to seven cell files wide including one or two files with stomata which are separated by a single file with long cells. Within the files with stomata, stomata alternate with a long cell and/or a short cell.

Subsidiary cells:	Triangular with a constricted apex.
Long cells:	Roughly rectangular with strongly sinuous walls.
Interstomatal cells:	As for long cells above (long and short cells).

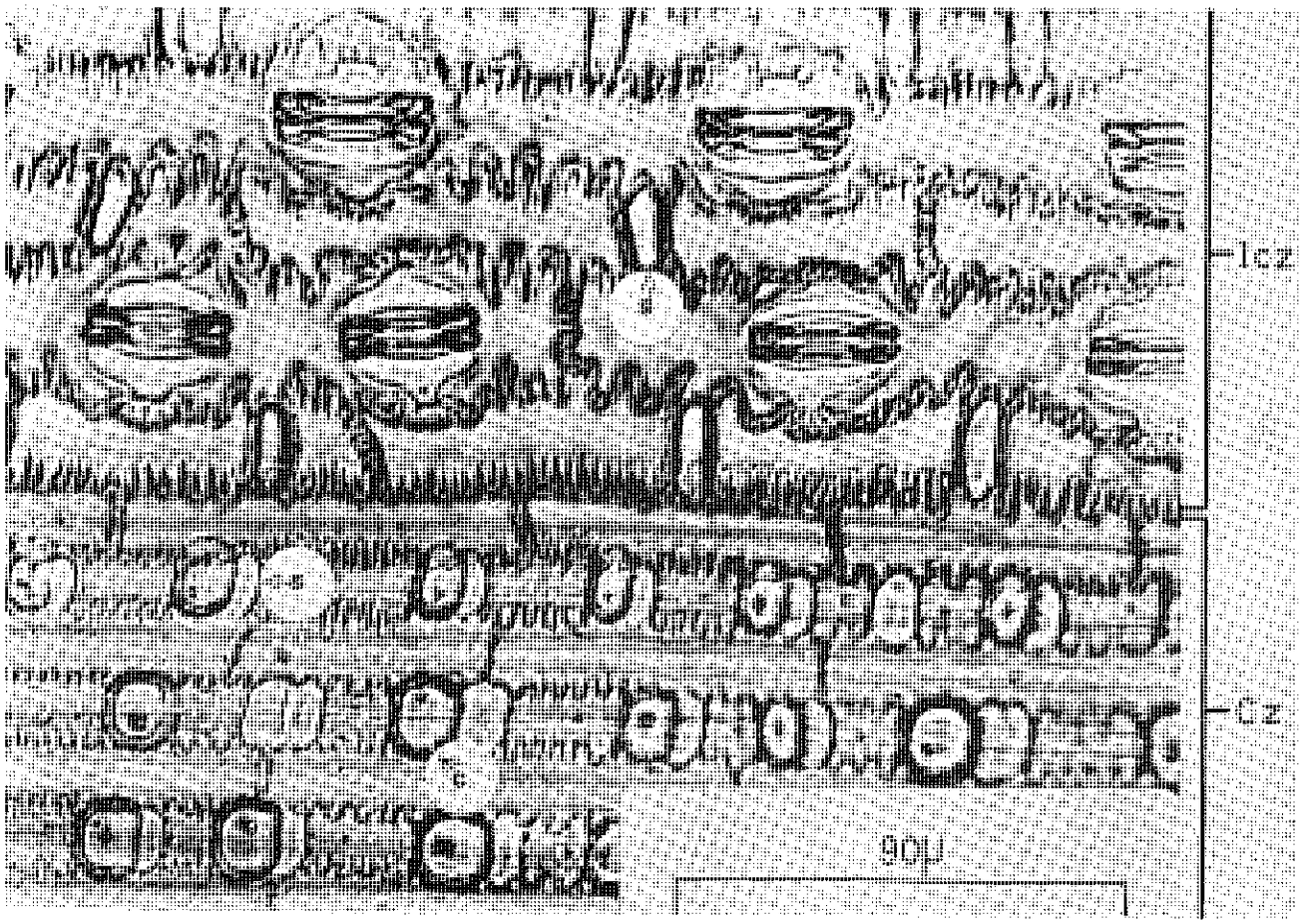


PLATE 37: Surface view of the abaxial epidermis of *Stipagrostis ciliata* (Desf.) De Winter

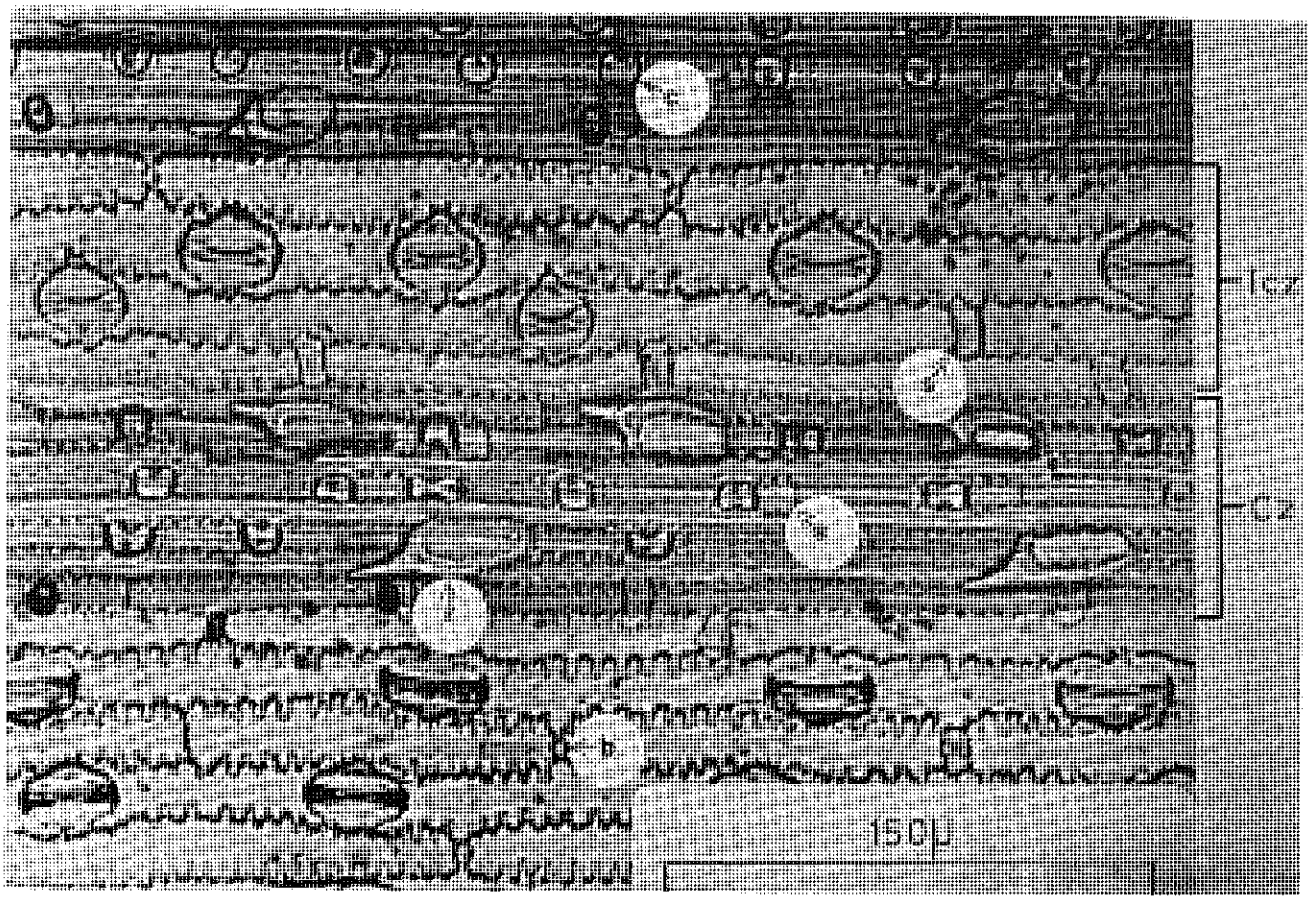


PLATE 38: Surface view of the abaxial epidermis of *Stipagrostis hirtigluma* (Steudel ex Trin. & Rupr.) De Winter ssp. *patula* (Hackel) De Winter

Short cells:	Two types occur: (1) Suberised short cells: Vertically flattened with smooth walls and may be accompanied by a silica cell. (2) Non-suberised short cells: Rectangular short forms of the long cells. Walls strongly sinuous.
Silica cells:	Paired with a suberised short cell but may also occur singly. Vertically flattened.
Microhairs:	Inconspicuous. Basal cells lost in all examples examined. Günzel (1913) mentions "angular hairs" but Metcalfe (1960) reports no microhairs for this species which both these authors described as *Aristida ciliata* Desf. Microhairs were not recorded by De Winter (1965).

Stipagrostis hirtigluma (Steudel ex Trin. & Rupr.) De Winter ssp. *patula* (Hackel) De Winter
(Plate 38)

Costal zones:

Five to 27 cell files wide. Two to 13 files with silica cells occur and they alternate with a single file with long cells. In the narrower zones silica cells are scattered whilst in the broader zones they alternate with one (sometimes two) long or short cells.

