THE ANATOMY AND DISTRIBUTION OF THE CYPERACEAE IN THE EASTERN CAPE REGION OF SOUTH AFRICA

VOLUME 1

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ABSTRACT

The principal objective of this investigation, was to collect the family Cyperaceae and to study their leaf, bract and culm anatomy. The second was to examine the collection for unique structures or forms, whilst a third was to classify the Cyperaceae according to their photosynthetic structures and types. distribution of the Cyperaceae within the broad region defined as the Eastern Cape would be influenced by rainfall pattern. It was expected that C3 species would predominate in more mesic environments and habitats, whilst the C4 species would be found in drier less favourable habitats.

Collection within the region (November 1993 to late January 1997), yielded 106 species, totalling some 600 specimens. Both sub-families of the Cyperaceae (Caricoideae and Cyperoideae), eight tribes (Abildgaardieae, Cariceae, Cypereae, Hypolytreae, Rhynchosporeae, Schoeneae, Scirpeae and Sclerieae) and twenty five genera were found to be present. Sixty percent of the species were C3 and forty percent were C4. Sixteen new species, which had not been collected within the boundaries of the region previously were also found.

Over 43 percent of the species collected had unique anatomical characteristics that appeared to be influenced by habitat and or climate influenced. These are the characters influenced by hydromorphic, mesomorphic and xeromorphic environments. These anatomical characters: Thickness of leaves and bracts; thickness of the adaxial and abaxial epidermis of the leaves and bracts; flush, sunken and raised stomata; presence or absence of bulliform cells; presence and distribution of sclerenchymatous structures; presence or absence of a hypodermis; presence or absence of cavities in the leaves, bracts and culms; mesophyll or ground tissue structure, and the presence or absence of secretary structures.

A few noteworthy anatomical characters that are influenced by climate are present in Cladium mariscus subsp. jamaicense (Schoeneae), the Cariceae, the Cypereae and the Sclerieae. Within Cladium mariscus subsp. jamaicense the pseudo-dorsiventral leaves and bracts, as well as the large lamina cavities, containing trans-lamina girders are unique. Papillate epidermal cells are limited to the tribe Cariceae. In the Cypereae many of the species lack bulliform cells and hypodermal layers. In Pycreus cooperi (Cypereae) the vascular bundles of the leaves and bracts, appear to be stacked in rows, that are inter-spaced with lamina cavities. In the Sclerieae the mesophyll structure is specific to the species level.

Unique anatomical characteristics were also present in the leaves, bracts and culms of the genus Carpha. In this genus distinctive lateral vascular bundles were present abutting the large bundles and/or midrib bundle. The most distinctive anatomical characteristics that could be used to separate the members of the Cyperaceae were the structures and associated structures related to the photosynthetic pathway.

The Eastern Cape Cyperaceae could be divided into three distinct groups based on photosynthetic structure, namely one C3, a C4 and a potential C3-C4 intermediate group. The C3 group was found to have non-radiate mesophyll and an outer parenchymatous sheath with small chloroplasts (Cariceae, Cyperaceae [in part], Hypolytreae [Chrysithrix capensis], Rhynchosporeae [R. brownii], Schoeneae, Scirpeae and Sclerieae). The C4 group has radiate mesophyll and an inner parenchymatous sheath with enlarged chloroplasts (Kranz or PCR sheath). The C4 species are present in tribes Abildgaardieae, Cypereae (in part) and Rhynchosporeae (R. barrosiana). In the Eastern Cape, a few species with C3 anatomy have anatomical characteristics that are similar to the species with C4 anatomy (Cyathocoma hexandra [bracts], Cyperus tennellus var. tennellus [leaves and bracts], Ficinia bulbosa [leaves], F. dura [leaves and bracts], F. lateralisomnal [leaves and bracts], F. oligantha [bracts], F. pingiour [bracts], F.
stolonifera [leaves and bracts], F. tribracteata [leaves and bracts], F. zeyheri [leaves and bracts], Isolepis cernua [leaves and bracts], I. costata var. macra [bracts], Schoenus nigricans [leaves], Scirpus nodosus [bracts] and Tetraria cuspidata [leaves and bracts]). The vascular bundles within this intermediate group, fall within the Hattersley and Watson (1975) minimal cell lateral count and maximal cell distal count criteria for C₄ grass species. However, no biochemical data exists to see whether they are C₃-C₄ intermediates or whether the Hattersley and Watson (1975) C₄ criteria for grasses applies to smaller, or scutiform Cyperaceae or not.

