A Scanning Electron Microscope Survey of the Epidermis of East African Grasses, II

Patricia G. Palmer
and Alice E. Tucker
ABSTRACT

Palmer, Patricia G., and Alice E. Tucker. A Scanning Electron Microscope Survey of the Epidermis of East African Grasses, II. *Smithsonian Contributions to Botany*, number 53, 72 pages, 52 plates, 1983.—In developing a reference collection as a standard for using fossil grass cuticles as a paleoecological tool, we have examined leaf epidermal features of grasses with SEM. Descriptions are presented of the abaxial and adaxial surfaces of the leaves of 26 East African species, comprising nine tribes of the subfamily Pooideae—Poeae, Bromeeae, Brachypodieae, Triticeae, Meliceae, Aveneae, Phalarideae, Agrostideae, Stipeae.

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A Scanning Electron Microscope Survey of the Epidermis of East African Grasses, II

Patricia G. Palmer and Alice E. Tucker

Introduction

By comparing the anatomical features of fossil grass leaves from East African lake sediments with those of modern-day grasses, it is often possible to identify fossil leaf fragments to the genus (Palmer, 1976). Because of the importance of fossil grasses as paleoecological indicators in tropical Africa, it has been necessary to develop a reference collection of modern grasses as a standard for comparison. For our purposes we have found that examination of the grass leaves with scanning electron microscopy (SEM) is preferable to light microscopy. In an earlier paper, we discussed our system of describing the diagnostic features of grass leaves as viewed with SEM and gave descriptions of 24 East African species representing ten tribes (Palmer and Tucker, 1981). The reader is referred to this earlier paper for discussion of terminology and illustrations of diagnostic features.

This paper represents the second part of a survey of East African grasses and includes 26 genera representing nine tribes of the Pooidae: Poeae, Bromaeae, Brachypodioideae, Triticeae, Meliceae, Aveneae, Phalarideae, Agrostideae, Stipeae. We delimit East Africa to include Uganda, Kenya and Tanzania, the region dealt with in the Flora of Tropical East Africa, Gramineae by Clayton (1970, 1974, in prep.). We also follow the nomenclature of the Flora of Tropical East Africa.

Hartley (1973) has shown that the pooid grasses are found in temperate regions of the world and in the tropics are limited to high altitudes. A recent study by Livingstone and Clayton (1980) indicates that temperature is the most likely environmental factor controlling the importance of pooid genera in the highlands of tropical Africa. Because the occurrence of pooid genera in the fossil record of East Africa will permit paleotemperature estimates (Livingstone and Clayton, 1980), the early inclusion of the tribes treated in this paper is extremely important in our overall survey.

Materials and Methods.—Leaf material for scanning electron microscopy was taken from dried herbarium material. A section from the middle portion of a blade from an upper, mature, undamaged leaf was chosen for study. In a few cases, where the epidermis proved to have a heavy coat of epicuticular wax, the wax was removed by soaking in xylene for 12 to 14 hours. Two pieces of the leaf (one exposing the abaxial or lower surface, the other exposing the adaxial or upper surface) were mounted on stubs with double-coated Scotch tape. The specimens were sputter-coated with gold-palladium, observed with a

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JEOL T20 or a Philips 501 scanning electron microscope and photographed, using Polaroid P/N 665 or P/N 55 film. Occasionally, specimens were examined by energy dispersive X-ray analysis using the EDAX 9100/60 to clarify certain anatomical features. The photomicrographs are deposited in the laboratory of D.A. Livingstone, Department of Zoology, Duke University.

Each specimen was analyzed at the microscope using a standard check sheet of diagnostic features. By comparing the photomicrographs and the check sheets, a complete description of each taxon was compiled. At least one species of each genus was examined, and for some large genera several species were examined to determine intrageneric variability. In some cases more than one specimen of a species was examined to determine intraspecific variability.

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Format for Species Descriptions

Stomata.—Frequency; subsidiary cell shape; distribution; special features.

Interstomatal Cells.—Shape; end walls; outline of walls. Papillae: Number/cell, distribution on each cell, shape, size.

Long Cells.—Shape; outline of walls. Papillae: Number/cell, distribution on each cell, shape, size.

Prickles.—Frequency; location and type.


Silica Bodies.—Location and shape.

Microhairs.—Frequency; number of cells; shape; shape of apex.

Macrohairs.—Frequency; location; nature of base.

Special Features.—Description of unique features not covered in other categories.

 Tribe Poeae

Briza maxima Linnaeus

Plates 1-2

Abaxial

Stomata.—Common; parallel; 2 stomatal bands/intercostal zone, 2 rows/band. Shape of subsidiary cell often unclear because of collapsed cells; veins not obvious (Plate 1b).

Interstomatal Cells.—Rectangular to long, narrow, width uniform to nonuniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 1c).

Long Cells.—Long, narrow, width uniform to nonuniform; nonsinuous. Papillae: None seen (Plate 1a,d,e).

Prickles.—None seen.

Short Cells.—Costal solitary; intercostal not seen. Silica Cells: Costal infrequent; intercostal not seen. Cork Cells: Costal infrequent; intercostal not seen (Plate 1f).

Silica Bodies.—Costal elongated-smooth, elongated-sinuous; intercostal not seen (Plate 1f).

Microhairs.—None seen.

Macrohairs.—None seen.

Adaxial

Stomata.—Common; parallel; 2 stomatal bands/intercostal zone, 2 rows/band (Plate 2a,b).

Interstomatal Cells.—Rectangular to long,
narrow, width nonuniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 2c).

**Long Cells.**—Long, narrow, width nonuniform; nonsinuous. Papillae: None seen (Plate 2d,e).

**Prickles.**—Infrequent; small costal prickles (Plate 2f).

**Short Cells.**—None seen.

**Silica Bodies.**—None seen.

**Microhairs.**—None seen.

**Macrohairs.**—None seen.

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**Colpodium chionogeiton (Pilger) Tzvelev**

**Plates 3–4**

**Abaxial**

Stomata.—Abundant; parallel to sometimes low-dome; 4–6 stomatal bands/intercostal zone, 1 or 2 rows/band (Plate 3a,b).

