

Culm Anatomy in Relation to Taxonomy.

By

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The problem of phylogenetic relations is not always to be solved by a study of external characters only. This is particularly true in the family Gramineae. A survey of characters that are useful in the classification of the grasses is presented by Stebbins (1956). During an investigation of anatomical characters in *Danthonia* it was noted that those species which could be referred to *Asthenatherum* Nevski differ from typical representatives of *Danthonia* in culm anatomy. These two species-groups also differ from each other in leaf anatomy (de Wet, 1954). To test the taxonomic significance of this character, a representative group of grasses from different tribes were studied.

MATERIAL AND METHODS

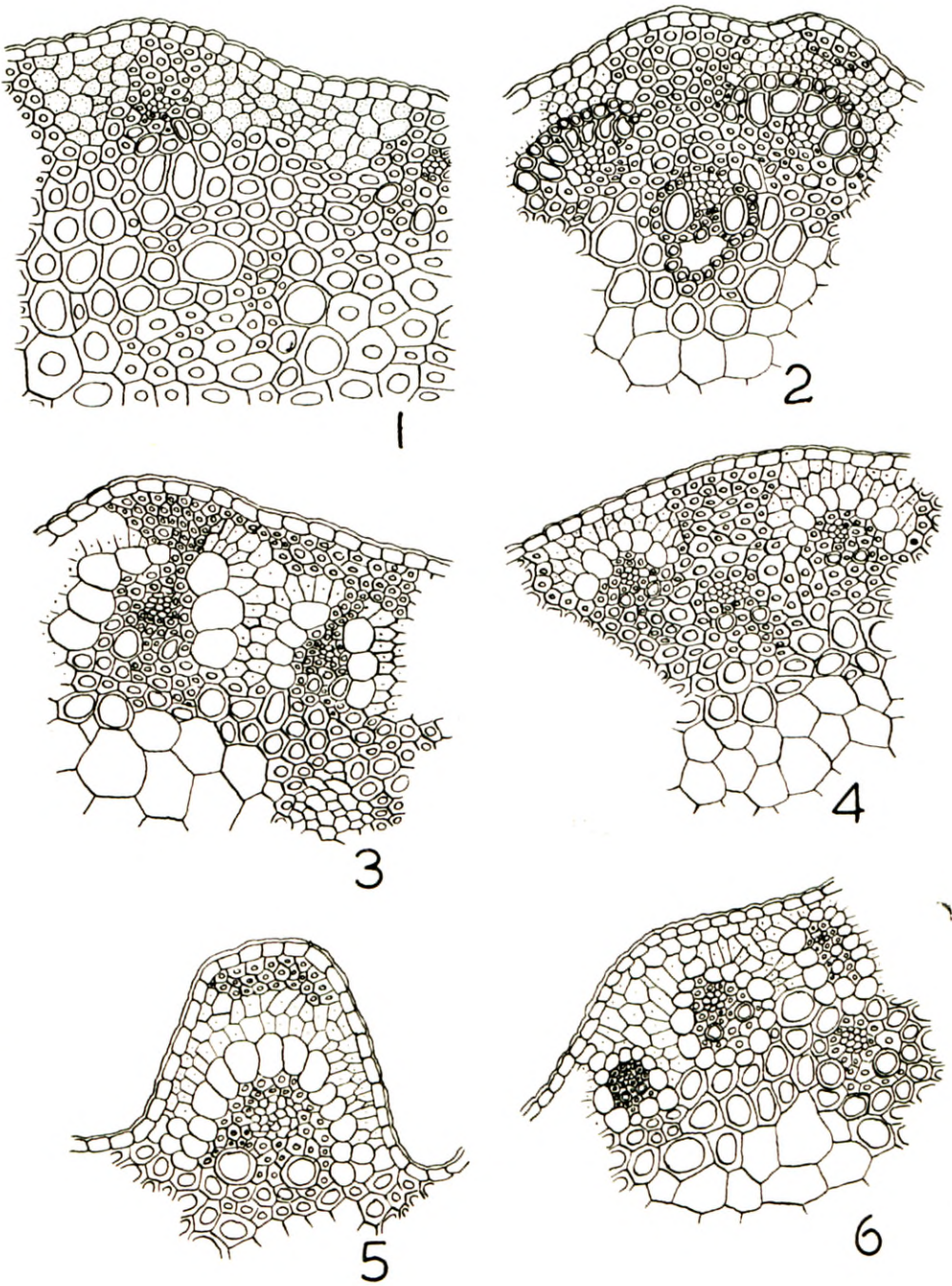
Specimens studied were obtained from the National Herbarium, Pretoria. Pieces of the culm taken just below the inflorescence were placed in a softening medium consisting of equal parts 50 per cent ethyl alcohol and glycerol for 24 hours. Sections were cut by hand and stained in a 1 per cent aqueous safranin solution. Drawings were made with the aid of a camera lucida.