Silica cells:	Mostly short dumbell-shaped in the narrower zones and mostly round in the broader zones. May also be vertically flattened, semi-lunar (horizontally oriented) or irregularly shaped.
Short cells:	Rectangular but may also be vertically flattened or irregularly shaped. Walls sinuous and thickened.
Long cells:	Rectangular with sinuous walls.
Prickle hairs:	Conspicuous near the margins of the broader zones and scattered in the narrower zones. Bases oval and broader than the adjacent cells.

Intercostal zones:

Three to six cell files wide of which one or two are files with stomata, adjacent or separated by one file with long cells. Stomata alternate with one long cell.

Subsidiary cells:	Triangular with a constricted apex.
Long cells:	Rectangular with sinuous walls.
Short cells:	Vertically flattened but may also be rectangular. Walls smooth or wavy.
Prickle hairs:	None observed but De Winter (1965) mentioned "retrorse barbs".
Microhairs:	More numerous near the zone margins than at the centre. Basal cells narrowed at the proximal end and apical cells longer and wider than basal cells. Apical cells often lost during processing. Stewart (1965) found no microhairs in material (*Aristida hirtigluma* Steud. ex Trin.) from East Africa.
Macrohairs:	None observed but Stewart (1965) mentioned the occurrence of macrohairs.

Stipagrostis hochstetterana (Beck ex Hackel) De Winter
(Plates 39 and 40)

Costal zones:

Eight to 14 cell files wide with the files with silica cells alternating with one or two files with long cells. Silica cells alternate with one long cell and/or a short cell.

Silica cells:	Round but may also be vertically flattened or square.
Short cells:	Appear to be suberised. Rectangular but may also be vertically flattened or square. Walls sinuous.
Long cells:	Rectangular with finely sinuous walls.
Prickle hairs:	Occur near zone margins. Bases oval (horizontally oriented) and broader than adjacent cells.

Intercostal zones:

Three to six cell files wide. Characterised by large numbers of appendages. There are two files with stomata (although only one file may also occur) which are separated by a single file with long cells. Within the files with stomata, stomata alternate with one or more long or short cells.

Subsidiary cells:	Dome-shaped but may also be triangular with constricted apices.
Long cells:	Irregularly rectangular with sinuous walls.
Short cells:	Occur singly or paired with a silica cell. Appear to be suberised. Irregularly shaped with sinuous walls.
Long cells:	Rectangular with finely sinuous walls.

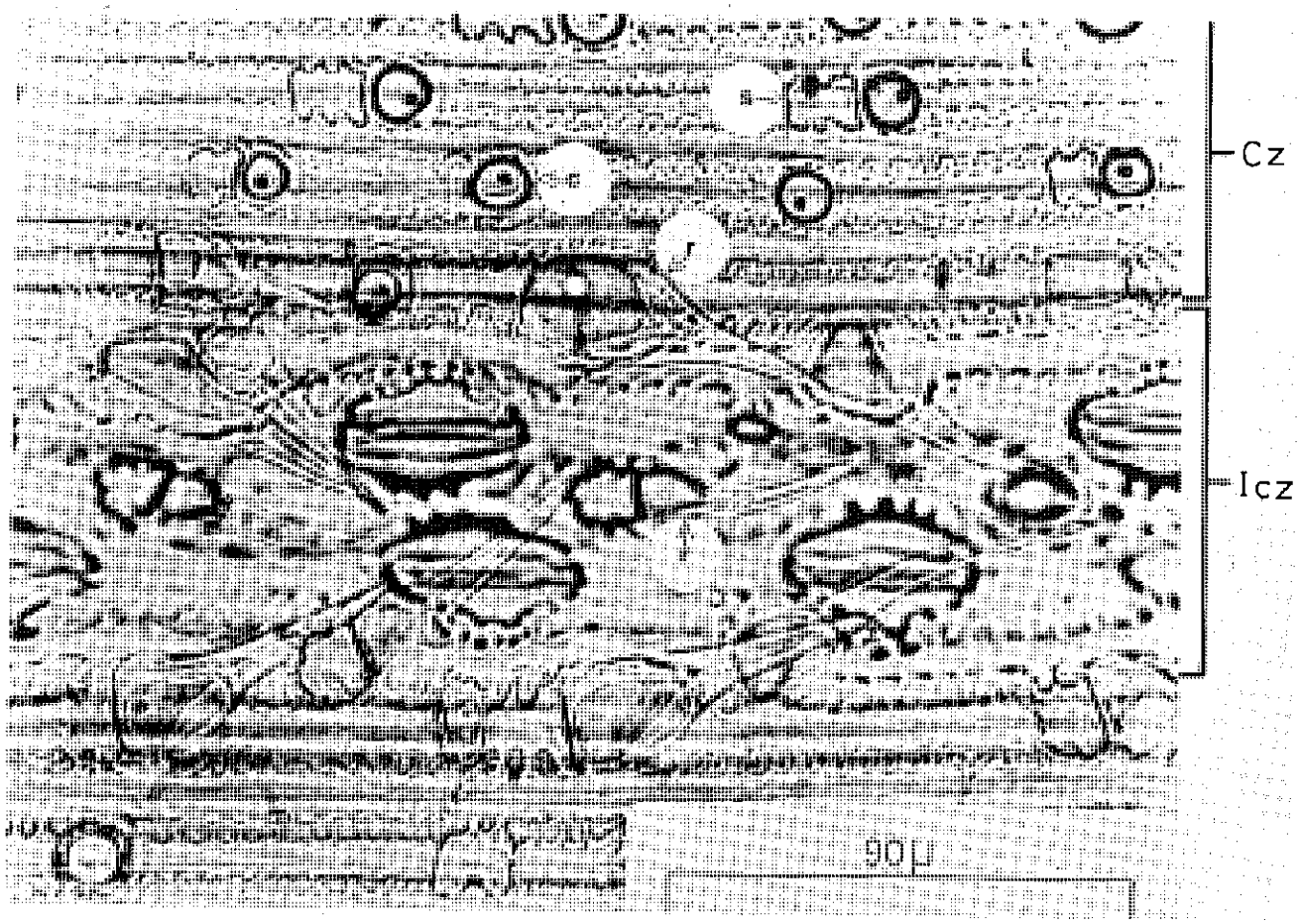


PLATE 39: Surface view of the abaxial epidermis of *Stipagrostis hochstetterana* (Beck ex Hackel) De Winter – focus on the costal zone.

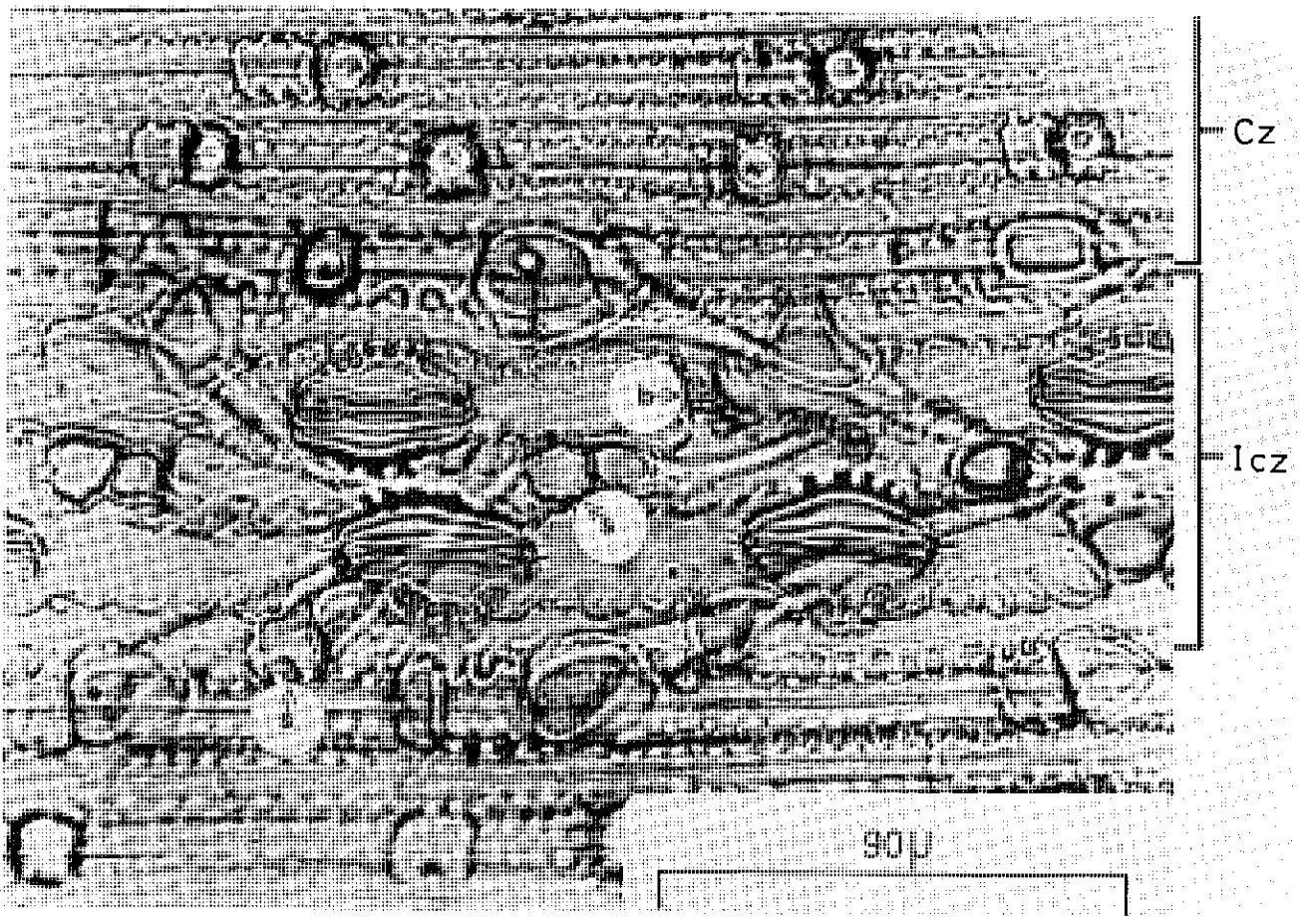


PLATE 40: Surface view of the abaxial epidermis of *Stipagrostis hochstetterana* (Beck ex Hackel) De Winter – focus on the intercostal zone.