Interstomatal Cells.—Rectangular to square; ends slightly concave; nonsinuous. Papillae: 1/cell, globose, uniform. Appear to be thin-walled because usually deflated (Plate 3a,b,c).

Long Cells.—Rectangular to long, narrow, width nonuniform; nonsinuous. Papillae: 1/cell, globose, uniform (Plate 3a,c).

Prickles.—Abundant; costal short, papillate-type (Plate 3d).

Short Cells.—Costal solitary, paired; intercostal not seen. Silica Cells: Costal common; intercostal not seen. Cork Cells: Costal common; intercostal not seen (Plate 3e,f).

Silica Bodies.—Costal oblong, square; intercostal not seen (Plate 3e,f).

Microhairs.—None seen.

Macrohairs.—None seen.

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**Dactylis glomerata Linnaeus**

**Plates 5–6**

**Abaxial**

Stomata.—Common; parallel; 2 or 3 stomatal bands/intercostal zone, 2 rows/band (Plate 5a,b).

Interstomatal Cells.—Rectangular to long, narrow, width nonuniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 5a,c).

Long Cells.—Long, narrow, width nonuniform; nonsinuous. Papillae: 1/cell, globose, uniform. Often deflated, probably thin-walled (Plate 4a,c).

Prickles.—Abundant on margin, absent elsewhere; short unpointed with swollen bases. Several rows of cells near margin have large papillate-type prickles (Plate 4f).

Short Cells.—Costal solitary; intercostal not seen. Silica Cells: Costal common; intercostal not seen. Cork Cells: Costal and intercostal not seen (Plate 4d).

Silica Bodies.—Costal oblong, elongated-smooth, square; intercostal not seen (Plate 4d,e).

Microhairs.—None seen.

Macrohairs.—None seen.

---

Stomata.—Abundant; parallel; 4 stomatal bands/intercostal zone, 1 row/band. Bands difficult to detect because of collapsed long cells. Costal regions often indistinct (Plate 4a,b).

Interstomatal Cells.—Rectangular; ends slightly concave or sometimes straight to convex; nonsinuous. Papillae: 1/cell, globose, uniform. Often deflated, probably thin-walled (Plate 4a,c).

Long Cells.—Long, narrow, width nonuniform; nonsinuous. Papillae: 1/cell, globose, uniform. Often deflated, probably thin-walled (Plate 4a,c).

Prickles.—Common to abundant; costal prickles. Size variable (Plate 5d,e).

Short Cells.—Costal 3–5/row; intercostal not seen. Silica Cells: Costal common; intercostal not seen. Cork Cells: Costal common; intercostal not seen. Short cells indistinct because of wax (Plate 5e,f).

Silica Bodies.—Costal oblong, elongated-smooth, elongated-sinuous; intercostal not seen (Plate 5e,f).

Microhairs.—None seen.

Macrohairs.—None seen.
**Adaxial**

**Stomata.**—Infrequent to common; parallel; 2 stomatal bands/intercostal zone, 1–3 rows/band. Cells collapsed and shape difficult to ascertain (Plate 6b).

**Interstomatal Cells.**—Long, narrow, width nonuniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 6c).

**Long Cells.**—Long, narrow, width nonuniform; nonsinuous. Papillae: None seen (Plate 6a,c).

**Prickles.**—Common; costal prickles. Size variable (Plate 6c,d).

**Silica Cells:**—Costal infrequent to common; intercostal not seen. Cork Cells: Costal infrequent to common; intercostal not seen. Cells often obscured by wax (Plate 6e,f).

**Silica Bodies:**—Costal elongated-sinuous, nodular; intercostal not seen (Plate 6e,f).

**Microhairs.**—None seen.

**Macrohairs.**—None seen.

**Festuca abyssinica** A. Richard

*Plates 7–8*

**Abaxial**

**Stomata.**—None seen.

**Long Cells.**—Long, narrow, width uniform; markedly sinuous, interlocking raised. Papillae: None seen (Plate 7a,c).

**Prickles.**—Infrequent to common; costal and intercostal prickles (Plate 7b,c).

**Short Cells.**—Costal and intercostal paired. Silica Cells: Costal and intercostal abundant. Cork Cells: Costal and intercostal abundant. Covered by reticulated wax (Plate 7e,f).

**Silica Bodies.**—Costal and intercostal elliptical or sometimes round, crescent-shaped (Plate 7e,f).

**Microhairs.**—None seen.

**Macrohairs.**—None seen.

**Lolium temulentum** Linnaeus

*Plates 9–10*

**Abaxial**

**Stomata.**—None seen.

**Long Cells.**—Long, narrow, width uniform to nonuniform; nonsinuous. Occasionally, marginal cells have indistinctly sinuous outlines. Papillae: None seen (Plate 9a).

**Prickles.**—Infrequent; costal prickles. Primarily in marginal areas (Plate 9b,c).

**Short Cells.**—Costal solitary; intercostal not seen. Silica Cells: Costal infrequent; intercostal not seen. Cork Cells: Costal and intercostal not seen. Silica cells found only in marginal areas and on mid-vein (Plate 9d–f).

**Silica Bodies.**—Costal elongated-sinuous, round; intercostal not seen (Plate 9e,f).
Microhairs.—None seen.
Macrohairs.—None seen.

Adaxial

Stomata.—Abundant; parallel; 2 stomatal bands/intercostal zone, 2 rows/band (Plate 10a–c).
Interstomatal Cells.—Rectangular to long, narrow, width nonuniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 10c).
Long Cells.—Long, narrow, width nonuniform; nonsinuous. Papillae: None seen (Plate 10a,c).
Prickles.—Abundant; costal and occasionally intercostal prickles (Plate 10d,e).
Short Cells.—Costal solitary; intercostal not seen. Silica Cells: Costal common; intercostal not seen. Cork Cells: Costal and intercostal not seen (Plate 10f).
Silica Bodies.—Costal elongated-smooth, elongated-sinuous; intercostal not seen (Plate 10f).
Microhairs.—None seen.
Macrohairs.—None seen.