RESULTS

The genera studied are listed in Table 1. Two or more species of each genus were investigated. The concepts of tribes are similar to those of Avdulov (1931), Prat (1936) and Chippindall (1955). Leaf anatomical data are mostly from Avdulov (1931) and Prat (1936). The letters F (festucoid), E (eragrostoid-chloridoid), P (panicoid) and B (bambusoid) refer to the types of characters discussed and illustrated by Stebbins (1956).

Sections were cut transversely through the stem at about 1 cm below the inflorescence. Below the epidermis a more or less continuous circular layer of sclerenchyma and collenchyma is present, carrying bundles which are solitary or in pairs. Other bundles lay irregularly scattered in the pith. The bundles included by this circular sclerenchymatous strand are usually connected with the epidermis by a strand of collenchyma cells. The chlorenchyma is entirely situated between these strands and the epidermis. In other words, these small vascular bundles are always girdered by chlorenchyma cells. The layer of chlorenchyma cells directly bordering onto the vascular bundle usually distinguish themselves clearly by their size from the rest of the chlorenchyma. It is this layer of cells (bundle sheath) that appears to be of use in grass taxonomy.

In the festucoid group of grasses: tribes Festuceae, Brachypodieae, Hordeae, Aveneae, Phalarideae and Agrostae this parenchymatous bundle sheath is poorly differentiated and can not be distinguished from the rest of the chlorenchymatous tissue (Fig. 1). This is also true in genera studied belonging to the tribes Oryzeae, Ehrharteae and Danthonieae (except for the genus *Asthenatherum*). This type of anatomical character was also observed in the genera *Lasiochloa*, *Plagiochloa* and *Urochlaena* which Chippindall (1955) refer to the tribe Eragrosteae.



In the eragrostoid-chloridoid group of grasses (Zoiseae, Eragrosteae, Chlorideae and Sporoboleae) the parenchymatous bundle sheath is composed of very large cells (Figs. 3 and 4). This bundle sheath is also obvious in the Paniceae, Arundinelleae

and the Andropogoneae (Figs. 5 and 6) but the individual cells are often not quite as large as is the case in the eragrostoid-chloridoid group. This is also true in representatives of the tribes Meliceae, Arundineae, Pappophoreae and the genus *Stipa*.

The genus *Aristida* is quite distinct from all the other grasses studied. A very obvious internal bundle sheath of sclerenchyma is present, surrounded by a parenchymatous sheath of smaller cells, which often are also thickened and apparently lack chlorophyll (Fig. 2).

TABLE 1.—Anatomical characteristics.*

Genus.	Culm anatomy.	Leaf anatomy.	Epid.
<i>Oryzeae</i> —			
Oryza.....	1	F	B
Potamophila.....	1	F	B
<i>Ehrharteae</i> —			
Ehrharta.....	1	F	B
<i>Meliceae</i> —			
Melica.....	2	F	P
<i>Arundineae</i> —			
Phragmites.....	2	P	P
<i>Pappophoreae</i> —			
Enneapogon.....	3	P	E
Schmidtia.....	2	P	E
<i>Danthonieae</i> —			
Asthenatherum.....	3	P	P
Chaetobromus.....	1	F	P
Danthonia.....	1	F	F-P
Pentameris.....	1	F	F
Pentaschistis.....	1	F	F-P
Poa.....	1	F	P
<i>Stipeae</i> —			
Aristida.....	4	P	P-F
Stipa.....	2	F	F
<i>Festuceae</i> —			
Briza.....	1	F	F
Festuca.....	1	F	F
Poa.....	1	F	F
Vulpia.....	1	F	F
<i>Brachypodieae</i> —			
Brachypodium.....	1	F	F
Bromus.....	1	F	F
<i>Hordeae</i> —			
Elymus.....	1	F	F
<i>Aveneae</i> —			
Avena.....	1	F	F
Helictotrichon.....	1	F	F
Holcus.....	1	F	F
Koeleria.....	1	F	F
<i>Phalarideae</i> —			
Phalaris.....	1	F	F
<i>Agrosteae</i> —			
Agrostis.....	1	F	F
Calamagrostis.....	1	F	F
<i>Zoiseae</i> —			
Tragus.....	3	P	E
Mosdenia.....	3	P	E
Monelytrum.....	3	P	E
Perotis.....	3	P	E

* In culm anatomy: Type 1—parenchymatous sheath not obvious; type 2—sheath cells small; type 3—sheath cells extremely large; type 4—*Aristida*. In leaf anatomy and epidermis: F—festucoid; E—eragrostoid-chloridoid; P—panicoid; B—bambusoid types.