Prickle hairs: Occur near zone margins. Bases oval (horizontally oriented) and broader than adjacent cells.

Intercostal zones:

Three to six cell files wide. Characterised by large numbers of appendages. There are two files with stomata (although only one file may also occur) which are separated by a single file with long cells. Within the files with stomata, stomata alternate with one or more long or short cells.

Subsidiary cells: Dome-shaped but may also be triangular with constricted apices.

Long cells: Irregularly rectangular with sinuous walls.

Short cells: Occur singly or paired with a silica cell. Appear to be suberised. Irregularly shaped with sinuous walls.

Silica cells: Rare. Occur near zone margins, paired with a short cell. Irregularly shaped.

Prickle hairs: Conspicuous. May be paired with a short cell. Bases vary in shape and are narrower than adjacent cells, many of them vertically oriented. Barbs long. De Winter (1965) termed them "one-celled sharp-pointed hairs" and described them as indistinct.

Microhairs: Basal cells narrowed at the proximal end and apical cells lost during processing. Many of the hairs near the zone margins are angled to one side from the base.

Stipagrostis namaquensis (Nees) De Winter
(Plate 41)

Costal zones:

Three to 11 cell files wide with the files with silica cells separated by one or two files with long cells. Silica cells are paired with short cells and alternate with two short cells or one short cell and one long cell.

Silica cells: Vertically flattened but may also be square with rounded corners or round. Günzel (1913) described the silica cells of this species (*Aristida namaquensis* Trin. ex Steud.) as saddle-shaped while De Winter (1965) mentions "oblong" silica cells.

Short cells: Two types can be distinguished: (1) Suberised short cells: Usually paired with a silica cell. Vertically flattened but may also be irregularly shaped. Walls smooth. (2) Non-suberised short cells: Shortened forms of the long cells. Rectangular but may also be square. Walls finely sinuous.

Long cells: Rectangular with finely sinuous walls.

Intercostal zones:

Four to eight cell files wide, including one or two files with stomata (which can be irregularly arranged), adjacent or separated by one or two files with long cells. Within the files with stomata, stomata alternate with one or two long cells and/or short cells.

Subsidiary cells: Triangular with a constricted apex.

Long cells: Roughly rectangular with strongly sinuous walls.

Interstomatal cells: As for long cells above (long and short cells).

Short cells: Both the types mentioned above (costal zones) occur. Suberised cells are vertically flattened with smooth walls and non-suberised cells are rectangular with sinuous walls.

Silica cells: None observed but De Winter (1965) observed one or two files with silica cells between the files with stomata.

Prickle hairs: None observed but Günzel (1913) stated that there are "almost no spiny hairs, or angular hairs" implying that he did observe them.

Stipagrostis uniplumis (Licht. ex Roemer & Schultes) De Winter
(Plate 42)

Costal zones:

Three to 18 cell files wide with files with silica cells alternating with one or two files with long cells. Within the files with silica cells, silica cells alternate with one or more long and/or short cells.

Silica cells: Round but may also be short dumbell-shaped, square, rectangular or irregularly shaped.

Short cells: Less numerous in the broader zones than in the narrower zones. Suberised cells could not be distinguished. Rectangular but may also be vertically flattened, square or irregularly shaped.

Long cells: Rectangular with sinuous walls.

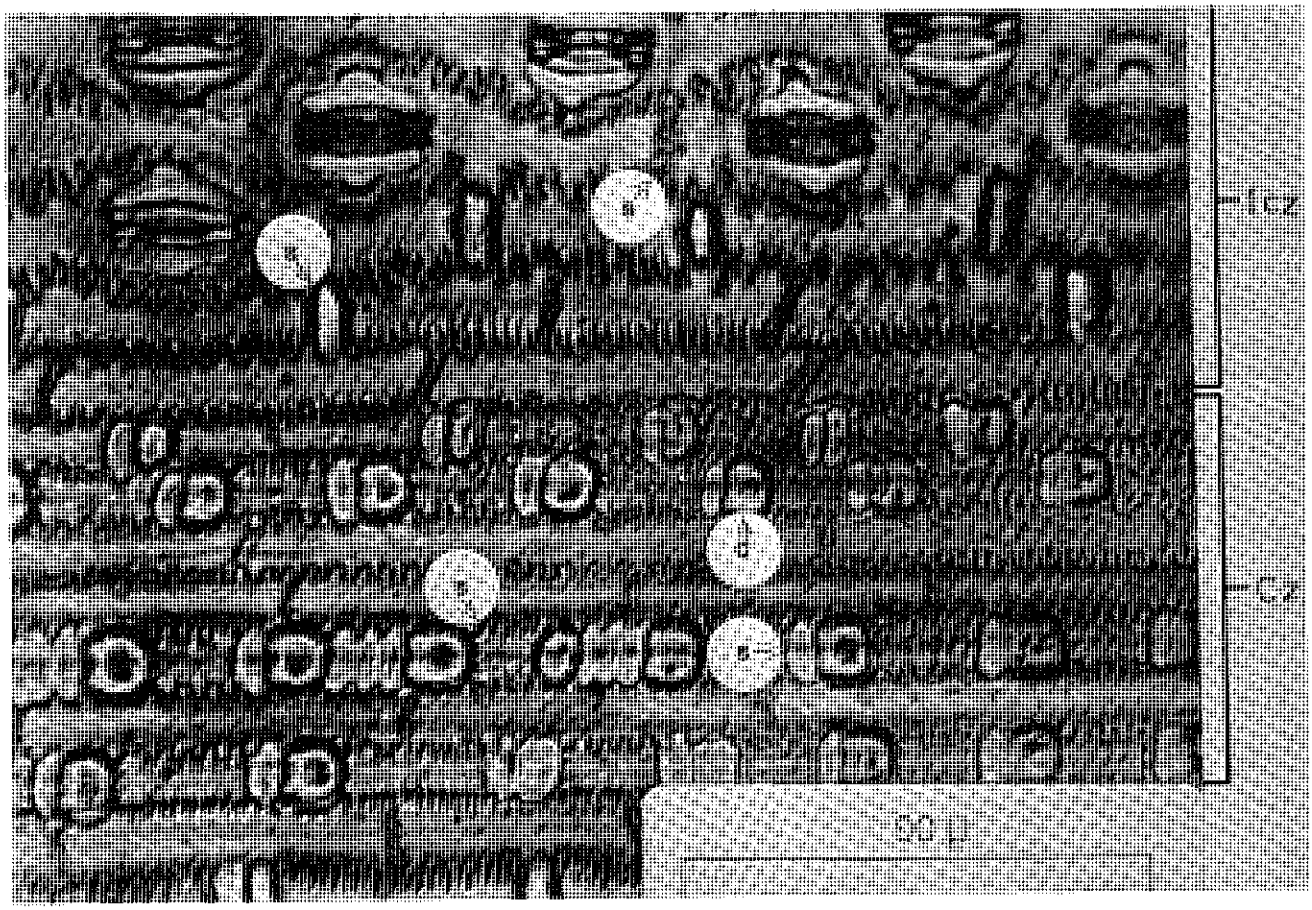


PLATE 41: Surface view of the abaxial epidermis of *Stipagrostis namaquensis* (Nees) De Winter