Poa schimperana A. Richard

Plates 11–12

Abaxial

Stomata.—None seen.
Long Cells.—Long, narrow, width uniform to nonuniform; nonsinuous. Papillae: None seen (Plate 11a–c).
Prickles.—Infrequent; costal prickles (Plate 11d).
Short Cells.—Costal solitary; intercostal not seen. Silica Cells: Costal common; intercostal not seen. Cork Cells: Costal and intercostal not seen (Plate 11e,f).
Silica Bodies.—Costal elongated-sinuous; intercostal not seen. Occasionally very long (Plate 11e,f).
Microhairs.—None seen.
Macrohairs.—None seen.

Adaxial

Stomata.—Abundant; parallel; 2 stomatal bands/intercostal zone, 2 rows/band (Plate 12a–c).
Interstomatal Cells.—Rectangular to long, narrow, width nonuniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 12c).
Long Cells.—Long, narrow, width nonuniform; nonsinuous. Papillae: None seen (Plate 12a,c).
Prickles.—Common; costal and occasionally intercostal prickles (Plate 12d,e).
Short Cells.—Costal solitary or sometimes paired; intercostal not seen. Silica Cells: Costal infrequent; intercostal not seen. Cork Cells: Costal and intercostal not seen (Plate 12f).
Silica Bodies.—Costal elongated-sinuous; intercostal not seen (Plate 12f).
Microhairs.—None seen.
Macrohairs.—None seen.

Pseudobromus sylvaticus Schumann

Plates 13–14

Abaxial

Stomata.—Infrequent; parallel to occasionally low-dome; 2 stomatal bands/intercostal zone, 1 row/band. Distribution difficult to determine because stomata not very numerous (Plate 13b).
Interstomatal Cells.—Long, narrow, width uniform to nonuniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 13b).
Long Cells.—Long, narrow, width nonuniform or occasionally uniform; nonsinuous. Papillae: None seen (Plate 13a,c).
Prickles.—Abundant to common; costal prickles. Abundant on margin and on two veins nearest margin but common on other veins (Plate 13a,d).
Short Cells.—Costal solitary, paired, 3–5/row; intercostal not seen. Silica Cells: Costal common; intercostal not seen. Cork Cells: Costal infrequent; intercostal not seen (Plate 13e,f).
Silica Bodies.—Costal oblong, elongated-
smooth or occasionally elongated-sinuous; intercostal not seen (Plate 13e,f).
  Microhairs.—None seen.
  Macrohairs.—None seen.

Adaxial

Stomata.—Common to abundant; parallel; 2 stomatal bands/intercostal zone, 3 rows/band. Bands adjacent to veins (Plate 14a-c).
  Interstomatal Cells.—Long, narrow, width uniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 14c).
  Long Cells.—Rectangular to long, narrow, width uniform; nonsinuous. Papillae: None seen (Plate 14d).
  Prickles.—Common; costal prickles. Basal portion of prickles very long (Plate 14c,e,f).
  Short Cells.—Costal solitary; intercostal not seen. Silica Cells: Costal infrequent; intercostal not seen. Cork Cells: Costal and intercostal not seen (Plate 14f).
  Silica Bodies:—Costal elongated-smooth; intercostal not seen (Plate 14f).
  Microhairs.—None seen.
  Macrohairs.—None seen.

Vulpia bromoides (Linnaeus) S.F. Gray

Plates 15-16

Abaxial

Stomata.—None seen.
  Long Cells.—Long, narrow, width uniform; markedly sinuous, interlocking, raised. Papillae: None seen (Plate 15b).
  Prickles.—Infrequent; costal prickles (Plate 15c).
  Short Cells.—Costal paired; intercostal paired or rarely 3–5/row. Silica Cells: Costal common; intercostal abundant. Cork Cells: Costal common; intercostal abundant (Plate 15d–f).
  Silica Bodies.—Costal and intercostal crescent-shaped or sometimes tall and narrow, round (Plate 15d–f).
  Microhairs.—None seen.
  Macrohairs.—None seen.
  Special Features.—Veins very prominent (Plate 15a).

Tribe Bromeeae

Bromus leptoclados Nees

Plates 17-18

Abaxial

Stomata.—None seen.
  Long Cells.—Long, narrow, width nonuniform; nonsinuous. Papillae: None seen (Plate 17a,b).
  Prickles.—Abundant; costal prickles (Plate 17c).
  Short Cells.—Costal solitary, paired, 3–5/
row; intercostal solitary. **Silica Cells:** Costal abundant; intercostal infrequent (only one seen). **Cork Cells:** Costal abundant; intercostal not seen (Plate 17a, d, e).

**Silica Bodies:**—Costal and intercostal oblong, midhorizontal ridge sometimes present (Plate 17a, d, e).

**Microhairs:**—None seen.

**Macrohairs:**—Abundant; intercostal; basal cells absent (Plate 17f).

### Adaxial

**Stomata:**—Abundant; parallel to low-dome; 4 stomatal bands/intercostal zone, 1 row/band. Intercostal zones wide and veins indistinct (Plate 18a, b).

**Interstomatal Cells:**—Rectangular to long, narrow, width nonuniform; ends straight to convex; nonsinuous. **Papillae:** None seen (Plate 18c).

**Long Cells:**—Long, narrow, width nonuniform; nonsinuous. **Papillae:** None seen (Plate 18a, c, e).

**Prickles:**—Infrequent; costal prickles primarily in marginal area (Plate 18d).

**Short Cells:**—Costal solitary; intercostal not seen. **Silica Cells:** Costal infrequent; intercostal not seen. **Cork Cells:** Costal and intercostal not seen (Plate 18e).

**Silica Bodies:**—Costal elongated-smooth, often with a midhorizontal ridge; intercostal not seen (Plate 18e).

**Microhairs:**—None seen.

**Macrohairs:**—Common; costal; basal cells absent (Plate 18a, f).

### Tribe Brachypodieae

**Brachypodium flexum** Nees

**Plates** 19–20

### Abaxial

**Stomata:**—None seen.

**Long Cells:**—Long, narrow, width uniform; markedly sinuous, interlocking, raised. **Papillae:** None to 1/cell. Many long cells appear to have a raised area (papilla?) near the middle of cell opposite a silica body in an adjacent row of cells (Plate 19b, e).