Genus.	Culm anatomy.	Leaf anatomy.	Epid.
<i>Eragrosteae</i> —			
Diplachne.....	3	P	E
Dinebra.....	3	P	E
Eragrostis.....	3	P	E
Entoplocamia.....	3	P	E
Lophacme.....	3	P	E
Leptocarydion.....	3	P	E
Lasiochloa.....	1	F	P
Odyssea.....	3	P	E
Plagiochloa.....	1	F	P
Pogonarthria.....	3	P	E
Stiburus.....	3	P	E
Tetrachne.....	3	P	E
Trichoneura.....	3	P	E
Triraphis.....	3	P	E
Tripogon.....	3	P	E
Urochlaena.....	1	F	P
<i>Chlorideae</i> —			
Cynodon.....	3	P	E
Chloris.....	3	P	E
Ctenium.....	3	P	E
Eustachys.....	3	P	E
Fingerhuthia.....	3	P	E
Harpechloa.....	3	P	E
Microchloa.....	3	P	E
Oropetium.....	3	P	E
Rendlia.....	3	P	E
<i>Arundinelleae</i> —			
Arundinella.....	2	P	P
Danthoniopsis.....	2	P	P
Loudetia.....	2	P	P
Tristachya.....	2	P	P
Trichopteryx.....	2	P	P
<i>Paniceae</i> —			
Antheophora.....	2	P	P
Alloteropsis.....	2	P	P
Acroceras.....	2	P	P
Brachiaria.....	3	P	P
Cenchrus.....	2	P	P
Digitaria.....	2	P	P
Eriochloa.....	2	P	P
Echinochloa.....	3	P	P
Melinis.....	2	P	P
Oplismenus.....	2	P	P
Panicum.....	2	P	P
Paspalum.....	2	P	P
Rhynchelytrum.....	2	P	P
Setaria.....	2	P	P
Tricholaena.....	2	P	P
Urochloa.....	2	P	P
<i>Andropogoneae</i> —			
Andropogon.....	2	P	P
Bothriochloa.....	2	P	P
Chrysopogon.....	2	P	P
Diectomis.....	2	P	P
Elyonurus.....	2	P	P
Hyparrhenia.....	2	P	P
Heteropogon.....	2	P	P
Hemarthria.....	2	P	P
Ischaemum.....	2	P	P
Imperata.....	2	P	P

Genus.	Culm anatomy.	Leaf anatomy.	Epid.
Monocymbium.....	2	P	P
Miscanthidium.....	2	P	P
Sehima.....	2	P	P
Sorghum.....	2	P	P
Themeda.....	2	P	P
Trachypogon.....	2	P	P
Urelytrum.....	2	P	P

DISCUSSION

Comparing the anatomical data presented in Table 1, it becomes evident that there is a close correlation between stem anatomy and leaf anatomy. The data have little value as such, but only supply another tool in studying grass phylogeny. Other characters which were proved to be useful in the taxonomy of the Gramineae are leaf anatomy (Duval-Jouve, 1875, Avdulov, 1931); histology of the epidermis (Prat, 1936); Cytology (Avdulov, 1931); embryo anatomy (Reeder, 1957); root-hair development (Row and Reeder, 1957); physiology (Harz, 1880, Cugnac, 1931, Al-Aish, 1956) and organization of the shoot apex (Brown, Heimsch and Emery, 1957.)

The data from stem anatomy further emphasize the difference in phylogenetic affinities between *Aristida* and *Stipa*. A further difference between *Danthonia* and *Asthenatherum* also becomes evident. In this respect *Danthonia* resembles the festucoid group and *Asthenatherum* the panicoid group of grasses. These anatomical data also show that the genera *Lasiochloa*, *Plagiochloa* and *Urochlaena* occupy an aberrant position in the tribe Eragrosteae.

SUMMARY

The culm was sectioned transversely about 1 cm. below the inflorescence. The bundles closest to the epidermis are flanked by parenchymatous cells which contain chloroplasts. Directly against the bundle these cells arrange themselves into a parenchymatous sheath which may be poorly differentiated or well developed and composed of small or large cells. It was pointed out that these anatomical data show a close correlation with data from leaf anatomy.

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