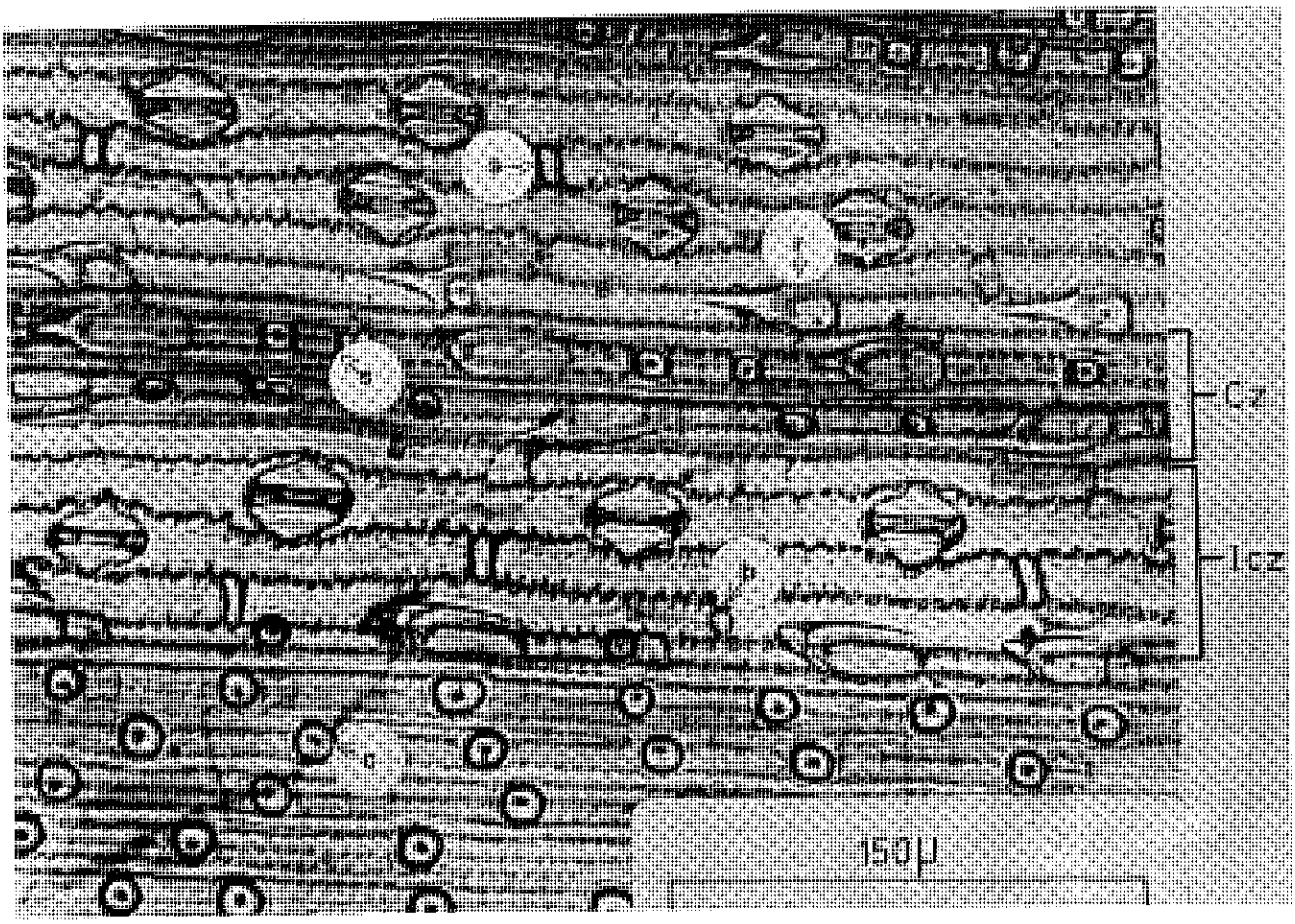


PLATE 42: Surface view of the abaxial epidermis of *Stipagrostis uniplumis* (Licht. ex Roemer & Schultes) De Winter

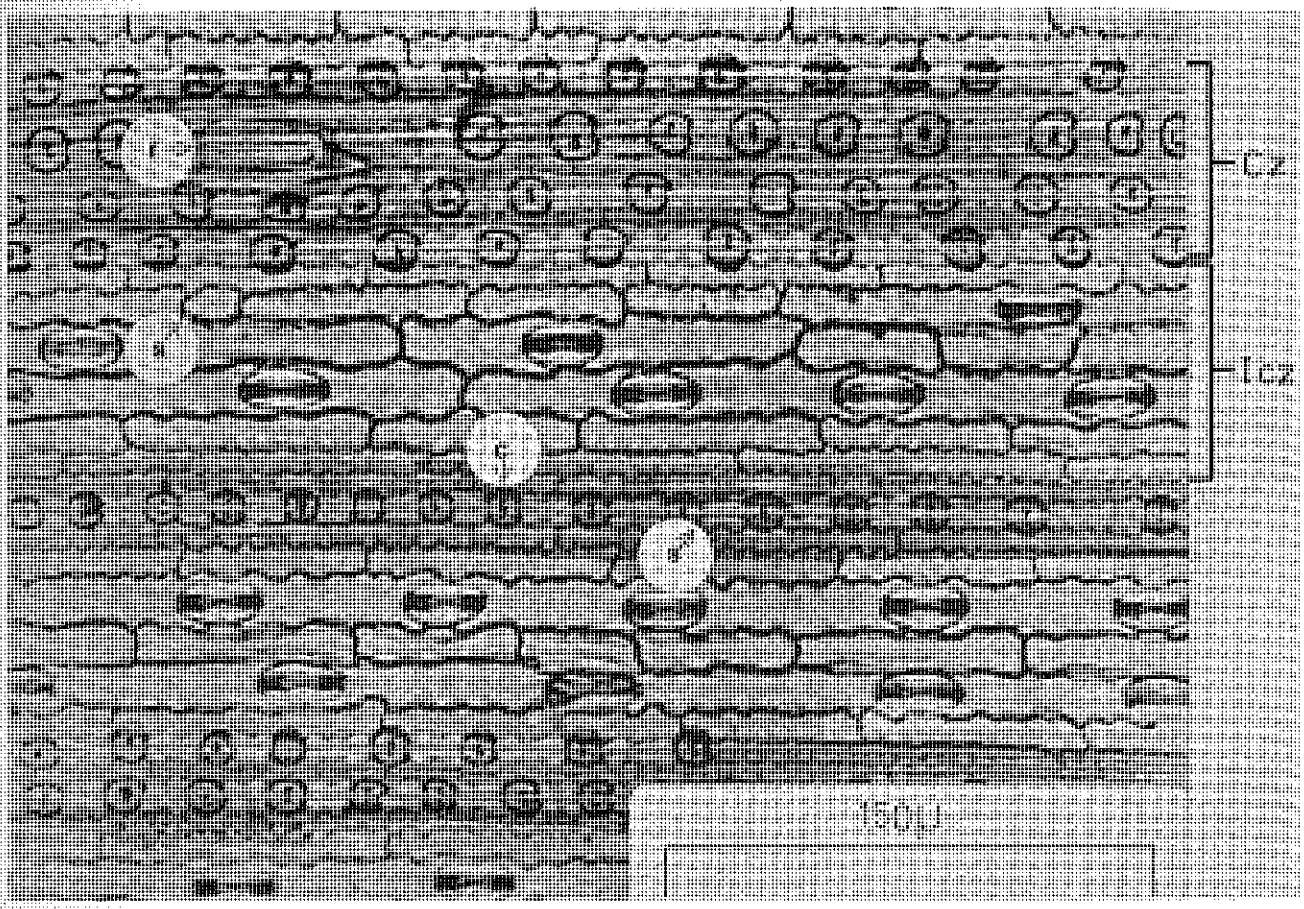


PLATE 43: Surface view of the abaxial epidermis of *Tragus berteronianus* Schultes

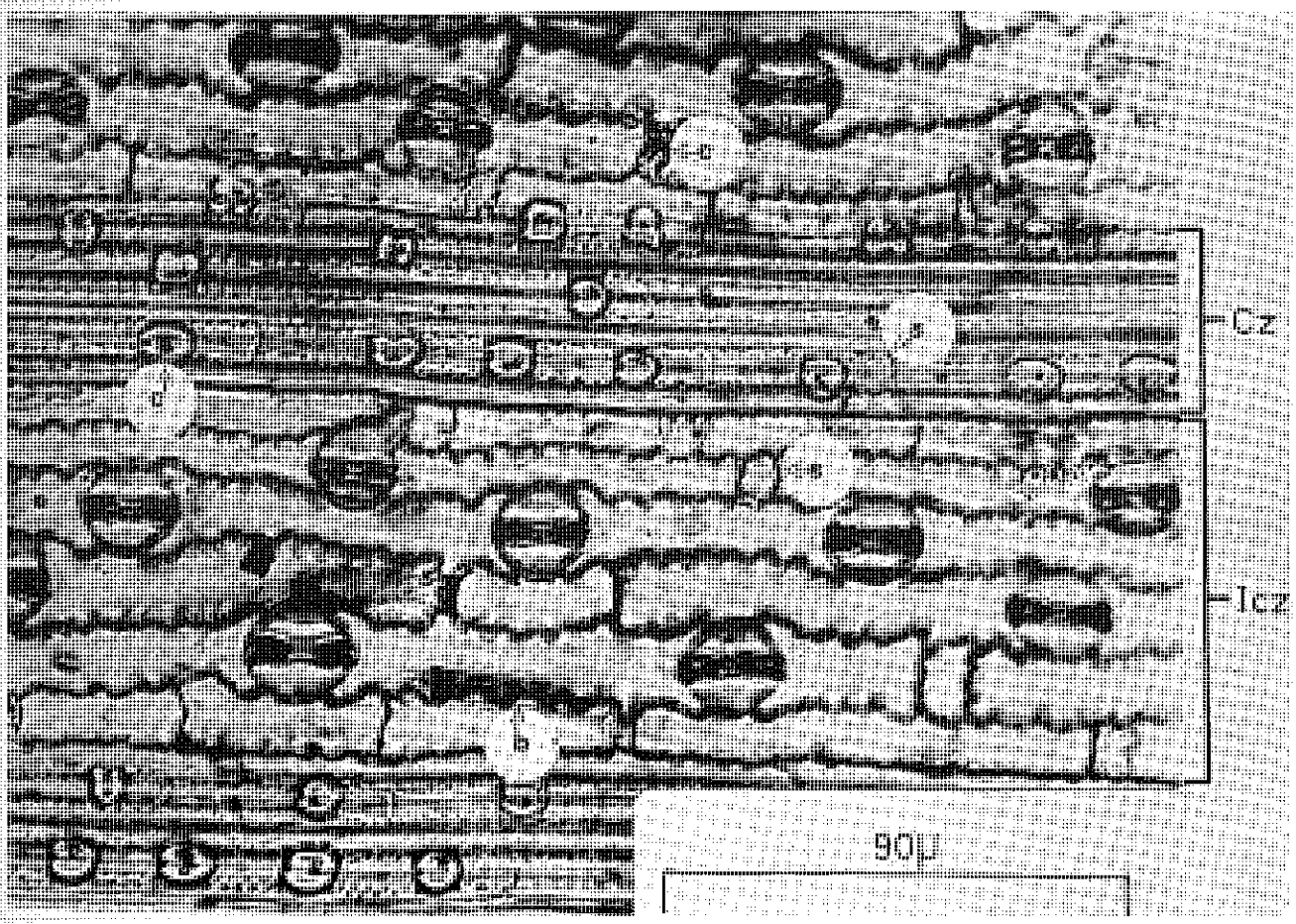


PLATE 44: Surface view of the abaxial epidermis of *Tricholaena rosea* Nees

Prickle hairs: Occur near margins of the broader zones but scattered in the narrower zones. Bases oval and broader than adjacent cells.