**Prickles:**—Infrequent to common; costal and occasionally intercostal on the sides of the veins. Veins indistinct (Plate 19a, d).

**Short Cells:**—Costal and intercostal solitary and paired. **Silica Cells:** Costal and intercostal common. **Cork Cells:** Costal and intercostal common (Plate 19e, f).

**Silica Bodies:**—Costal and intercostal round or sometimes elliptical (Plate 19e, f).

**Microhairs:**—None seen.

**Macrohairs:**—None seen.

### Adaxial

**Stomata:**—Common; parallel; 2 stomatal bands/intercostal zone, 3 rows/band. Very collapsed and difficult to ascertain (Plate 20b).

**Interstomatal Cells:**—Rectangular to long, narrow, width nonuniform; ends straight to convex; nonsinuous. **Papillae:** None seen. Cells collapsed and shape not always obvious (Plate 20b).

**Long Cells:**—Pentagonal, hexagonal or occasionally rectangular or long, narrow, width nonuniform; nonsinuous. **Papillae:** None seen. Cells collapsed and shape not always obvious (Plate 20a, c).

**Prickles:**—Common; costal prickles, intercostal short macrohair type or occasionally hooks (Plate 20c).

**Short Cells:**—Costal and intercostal solitary. **Silica Cells:** Costal and intercostal infrequent to common. **Cork Cells:** None seen (Plate 20d, e).

**Silica Bodies:**—Costal tall and narrow or sometimes oblong, acutely angled, square; intercostal tall and narrow or sometimes acutely angled (Plate 20d, e).

**Microhairs:**—None seen.

**Macrohairs:**—Common; costal and sometimes intercostal; raised basal cells absent (Plate 20f).
Tribe TRITICEAE

_Hordeum marinum_ Hudson

_Plates 21–22_

**ABAXIAL**

Stomata.—Infrequent to common; parallel; 3 stomatal bands/intercostal zone, 1 row/band (Plate 21a,b).

Interstomatal Cells.—Rectangular; straight to convex; nonsinuous. Papillae: None seen. Shape and outline of walls difficult to determine because of collapsed cells and numerous prickles (Plate 21c).

Long Cells.—Long, narrow, width uniform to nonuniform; nonsinuous. Papillae: None seen. Cells usually collapsed and shape difficult to determine (Plate 21c).

Prickles.—Abundant; costal and intercostal short macrohair-type prickles. Prickles quite variable in length from regular macrohair length to mainly short macrohair type (Plate 21d,e).

Short Cells.—Costal and intercostal solitary. Silica Cells: Costal infrequent to common; intercostal infrequent. Cork Cells: Costal and intercostal absent (Plate 21e,f).

Silica Bodies.—Costal elongated-smooth; intercostal round (Plate 21e,f).

Microhairs.—None seen.

Macrohairs.—Common; costal and intercostal; basal cells absent (See Prickles) (Plate 22a).

**Secale africanum** Stapf

_Plates 23–24_

**ABAXIAL**

Stomata.—Infrequent to common; parallel; 2 stomatal bands/intercostal zone, 1 row/band. Stomata slightly sunken adjacent to veins and somewhat obscured by veins and macrohairs (Plate 23a–c).

Interstomatal Cells.—Long, narrow, width uniform; end straight to convex; walls nonsinuous. Papillae: None seen (Plate 23c).

Long Cells.—Long, narrow, width uniform; nonsinuous. Papillae: None seen (Plate 23c).

Prickles.—None seen.

Short Cells.—Costal solitary, paired, 3–5/row; intercostal not seen. Silica Cells: Costal infrequent to common; intercostal not seen. Cork Cells: Costal infrequent to common; intercostal not seen (Plate 23d–f).

Silica Bodies.—Costal round, oblong, elongated-sinuous; intercostal not seen (Plate 23d–f).

Microhairs.—None seen.

Macrohairs.—Abundant; intercostal and costal; raised basal cells absent. Most macrohairs are the short macrohair type (Plate 21d,e).

**ADAXIAL**

Stomata.—Common; parallel to low-dome; 2 stomatal bands/intercostal zone; 1–2 rows/band. Pattern difficult to ascertain; interstomatal areas narrow; subsidiary cells collapsed (Plate 22a–c).

Interstomatal Cells.—Rectangular; ends straight to convex; nonsinuous. Papillae: None seen. Shape difficult to determine because of folding (Plate 22c).

Long Cells.—Long, narrow, width uniform to nonuniform; nonsinuous. Papillae: None seen.

Shape and outline difficult to determine because of wax and folding (Plate 22a,c).

Prickles.—Abundant; costal and intercostal straight, short macrohair type. Variable in length and many long enough to be classified as macrohairs (See Macrohairs) (Plate 22a,d,e).

Short Cells.—Costal solitary, paired (?); intercostal not seen. Silica Cells: Costal common; intercostal not seen. Cork Cells: Costal infrequent; intercostal not seen (Plate 22d–f).

Silica Bodies.—Costal oblong, elongated-smooth, square; intercostal not seen. Some are very elongated (Plate 22d–f).

Microhairs.—None seen.

Macrohairs.—Common; costal and intercostal; basal cells absent (See Prickles) (Plate 22a).
**Adaxial**

**Stomata.**—Infrequent to common; parallel to low-dome; 2 stomatal bands/intercostal zone, 1 or 2 rows/band. Stomata slightly sunken adjacent to veins and somewhat obscured by veins and macrohairs (Plate 24b,c).

**Interstomatal Cells.**—Square, rectangular, long, narrow, width uniform; ends straight to convex; nonsinuous. *Papillae:* None seen (Plate 24c).

**Long Cells.**—Pentagonal to long, narrow, width uniform; nonsinuous. *Papillae:* None seen (Plate 24a,c,e).

**Papillae:** None seen.

**Short Cells.**—Costal solitary; intercostal not seen. *Silica Cells:* Costal infrequent; intercostal not seen. *Cork Cells:* Costal and intercostal not seen (Plate 24d).

**Silica Bodies.**—Costal oblong; intercostal not seen (Plate 24d).

**Microhairs.**—None seen.

**Macrohairs.**—Abundant; intercostal and costal; raised epidermal cells absent. Macrohairs vary in length (Plate 24a,e,f).

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**Triticum aestivum** Linnaeus

*Plates 25-26*

**Abaxial**

**Stomata.**—Common; low-dome; 2(?). stomatal bands/intercostal zone, 1 row/band. Veins broad and indistinct, distribution not clear (Plate 25a,b).

**Interstomatal Cells.**—Square, rectangular, long, narrow, width uniform; ends straight to convex; nonsinuous. *Papillae:* None seen (Plate 25c).

**Long Cells.**—Long, narrow, width uniform to nonuniform; nonsinuous. *Papillae:* None seen (Plate 25a,d).

**Papillae:** None seen.

**Papillae:** None seen.

**Short Cells.**—Costal solitary, paired(?). *Silica Cells:* Costal infrequent to common; intercostal not seen. *Cork Cells:* Costal infrequent to common(?); intercostal not seen. Cork cells indistinct; some suggest a silica cell paired with a cork cell (Plate 25e,f).

**Silica Bodies.**—Oblong, or sometimes elongated-sinuous (Plate 25e,f).

**Microhairs.**—None seen.

**Macrohairs.**—None seen.

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**Tribe MELICÆAE**

**Streblochaete longiarista** (A. Richard) Pilger

*Plates 27-28*

**Abaxial**

**Stomata.**—Infrequent; parallel to low-dome; distribution indeterminable because stomata too infrequent (Plate 27b).

**Long Cells.**—Long, narrow, width uniform; markedly sinuous, interlocking, raised. *Papillae:* None seen (Plate 27a,c).

**Papillae:** Common; costal and occasionally intercostal prickles (Plate 27a,d).
Short Cells.—Costal and intercostal solitary. Silica Cells: Costal infrequent to common; intercostal not seen (Plate 27e,f).
Silica Bodies.—Costal oblong, elongated-sinuous; intercostal square (Plate 27e,f).
Microhairs.—None seen.
Macrohairs.—None seen.

Adaxial

Stomata.—Common; parallel to low-dome; 2 stomatal bands/intercostal zone, 2 rows/band (Plate 28a,b).
Interstomatal Cells.—Rectangular or sometimes square or long, narrow, width uniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 28b,c).
Long Cells.—Pentagonal to long, narrow, width nonuniform; nonsinuous. Papillae: None seen (Plate 28a,c,e).
Prickles.—Abundant; costal prickles and short, straight, macrohair type; intercostal hooks and short, straight, macrohair type. Some of the short macrohair type have sunken bases (Plate 28d–f).
Short Cells.—Costal solitary; intercostal not seen. Silica Cells: Costal common; intercostal not seen. Cork Cells: Costal and intercostal not seen (Plate 28d).
Silica Bodies.—Costal oblong, elongated-smooth, square; intercostal not seen (Plate 28d).
Microhairs.—None seen.
Macrohairs.—None seen.

Tribe Aveneae

Aira caryophyllea Linnaeus

Plates 29–30

Abaxial

Stomata.—Abundant; parallel; 1 stomatal band/intercostal zone, 3 or 4 rows/band. Inter-costal areas very narrow. Veins prominent and numerous. Shape of subsidiary cell difficult to ascertain because of collapsed cells (Plate 29a,b).
Interstomatal Cells.—Rectangular to occasionally long, narrow, width uniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 29c).
Long Cells.—Long, narrow, width uniform; nonsinuous. Papillae: None seen (Plate 29c, d).
Prickles.—Abundant; costal prickles and short macrohair-type prickles (Plate 29d).
Short Cells.—Costal solitary; intercostal not seen. Silica Cells: Costal common; intercostal not seen. Cork Cells: Costal and intercostal not seen (Plate 29d–f).
Silica Bodies.—Costal elongated-sinuous to occasionally elongated-smooth, square; intercostal not seen (Plate 29e,f).
Microhairs.—None seen.
Macrohairs.—See section on Prickles.

Adaxial

Stomata.—Common; parallel; 1 stomatal band/intercostal zone, 3 or sometimes 1 row/band. Costal areas very prominent, intercostal very narrow (Plate 30a,b).
Interstomatal Cells.—Rectangular to long, narrow, width uniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 30c).
Long Cells.—Long, narrow, width uniform to occasionally nonuniform; nonsinuous. Papillae: None seen (Plate 30a,c,e).
Prickles.—Abundant; costal prickles and occasional hooks (Plate 30d).
Short Cells.—Costal solitary, paired, 3–5/row; intercostal not seen. Silica Cells: Costal abundant; intercostal not seen. Cork Cells: Costal common; intercostal not seen (Plate 30e,f).
Silica Bodies.—Costal nodular or sometimes elongated-sinuous, square; intercostal not seen (Plate 30e,f).
Microhairs.—None seen.
Macrohairs.—None seen.
**Anthoxanthum nivale K. Schumann**  
Plates 31-32  

**Abaxial**

Stomata.—Infrequent to common; parallel; 2 stomatal bands/intercostal zone, 2 rows/band (Plate 31a).

Interstomatal Cells.—Long, narrow, width uniform (often appearing nonuniform because of collapsed cells); ends straight to convex; nonsinuous. Papillae: None seen (Plate 31b).

Long Cells.—Long, narrow, width uniform to nonuniform; nonsinuous. Papillae: None seen (Plate 31c,d).

Prickles.—Infrequent; costal prickles (Plate 31e).

Short Cells.—Costal solitary; intercostal not seen. Silica Cells: Costal abundant; intercostal not seen. Cork Cells: Costal abundant; intercostal not seen (Plate 31f).

Silica Bodies.—Costal elongated-smooth; intercostal not seen (Plate 31f).

Microhairs.—None seen.

Macrohairs.—None seen.