Intercostal zones:

Five to nine cell files wide including one to two files with stomata which are usually separated by one or two files with long cells, but may also be adjacent. The files with stomata can also be irregularly arranged. Within the files with stomata, stomata alternate with one or two long cells or a short cell.

Subsidiary cells: Triangular with constricted apices.
Long cells: Roughly rectangular with sinuous walls.
Interstomatal cells: As for long cells above (long and short cells).
Short cells: Vertically flattened with smooth walls.
Prickle hairs: Occur near zone margins. Bases round and usually narrower than adjacent cells.
Microhairs: Basal cells narrowed at the proximal end. Apical cells have a pointed apex and are longer than the basal cells, but often lost or distorted during preparation.

Tragus berteronianus Schultes
(Plate 43)

Costal zones:

One to five cell files wide. Files with silica cells alternate with one file with long cells. Within the files with silica cells, silica cells alternate with one or two long cells or one or two short cells.

Silica cells: Saddle-shaped (vertically or horizontally oriented).
Short cells: Short dumbell-shaped but may also be cross-shaped, vertically flattened or rectangular. Walls smooth or wavy.
Long cells: Rectangular with sinuous walls.
Prickle hairs: Occur in broader zones. Bases oval and broader than adjacent cells.

Intercostal zones:

Three to eight cell files wide including two to three files with stomata which are usually separated by a file with long cells but may be adjacent. Within the files with stomata, stomata alternate with one or two long or short cells.

Subsidiary cells: Dome-shaped, horizontally flattened.
Long cells: Roughly rectangular with wavy walls.
Short cells: Rectangular with wavy walls.
Microhairs: Rare, occur near leaf margins. Basal cells narrowed at the proximal end. Apical cells hemispherical and shorter than basal cells.

Schweickerdt (1941), Metcalfe (1960) and Stewart (1965) found no evidence of microhairs or prickle hairs in this species. Kok (1968), however, observed both types of appendages. Schweickerdt (1941), Stewart (1965) and Kok (1968) described macrohairs near the leaf margin but Metcalfe (1960) did not see any macrohairs nor were any observed during the present study. Metcalfe (1960) and Kok (1968) both observed papillae, the former giving the impression that the material he examined possessed numerous papillae, but papillae were not observed by Stewart (1965) nor were any seen in the present study.

Triraphis ramosissima Hackel
(Plate 44)

Costal zones:

Three to 10 cell files wide. Files with silica cells alternate with one or two files with long cells. Silica cells are scattered and alternate with one or more short and/or long cells.

Silica cells: Saddle-shaped (horizontally oriented) but may also be short dumbell-shaped, cross-shaped, semilunar, round or irregularly shaped.
Short cells: Rectangular with sinuous walls but may also be square.
Long cells: Rectangular with sinuous walls

Intercostal zones:

Four to six cell files wide including two to four adjacent files with stomata. Files with long cells occur at the zone margins. Stomata alternate with one or more short or long cells.

Subsidiary cells: Dome-shaped.
Long cells: Rectangular with sinuous walls.
Short cells: Irregularly shaped but may also be vertically flattened, square or rectangular. Walls sinuous.
Microhairs: Scattered, even occurring in files with stomata. Basal cells long and narrowed at the proximal end. Apical cells shorter than the basal cells, sometimes lost or distorted during processing.

3.3 Family Cyperaceae

Cyperus longus L. ssp. *tenuiflorus* (Rottb.) Kükenthal
(Plate 45)

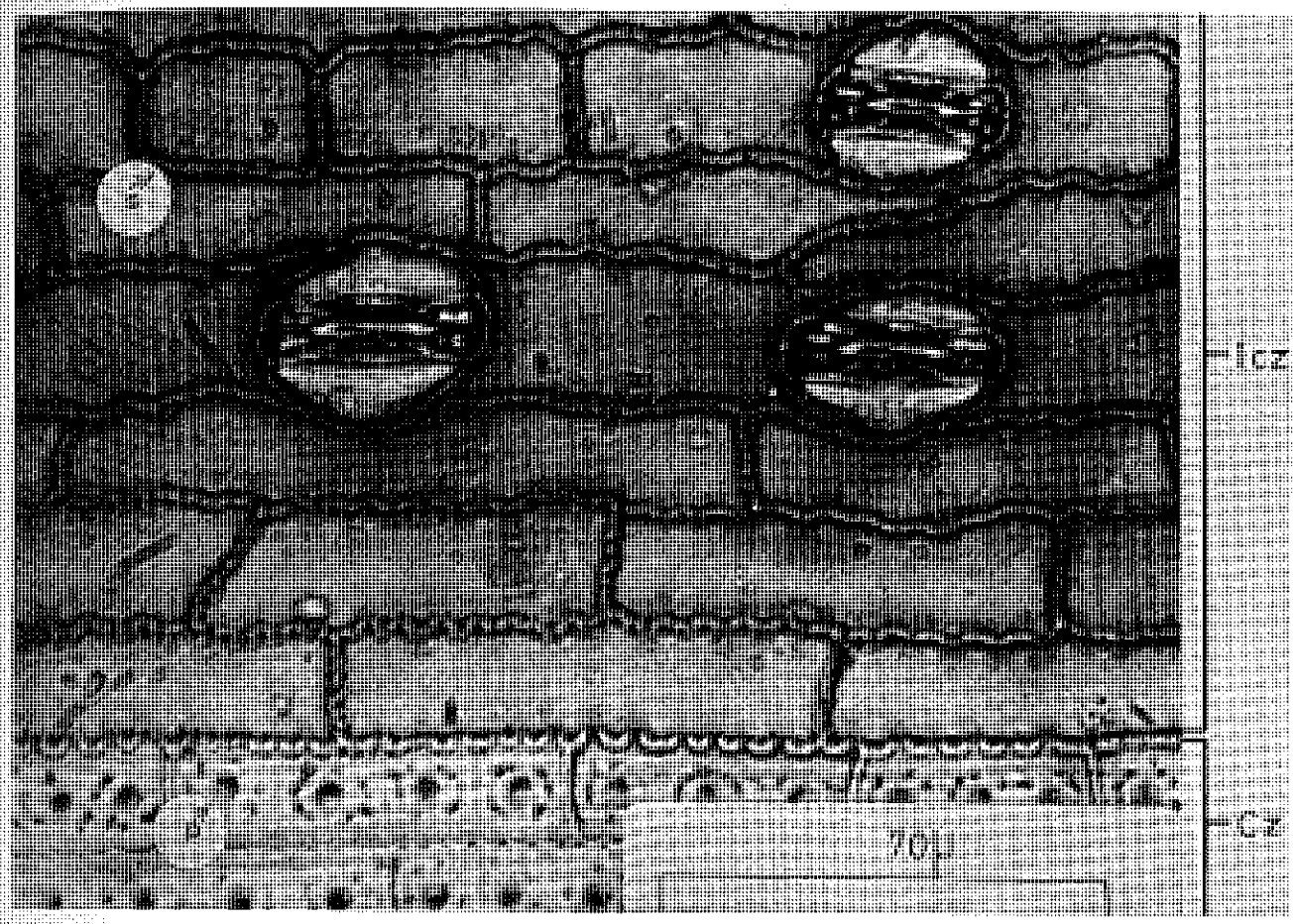


PLATE 47: Surface view of the abaxial epidermis of *Cyperus longus* L. ssp. *tenuiflorus* (Rottb.) Rikli (sic)

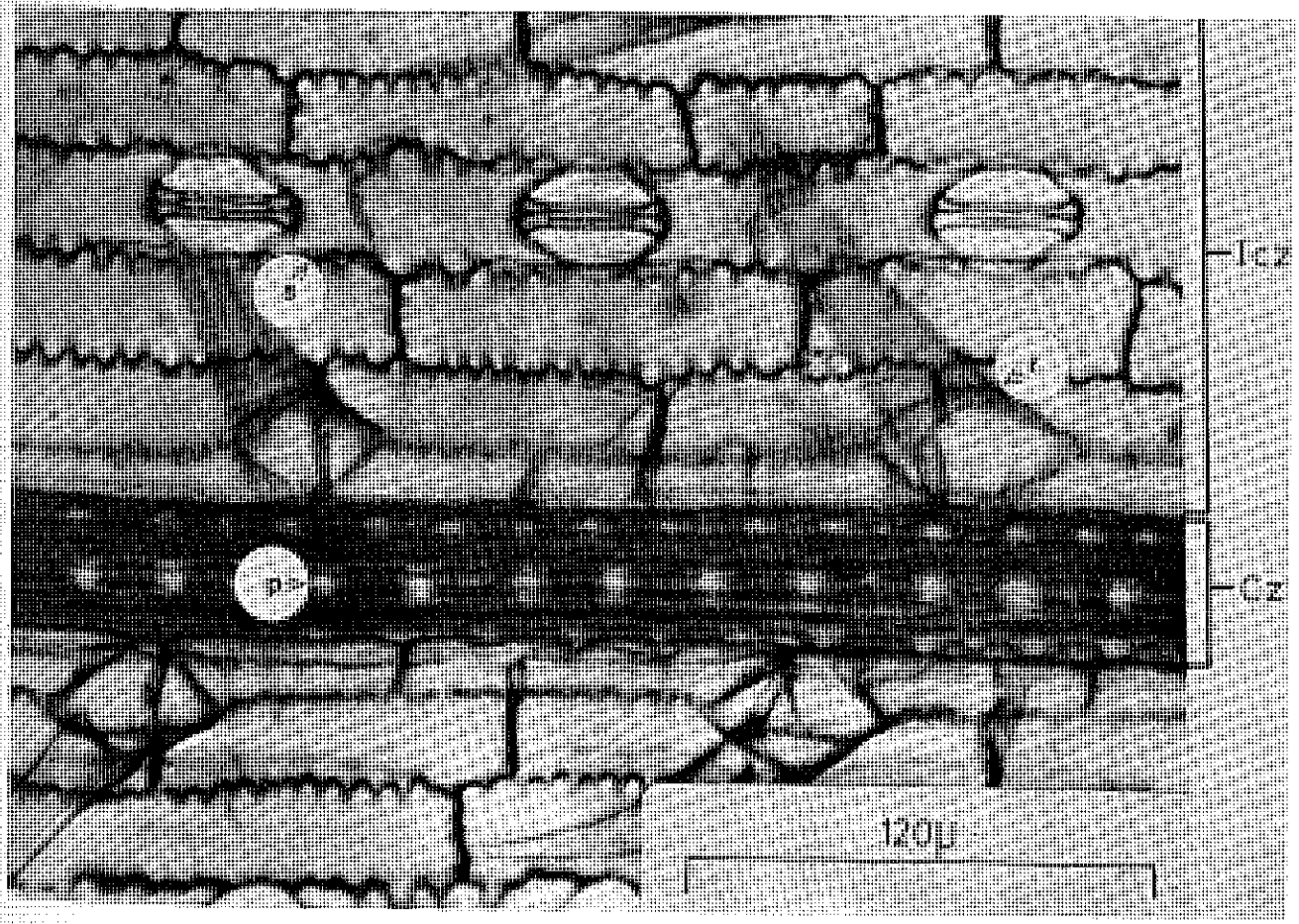


PLATE 48: Surface view of the abaxial epidermis of *Fimbristylis ovata* (Burm. f.) Kern & Schelpe

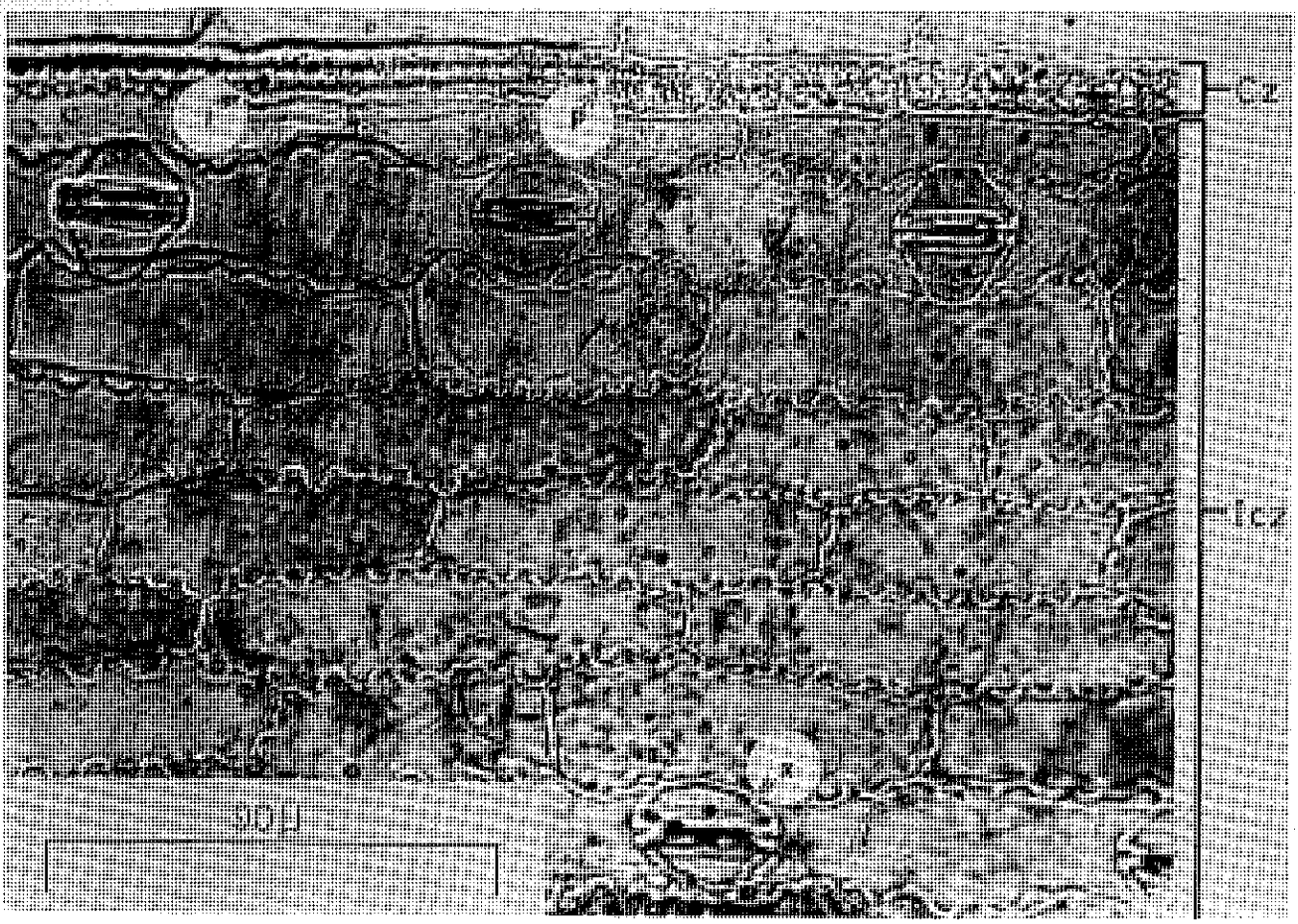


PLATE 47: Surface view of the abaxial epidermis of *Mariscus aristatus* (Rottb.) Chermezon

Costal zones:

Consist of one or two files with long cells. Long cells are rectangular with sinuous walls and can be distinguished from other long cells in the epidermis by the presence of two to six papillae arranged in a single file on each cell. Each of these papillae are surrounded by 10 to 15 small granules which are presumed to be silica crystals.

Intercostal zones:

Eight to 12 cell files wide. There are one or two files with stomata which are usually separated by one to four files with long cells but can also be adjacent. Files with stomata may be irregularly arranged. Stomata alternate with one or more long and/or short cells.

Subsidiary cells:	Dome-shaped but may also be irregularly shaped.
Long cells:	Rectangular with sinuous walls.
Short cells:	Rectangular but may also be square or irregularly shaped. Walls sinuous.

Fimbristylis exilis (Humb., Bonpl. & Kunth) Roemer & Schultes
(Plate 46)

Costal zones:

Consist of one to three files with long cells. Long cells are rectangular with sinuous walls. Papillae occur on almost all cells and are surrounded by three to seven small granules, presumably silica crystals. The outer cell files of the costal zones overlie the margins of the adjacent intercostal zones.

Intercostal zones:

Six to seven cell files wide including a single file with stomata in the middle of the zone. Within this file, stomata alternate with a single long or short cell, but can also alternate with two short cells or one long and one short cell.

Subsidiary cells:	Triangular.
Long cells:	Rectangular with sinuous walls.
Short cells:	Rectangular with sinuous walls.
Prickle hairs:	Occur in outer two files of the intercostal zones. Bases diamond-shaped and broader than adjacent cells. Barbs vertically oriented and conspicuously long, extending over the zone.