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**Avena abyssinica Hochstetter**  
Plates 33-34  

**Abaxial**

Stomata.—Common; parallel to low-dome; 2 stomatal bands/intercostal zone, 1-3 rows/band. Stomatal bands adjacent to veins (Plate 33a-c).

Interstomatal Cells.—Long, narrow, width uniform to nonuniform (perhaps an artifact of folding); ends straight to convex; nonsinuous. Papillae: None seen (Plate 33a).

Long Cells.—Long, narrow, width uniform to nonuniform (perhaps an artifact of folding); nonsinuous to slightly sinuous (marginal area). Papillae: None seen (Plate 33a).

Prickles.—Common; costal prickles (Plate 33c).

Short Cells.—Costal paired, 3-5/row; intercostal not seen. Silica Cells: Costal abundant; intercostal not seen. Cork Cells: Costal abundant; intercostal not seen (Plate 33d).

Silica Bodies.—Costal elongated-sinuous; intercostal not seen (Plate 33d).

Microhairs.—None seen.

Macrohairs.—Infrequent to common; intercostal; basal cells absent. Primarily adjacent to midvein (Plate 33e,f).

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**Adaxial**

Stomata.—Common; parallel; 2 stomatal bands/intercostal zone, 1-3 rows/band (Plate 34b).

Interstomatal Cells.—Long, narrow, width uniform to nonuniform; nonsinuous. Papillae: None seen (Plate 34a,d).

Long Cells.—Long, narrow, width uniform to nonuniform; nonsinuous. Papillae: None seen (Plate 34a,d).

Prickles.—Common; costal and intercostal prickles. Intercostal infrequent (Plate 34c).

Short Cells.—Costal solitary, paired, 3-5/row; intercostal not seen. Silica Cells: Costal abundant; intercostal not seen. Cork Cells: Costal abundant; intercostal not seen (Plate 34a,d).

Silica Bodies.—Costal elongated-sinuous; intercostal not seen (Plate 34a,d).

Microhairs.—None seen.

Macrohairs.—Common; costal; basal cells absent (Plate 34e,f).
Deschampsia caespitosa (Linnaeus) Beauvois var. oliveri Hubbard

Plates 35-36

**ABAXIAL**

**STOMATA.**—None seen.

**LONG CELLS.**—Long, narrow, width uniform; markedly sinuous, interlocking, raised. **Papillae:** None seen (Plate 35b).

**PRICKLES.**—Abundant; costal and intercostal prickles. Extremely abundant and uniformly distributed (Plate 35a,c,d).

**SHORT CELLS.**—Costal and intercostal solitary and paired. **Silica Cells:** Costal and intercostal abundant. **Cork Cells:** Costal and intercostal abundant (Plate 35c,ef).

**SILICA BODIES.**—Costal and intercostal elliptical to round (Plate 35c,ef).

**MICROHAIRS.**—None seen.

**MACROHAIRS.**—None seen.

**SPECIAL FEATURES.**—Regular raised areas that appear to be veins, but epidermis in these costal zones and in the intercostal regions uniform (Plate 35a).

**ADAXIAL**

**STOMATA.**—Common; low-dome; 2 stomatal bands/intercostal zone, ca. 15 row/band. Inter-
costal zones very wide (Plate 36a,b).

**INTERSTOMATAL CELLS.**—Long, narrow, width uniform; ends straight to convex; markedly sin-
uous, interlocking, raised. **Papillae:** None seen (Plate 36a).

**LONG CELLS.**—Long, narrow, width uniform; markedly sinuous, interlocking raised. **Papillae:** None seen. In the center of each intercostal zone a narrow belt (2 or 3 cells wide) of waxy, nonsinuous long cells. On each side of the narrow belt a region containing markedly sinuous long cells (Plate 36c).

**PRICKLES.**—Common; costal prickles. Only along top of veins; usually a double row of mainly large but a few small ones on the side (Plate 36d,e).

**SHORT CELLS.**—Costal solitary or sometimes paired; intercostal solitary. **Silica Cells:** Costal and intercostal common. **Cork Cells:** Costal infrequent; intercostal not seen (Plate 36d,f).

**SILICA BODIES.**—Costal and intercostal elliptical, round (Plate 36f).

**MICROHAIRS.**—None seen.

**MACROHAIRS.**—None seen.

**Helictotrichon elongatum** (Hochstetter) Hubbard

Plates 37-38

**ABAXIAL**

**STOMATA.**—Common; parallel to low-dome; 2 stomatal bands/intercostal zone, 1 or 2 rows/band (Plate 37a,b).

**INTERSTOMATAL CELLS.**—Long, narrow, width uniform to nonuniform; ends straight to convex; nonsinuous. **Papillae:** None seen (Plate 37a).

**LONG CELLS.**—Long, narrow, width uniform to nonuniform; nonsinuous. **Papillae:** None seen (Plate 37a,c).

**PRICKLES.**—Common; costal prickles (on sides of veins) (Plate 37d).

**SHORT CELLS.**—Costal solitary, paired, 3-5/row; intercostal not seen. **Silica Cells:** Costal common; intercostal not seen. **Cork Cells:** Costal infrequent to common; intercostal not seen (Plate 37e,f).

**SILICA BODIES.**—Costal elongated-sinuous; intercostal not seen (Plate 37e,f).

**MICROHAIRS.**—None seen.

**MACROHAIRS.**—None seen.

**ADAXIAL**

**STOMATA.**—Common; parallel to low-dome; 2 stomatal bands/intercostal zone, 1-3 rows/band. Bands adjacent to veins (Plate 38b,c).

**INTERSTOMATAL CELLS.**—Long, narrow, width uniform to nonuniform; ends straight to convex; nonsinuous. **Papillae:** None seen (Plate 38c).

**LONG CELLS.**—Long, narrow, width uniform to
nonuniform; nonsinuous. Papillae: None seen (Plate 38a,d).

Prickles.—Common; costal prickles (Plate 38e).

Short Cells.—Costal solitary, paired, 3–5/row; intercostal not seen. Silica Cells: Costal common; intercostal not seen. Silica cells frequently solitary, alternating with prickles. Cork Cells: Costal infrequent to common; intercostal not seen (Plate 38e).

Silica Bodies.—Costal elongated-sinuous (many very long); intercostal not seen (Plate 38e).

Microhairs.—None seen.

Macrohairs.—None seen.

Koeleria capensis (Steudel) Nees

Plates 39–40

Abaxial

Stomata.—Common; low-dome; 2 stomatal bands/intercostal zone, 3 rows/band. Stomata are small, often collapsed, and difficult to observe in narrow intercostal zones sunken between large veins (Plate 39a,b).

Interstomatal Cells.—Probably long, narrow. Shape and nature of walls not discernible because of collapsed cells. Papillae: None seen.

Long Cells.—Long, narrow, width uniform; nonsinuous. Papillae: None seen (Plate 39c).

Prickles.—Abundant; costal prickles and short macrohairs (Plate 39c).

Short Cells.—Costal solitary, rarely paired; intercostal not seen. Silica Cells: Costal abundant; intercostal not seen. Cork Cells: Costal and intercostal not seen (Plate 39c).

Silica Bodies.—Costal oblong, elongated-smooth, and square; intercostal not seen (Plate 39e).

Microhairs.—None seen.

Macrohairs.—Common; costal; basal cells absent (Plate 39b,d,f).

Adaxial

Stomata.—None seen.

Long Cells.—Long, narrow, width uniform; nonsinuous. Papillae: None seen (Plate 40b,c).

Prickles.—Abundant; costal prickles and short macrohairs (Plate 40a–c).

Short Cells.—Costal paired, rarely solitary or 3–5/row; intercostal not seen. Silica Cells: Costal abundant; intercostal not seen. Cork Cells: Costal abundant; intercostal not seen (Plate 40c–e).

Silica Bodies.—Costal oblong, elongated-smooth, and square; intercostal not seen (Plate 40c–e).

Microhairs.—None seen.

Macrohairs.—Common; intercostal; basal cells absent. Collapsed macrohairs are twisted (Plate 40a,c,f).

Special Features.—Surface ridged because of wide, raised costal zones and narrow, sunken intercostal zones (Plate 40a,c).

Tribe Phalarideae

Phalaris arundinacea Linnaeus

Plates 41–42

Abaxial

Stomata.—Abundant; parallel or sometimes low-dome; 2 stomatal bands/intercostal zone, 4 rows/band (Plate 41a–c).

Interstomatal Cells.—Rectangular to long, narrow, width uniform; ends straight to convex; nonsinuous. Papillae: None seen. Cell slightly raised (Plate 41c).

Long Cells.—Long, narrow, width uniform; nonsinuous. Papillae: None seen (Plate 41a,b,e).

Prickles.—Common; costal prickles and intercostal hooks (Plate 41a,d).

Short Cells.—Costal 3–5/row, 5/row, or sometimes paired; intercostal solitary, paired. Silica Cells: Costal common to abundant; intercostal common. Cork Cells: Costal common to abundant; intercostal infrequent (Plate 41d–f).
Silica Bodies.—Costal square; intercostal square, round, crescent-shaped (Plate 41d–f).
Microhairs.—None seen.
Macrohairs.—None seen.

Adaxial

Stomata.—Abundant; parallel to low-dome; 1 stomatal band/intercostal zone, 1 or sometimes 2 rows/band. Wax somewhat obscures the shape (Plate 42a,b).
Interstomatal Cells.—Rectangular to long, narrow, width uniform; ends straight to convex; nonsinuous. Papillae: None seen. Cell slightly raised (Plate 42c).
Long Cells.—Rectangular to long, narrow, width uniform; nonsinuous. Papillae: None seen. Veins numerous; long cells more collapsed in narrow intercostal regions (Plate 43a,c).
Prickles.—Abundant; costal prickles. Many prickles rather long and thin (Plate 44a,e).
Silica Bodies.—Costal nodular; intercostal not seen. Silica bodies very long, often indistinct (Plate 44d,f).
Microhairs.—None seen.
Macrohairs.—None seen.
Special Features.—Specimen very waxy.

Tribe Agrostideae

Agrostis schimperiana Hochstetter

Plates 43–44

Abaxial

Stomata.—Infrequent; parallel; 2 stomatal bands/intercostal zone, 1 row/band. Cells collapsed; intercostal zones very narrow; distribution not obvious (Plate 43b).
Interstomatal Cells.—Long, narrow, width nonuniform; ends straight to convex; nonsinuous. Papillae: None seen (Plate 43b).

Calamagrostis epigeios (Linnaeus) Roth

var. capensis Stapf

Plates 45–46

Abaxial

Stomata.—Common; parallel to low-dome; 1 stomatal band/intercostal zone, 1–3 rows/band (Plate 45a,b,c).
**Interstomatal Cells.**—Rectangular to long, narrow, width uniform; ends straight to convex or slightly concave; nonsinuous. *Papillae:* None seen (Plate 45c).

**Long Cells.**—Long, narrow, width uniform; nonsinuous. *Papillae:* Cells adjacent to stoma have 1 papilla/cell; all other cells have none (Plate 45b).

**Prickles.**—Common; costal prickles (Plate 45d).

**Short Cells.**—Costal solitary, 3–5/row, >5/row; intercostal solitary. *Silica Cells:* Costal infrequent to common; intercostal not seen. *Cork Cells:* Costal infrequent to common; intercostal common (Plate 45ef).

**Silica Bodies.**—Costal dumbbell with ends straight, middle wide and short, occasionally oblong or nodular; intercostal not seen (Plate 45e).

**Microhairs.**—None seen.

**Macrohairs.**—None seen.

**Adaxial**

**Stomata.**—Abundant; parallel to low-dome; 2 stomatal bands/intercostal zone, 3–4 rows/band (Plate 46b).

**Interstomatal Cells.**—Rectangular to square; ends straight to convex; nonsinuous. *Papillae:* None seen (Plate 46c).

**Long Cells.**—Long, narrow, width uniform; nonsinuous. *Papillae:* Occasionally cells adjacent to stoma have raised area; all other cells have none. Midintercostal area of raised long cells with no distinct boundaries, i.e., appears to be one enormous cell (Plate 46a,d).