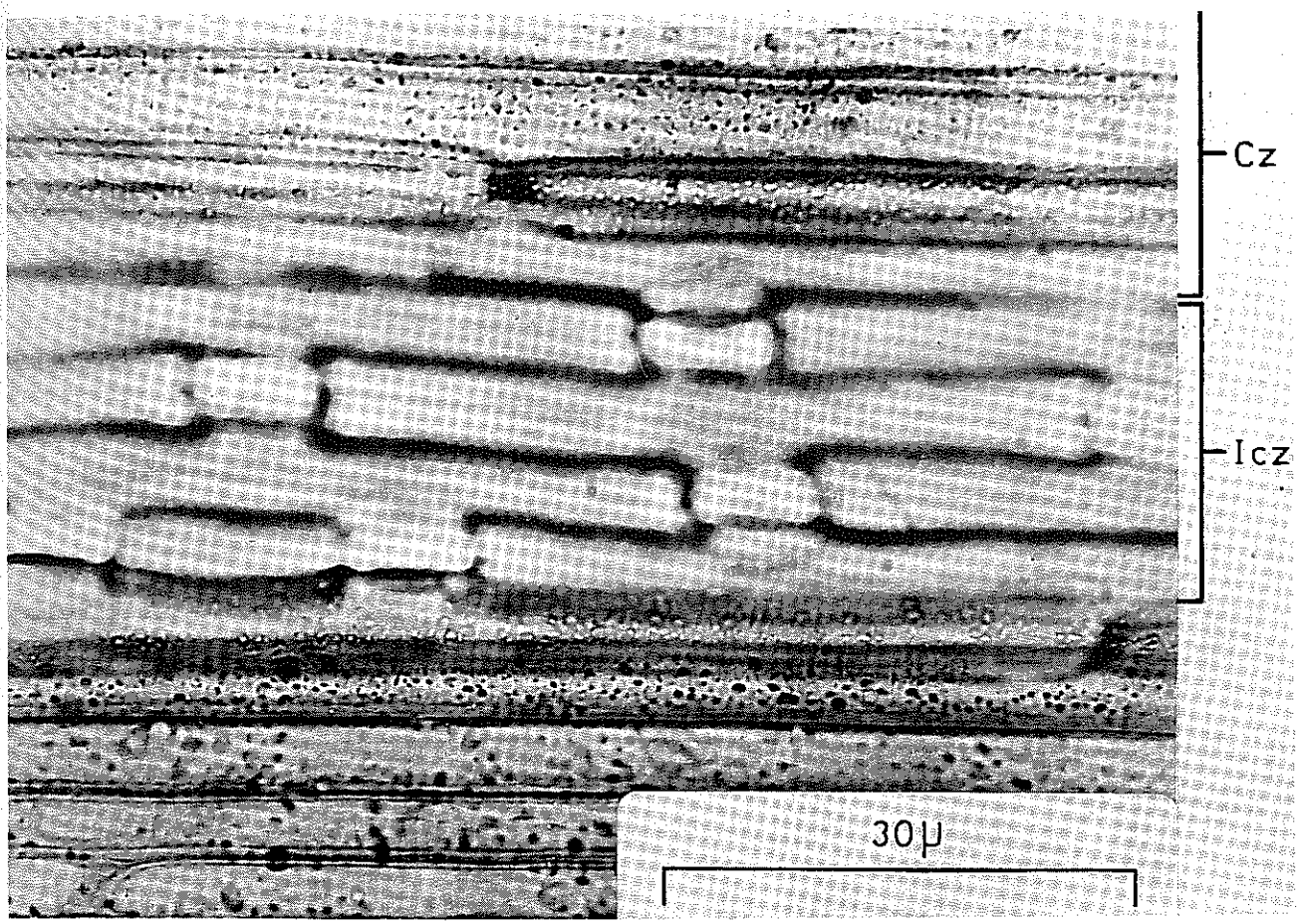


PLATE 48: Surface view of the epidermis of *Trachyandra arvensis* (Schinz) Oberm. — focus on the costal zone.

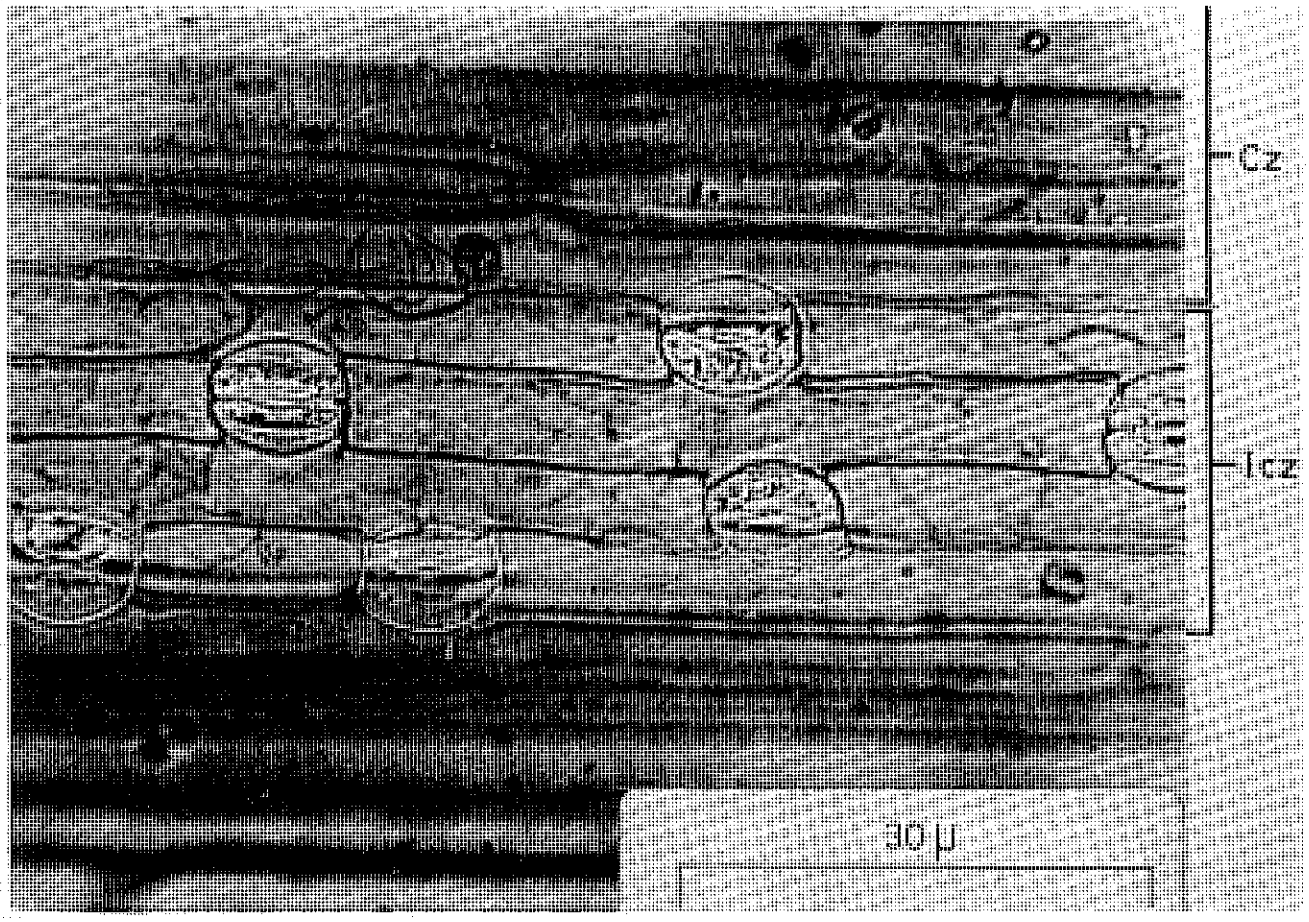


PLATE 49: Surface view of the epidermis of *Trachyandra arvensis* (Schinz) Oberm. — focus on the intercostal zone.

Mariscus aristatus (Rottb.) Chermezon
(Plate 47)

Costal zones:

Consist of one or two files with long cells. Long cells are rectangular with sinuous walls. Each of the long cells possesses three to five papillae, each of which is surrounded by 20 to 30 small granules, probably silica crystals.

Intercostal zones:

Consist of two to 10 cell files including two to four files with stomata, which are separated by one to five files with long cells. Files with stomata can be irregularly arranged. Within the files with stomata, stomata alternate with one or more short or long cells.

Subsidiary cells:	Roughly triangular (vertically compressed) but may also be irregular.
Long cells:	Roughly rectangular but may also be coffin-shaped or irregularly shaped. Walls sinuous.
Short cells:	Rectangular but may also be oval or irregularly shaped. Walls sinuous.

3.4 Family Liliaceae

Trachyandra arvensis (Schinz) Oberm.
(Plate 48 and 49)

The leaf of this species is fleshy and round so that it was impossible to identify the abaxial side. The surface is grooved, with stomata arranged along the length of the grooves. It was on this basis that the costal and intercostal zones were identified. The epidermis exhibits little differentiation.

Costal zones:

Consist of seven to nine undifferentiated files with long cells. The cells are rectangular with slanted, overlapping ends and smooth, straight walls.

Intercostal zones:

Five to seven cell files wide. Stomata occur in all the files and alternate with a single smooth-walled, rectangular long cell of which the ends are square. No subsidiary cells occur and the two guard cells are hemispherical. Short cells are rare and are simply shortened forms of the long cells.