**Prickles.**—Infrequent to common; costal and intercostal prickles, intercostal hooks. Interstomal larger and more frequent than costal prickles (Plate 46e).

**Short Cells.**—Costal >5/row; intercostal solitary. *Silica Cells:* Costal abundant; intercostal not seen. *Cork Cells:* Costal abundant; intercostal common. Short cells are waxy (Plate 46f).

**Silica Bodies.**—Costal dumbbell with ends straight, middle wide and short; intercostal not seen (Plate 46f).

**Microhairs.**—None seen.

**Macrohairs.**—None seen.

**Gastridium phleoides** (Nees and Meyen) Hubbard

**Plates 47–48**

**Abaxial**

**Stomata.**—Common; parallel; 2 stomatal bands/intercostal zone, 1 row/band. Intercostal zones very narrow and sunken (Plate 47a,b).

**Interstomatal Cells.**—Rectangular to long, narrow, width uniform; ends straight to convex; nonsinuous. *Papillae:* None seen (Plate 47c).

**Long Cells.**—Long, narrow, width uniform; nonsinuous. *Papillae:* None seen (Plate 47a,c).

**Prickles.**—Abundant; costal prickles, intercostal prickles and hooks (Plate 47d,e).

**Short Cells.**—Costal solitary or sometimes paired, 3–5/row; intercostal paired. *Silica Cells:* Costal common; intercostal infrequent. *Cork Cells:* Costal infrequent to common; intercostal infrequent (Plate 47c–f).

**Silica Bodies.**—Costal nodular, sometimes very short; intercostal not seen (Plate 47c–f).

**Microhairs.**—None seen.

**Macrohairs.**—None seen.

**Adaxial**

**Stomata.**—Common; parallel to low-dome; 2 stomatal bands/intercostal zone, 1 row/band (Plate 48a,b).

**Interstomatal Cells.**—Rectangular to long, narrow, width uniform or sometimes nonuniform; ends straight to convex; nonsinuous. *Papillae:* None seen (Plate 48c).

**Long Cells.**—Long, narrow, width uniform to nonuniform; nonsinuous. *Papillae:* None seen (Plate 48c).

**Prickles.**—Abundant; costal prickles; intercostal prickles and hooks (Plate 48c,d).

**Short Cells.**—Costal solitary and occasionally paired; intercostal not seen. *Silica Cells:* Costal
common; intercostal not seen. **Cork Cells:** Costal and intercostal not seen. The occasional pairs appear to be two silica cells (Plate 48e,f).

**Silica Bodies:**—Costal nodular; intercostal not seen (Plate 48e,f).

**Microhairs:**—None seen.

**Macrohairs:**—None seen.

Polypogon monspeliensis (Linnaeus) Desfontaines

Plates 49-50

**Abaxial**

**Stomata:**—Abundant; parallel to occasionally low-dome; 1 stomatal band/intercostal zone, 1 or 2 rows/band. Difficult to distinguish costal and intercostal zones (Plate 49b,c).

**Interstomatal Cells:**—Long, narrow, width nonuniform to occasionally rectangular or square; ends straight to convex; nonsinuous. **Papillae:** None seen (Plate 49c).

**Long Cells:**—Long, narrow, width nonuniform; nonsinuous. **Papillae:** None seen (Plate 50a,c).

**Prickles:**—Abundant; costal prickles and short, straight, macrohair-like prickles (Plate 50d,f).

**Short Cells:**—Costal solitary, 3–5/row; intercostal not seen. **Silica Cells:** Costal common; intercostal not seen. **Cork Cells:** Costal common; intercostal not seen (Plate 50e,f).

**Silica Bodies:**—Costal elongated-sinuous; intercostal not seen. Some very long (Plate 50e,f).

**Microhairs:**—None seen.

**Macrohairs:**—See section on Prickles.

Tribe Stipeae

Stipa dregeana Steudel

Plates 51-52

**Abaxial**

**Stomata:**—Common; parallel to low-dome; 2 stomatal bands/intercostal zone, 1 row/band (Plate 51a,b).

**Interstomatal Cells:**—Long, narrow, width uniform; ends straight to convex or slightly concave; markedly sinuous, interlocking, raised. **Papillae:** None seen (Plate 51c).

**Long Cells:**—Long, narrow, width uniform; markedly sinuous, interlocking, raised. **Papillae:** None seen (Plate 51a,e).

**Prickles:**—Infrequent; costal prickles (Plate 51d).

**Short Cells:**—Costal 3–5 row, >5/row; intercostal solitary. **Silica Cells:** Costal abundant; intercostal common. **Cork Cells:** Costal abundant; intercostal not seen (Plate 51c,e,f).

**Silica Bodies:**—Costal dumbbell, ends rounded (with small terminal lobe), middle wide, long or short; intercostal elliptical (Plate 51c,e,f).

**Microhairs:**—None seen.

**Macrohairs:**—None seen.
Adaxial

Stomata.—Abundant; parallel to low-dome; 1-3 stomatal bands/intercostal zone, 1-4 (?) rows/band. Costal regions hard to distinguish (Plate 52a–c).

Interstomatal Cells.—Rectangular to long, narrow, width uniform, ends straight to convex to slightly concave; markedly sinuous, interlocking, raised. Papillae: None seen (Plate 52c).

Long Cells.—Long, narrow, width uniform; markedly sinuous, interlocking, raised. Papillae: None seen (Plate 52a,c).

Prickles.—Infrequent; costal prickles (Plate 52a).

Short Cells.—Costal paired, 3-5/row; >5/row; intercostal paired, 3-5/row. Silica Cells: Costal abundant; intercostal common. Cork Cells: Costal abundant; intercostal common (Plate 52d–f).

Silica Bodies.—Costal dumbbell, ends rounded, middle wide, long or short, intercostal square, round, dumbbell, ends rounded, middle wide, long or short (Plate 52d–f).

Microhairs.—None seen.

Macrohairs.—Common; intercostal and costal; basal cells absent (Plate 52f).
## Appendix

### Material Studied

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<td>Wood 923</td>
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