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6 APPENDIX: KEY TO 39 MONOCOTYLEDON SPECIES FROM SOUTHERN SOUTH WEST AFRICA BASED ON THE ANATOMY OF THE ABAXIAL LEAF EPIDERMIS

1.	Silica cells present	5
	Silica cells absent	2
2.	Long cell walls smooth	*Trachyandra arvensis*
	Long cell walls sinuous	3
3.	Prickle hairs present	*Fimbristylus exilis*
	Prickle hairs absent	4
4.	Papillae on long cells of costal zones surrounded by 10 to 15 silica granules	*Cyperus longus*
	Papillae on long cells of costal zones surrounded by 20 to 30 silica granules	*Mariscus aristatus*
5.	Bicellular glandular macrohairs present	6
	Bicellular glandular macrohairs absent	9
6.	Long unicellular macrohairs present	7
	Long unicellular macrohairs absent	*Enneapogon scaber*
7.	Bicellular microhairs present	*Enneapogon brachystachyus*
	Bicellular microhairs absent	8
8.	Short cells in intercostal zones uncommon, mostly rectangular	*Enneapogon cenchroides*
	Short cells in intercostal zones common, mostly vertically flattened	*Schmidtia kalahariensis*
9.	Short, bulbous, almost erect microhairs present	10
	Microhairs absent or, if present, not as above	13
10.	Microhairs unicellular	11
	Microhairs bicellular (basal cells very small, sharply narrowed at the proximal end)	12
11.	Long cells in intercostal zones have sinuous walls	*Chloris virgata*
	Long cells in intercostal zones have smooth walls	*Dactyloctenium aegyptium*
12.	Silica cells in costal zones square	*Oropetium capense*
	Silica cells in costal zones saddle-shaped	*Cynodon dactylon*
13.	Long cells and/or interstomatal cells in intercostal zones each possess a single acentric papilla	14
	Papillae absent	15
14.	Papillae large, asymmetrical, occupying almost the whole of the cell surface, sometimes overlying adjacent cells	*Dichanthium papillosum*
	Papillae small, do not overlie adjacent cells	*Heteropogon contortus*
15.	Bicellular microhairs with basal cells prominently narrowed at the proximal end; apical cells clearly visible, much shorter than the former and hemispherical with a rounded apex	16
	Bicellular microhairs absent or rare and if present, not as above; apical cells not clearly visible or, if visible, not as above	21
16.	Multicellular epidermal glands present in some costal zones	17
	Multicellular epidermal glands absent	18
17.	Multicellular epidermal glands consist of approximately 25 specialised epidermal cells	*Eragrostis echinochloidea*
	Multicellular epidermal glands consist of approximately 60 specialised epidermal cells	*Eragrostis rotifer*
18.	Prickle hairs present in intercostal zones	20
	Prickle hairs absent from intercostal zones	19

19.	Silica cells in broader costal zones mostly saddle-shaped	*Eragrostis biflora*
	Silica cells in broader costal zones mostly short dumbell-shaped	*Eragrostis porosa*
20.	Silica cells uncommon or absent in intercostal zones	*Eragrostis trichophora*
	Silica cells common in intercostal zones, usually paired with a vertically flattened short cell	*Eragrostis nindensis*
21.	Short sharp-pointed macrohairs, their bases supported by one to four specialised epidermal cells present in intercostal zones	22
	Macrohairs absent	25
22.	Silica cells in costal zones mostly nodular	*Rhynchelytrum villosum*
	Silica cells in costal zones mostly short dumbell, long dumbell or cross-shaped	23
23.	Silica cells present in intercostal zones	24
	Silica cells absent from intercostal zones	*Anthephora pubescens*
24.	Inflated long cells which protrude from the surface present in intercostal zones	*Digitaria eriantha*
	Inflated long cells absent	*Leucophrys mesocoma*
25.	Silica cells in costal zones short dumbell, long dumbell, cross-shaped or rectangular	26
	Silica cells in costal zones round, square, saddle-shaped or vertically flattened	33
26.	Cell walls of long cells in intercostal zones smooth or wavy	27
	Cell walls of long cells in intercostal zones prominently sinuous	29
27.	Prickle hairs present in intercostal zones	28
	Prickle hairs absent from intercostal zones	*Setaria verticillata*
28.	Silica cells in costal zones cross-shaped or rectangular and scattered. Long cells in intercostal zones smooth-walled, irregularly shaped and inflated	*Asthenatherum glaucum*
	Silica cells in costal zones mostly short dumbell-shaped. Long cells in intercostal zones smooth- or wavy-walled, coffin-shaped and seldom inflated	*Setaria appendiculata*
29.	Inflated long cells present in intercostal zones	30
	Inflated long cells absent from intercostal zones	31
30.	Prominent prickle hairs common in costal zones	*Cenchrus ciliaris*
	Prickle hairs absent, or if present, occur infrequently only in narrower costal zones	*Panicum arbusculum*
31.	Silica cells present in intercostal zones	32
	Silica cells absent from intercostal zones	*Aristida adscensionis*
32.	Silica cells uncommon in intercostal zones, occurring near zone margins, mostly short dumbell-shaped	*Aristida congesta*
	Silica cells numerous in intercostal zones, usually paired with a suberised short cell, mostly vertically flattened	*Aristida engleri*
33.	Silica cells in costal zones mostly saddle-shaped	34
	Silica cells in costal zones mostly round, square or vertically flattened	35
34.	Long bicellular microhairs with apical cells only slightly shorter than basal cells common in intercostal zones	*Triraphis ramosissima*
	Bicellular microhairs absent or rare. If present, then short, with apical cells much shorter than basal cells	*Tragus berteronianus*
35.	Prickle hairs present	36
	Prickle hairs absent	*Stipagrostis namaquensis*
36.	Prickle hairs present in intercostal zones	37
	Prickle hairs absent from intercostal zones	38

37. Prickle hairs numerous in intercostal zones and have long barbs to the extent that they interlace over the entire zone — *Stipagrostis hochstetterana*
    Prickle hairs common, but not as above — *Stipagrostis uniplumis*
38. Silica cells in costal zones square with rounded corners (subcircular). Prominent pairing between these and vertically flattened suberised short cells occurs — *Stipagrostis ciliata*
    Silica cells in costal zones mostly round. No regular pairing between silica cells and short cells, the latter mostly rectangular — *Stipagrostis hirtigluma*

SHORT NOTE

A record of the white-backed night heron from the lower Orange River

by

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The distribution of the white-backed night heron (*Gorsachius leuconotos*) in southern Africa is shown by McLachlan and Liversidge (1978, 43) as the eastern areas of Cape Province, Natal and Mozambique, the Zambezi River, the Okavango Delta, Caprivi and eastern Kavango. In South West Africa/Namibia it occurs in the extreme north-eastern region, where it has been collected from Ndwaki and sighted at Kapaku, Bagani and Andara (Winterbottom 1966). In addition, there is an undocumented record from the Fish River, in the south (Winterbottom 1971, 41). Here we present another record of its presence in the southern region.

On 25 December 1978, at mid-morning, we saw a single white-backed night heron on the true right bank of the Orange River, 5 km upstream from Aussenkehr (28°22′S, 17°25′E). When first seen it was standing on a branch of a willow (*Salix mucronata*) of the fringing forest, but it soon flew off and disappeared into the dense foliage. It was seen from a canoe at a distance of 10 m. The pale mark on its back, the yellowish rings around its eyes, and the yellow legs and feet were conspicuous.

Since the habitat in which this bird was seen, fringing forest comprised chiefly of willows, acacias (*Acacia* spp.) and tamarisks (*Tamarix usneoides*), extends along both banks of the lower Orange River, it is possible that the white-backed night heron has been overlooked in this region of southern South West Africa/Namibia and northern Cape Province. The lack of records of this species may result from its secretive habits and the fact that much of this remote section of the Orange River is not easily accessible to humans.

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SHORT NOTE
Bradfield's swift *Apus bradfieldi* feeding on bees

by

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Received: 22 October 1979

Bradfield's swift ranges through southern Angola, South West Africa and across to Kuruman and Kimberley in the Republic of South Africa. The nominate race occurs in South West Africa and Angola while the southern population is regarded as a separate race *A. b. deserticolus* (Brooke 1970). The species occurs regularly within the Skeleton Coast Park and is known to breed there.

During January 1979 a party of these swifts was observed feeding above reed-beds 3 km inland of the Uchab River Mouth 21°11'S, 13°45'E. Closer observation showed that the birds were catching honey bees *Apis mellifere* in flight near a hive. Up to eight swifts at a time were noted taking bees apparently returning to the hive after foraging flights.

Three points of interest emerge from these observations:

1 McLachlan and Liversidge (1978) state that swifts are unable to perch but rather cling to rough perpendicular surfaces. Following periods of feeding Bradfield's swifts were frequently noted resting on the ground near the hive. Although the birds were confiding and could be closely approached they experienced no difficulty in taking off when disturbed.

2 Observations showed that swifts arrived from up-river and returned eastwards after feeding. A colony of Bradfield's swifts was located some 24 km inland in the Uchab River in late January. Adult birds were seen entering inaccessible crevices in basalt cliffs 30 m above the river-bed. The birds were thought to be feeding nestlings. No other swift colonies were found closer to the Uchab Mouth. It is likely that the birds feeding on bees at the river-mouth undertook a return flight of some 40 km to utilise the food source.

3 While it is well documented that long-billed birds e.g. Meropidae are equipped to deal with venomous insects (Fry 1969) swifts being short-billed and wide-gaped are not. It is unlikely that swifts are able to rid bees of their stings while in flight.

The possibility exists that Bradfield's and other swifts are immune to bee venom. Fry (1969) suggests partial immunity for some bee eaters and cites Koenig (1951) who reported that pulli of *Merops apiaster* were immune to the poison of bees and wasps.

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