Based on the results presented here, five distinct structural forms/types were found to be present in the C₃, C₄ and C₃-C₄ intermediate groups. The C₃ and the potential C₁-C₄ intermediate species may be divided into two types, based on the number of vascular sheaths present. In the first or A-type, vascular bundles are surrounded by two sheaths and in the more dominant B-type, by three. The A-type was found in the Cyperaceae (Cyperus denudatus and C. textilis) and most of the Scirpoeae. B-type anatomy occurred in the Cariceae, Cyperaceae (C. difformis, C. pulcher, C. sphaerospermus, C. tennellus var. tennellus and P. mundii), Hypolytreae, Rhynchosporaeae (R. brownii), Schoenoeae, Scirpeae (Bolboschoenus maritimus, Ficinia cinnamomea, F. fascicularis, F. lateralis, F. pingiour, the genus Fuirena, I. diabolica, I. fluviata, I. prolifera and Schoenoplectus paludicola) and Scieaeaeae tribes.

Based on the vascular sheath structure, the C₄ species could be divided into three groups, namely bulbostyloid, chlorocyperoid and fimbristyloid, where the bulbostyloid structure occurred in Bulbostylis schoenoides. Cyperus (in part), Kylinga, Mariscus and Pyreus (except P. mundii) had a chlorocyperoid structure. Genera with fimbristyloid structure were recorded in the genera Abildgaardia, Bulbostylis and Simbristylis.

The bulbostyloid type represents a potential a fifth C₄ anatomical type within the C₄ Cyperaceae. As a result of this observation, it is possible that the C₄ syndrome may have evolved five times in the Cyperaceae and not four as previously suggested by Bruhl and Perry (1995) and by Soros and Dengler (2001).

The C₃ Cyperaceae species within the Eastern Cape are more dominant in higher elevation habitats the C₄ species, similar to the C₃ grasses. The only C₄ species that occur at high elevations are those with three sheaths. The C₃ and C₄ species within the region occur in similar low rainfall habitat ranges, where the C₄'s are more dominant in xeric habitats on drier soils than the C₃ species, similar to the grasses. Where more C₃ species occur in higher rainfall habitats than the C₄ species. With the exception of the Afromontane Bulbostylis schoenoides and R. barrosiana, the C₃ species similar to the grasses are dominant in high light and temperature habitats with low rainfall, unlike the C₄ Cyperaceae of Japan and America. Only five species occur in the desert like conditions of the Karoo-Namib biome (Cyperus laevigatus, C. rupestris var. rupestris, I. cernua, M. capensis and M. uitenhagensis), which have less than 250mm of rainfall per annum.

Only three species are habitat-specific or may be endemic to a specific area within the Eastern Cape, namely A. capensis, Chrysiithrix capensis and R. barrosiana. A. capensis in marshes on the Amatole mountains near Alice and Hogsback. C. capensis to the Tsitsikamma mountains of the Wite Els Bosch forests. R. barrosiana to the marshlands of the Cape Morgan coastal Nature reserve at Kei Mouth.

The anatomical types of the C₃ and more especially C₄ Cyperaceae are not specifically found in a particular rainfall regime or habitat type, which is contrary to the thesis hypothesis. However, the C₃ species are mostly correlated with hydrophytic to mesic habitats, with the exception of Ficinia and the two sheathed species. Ficinia is dominant.
in mesic grasslands and halophytic habitats. The two sheathed C\textsubscript{3} species are mostly present in halophytic habitats. The C\textsubscript{4} species are also more dominant in mesic to xerophytic grasslands, as expected in the hypothesis. Where only a few species occur in habitats correlated with increasing rainfall and temperature similar to the C\textsubscript{4} Cyperaceae of Japan and America. It may thus be that the development and evolution of the different C\textsubscript{4} anatomical forms (or phylogenetic forms) within the Cyperaceae may have enabled these species to establish themselves in habitats that were alien to their origins. It may be that the ability to regulate photoassimilate and water transport within the Cyperaceae enables their success in a dynamic and unpredictable climate, such as the Eastern Cape.

Many of the anatomical characteristics reported in this thesis and its appendices are unique to the tribes, genera and/or species of the Eastern Cape Cyperaceae and thus may be valuable to future taxonomic classifications of the family. The research presented here should provide a good working platform for future, more detailed research on this often forgotten component of the vegetation.
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List of Abbreviations and symbols

1- first row of bundles;  
4- fourth row of bundles;  
A- aerenchyma;  
Ad- adaxial epidermis;  
Ba- banks of dams, estuaries, marshes, rivers or streams;  
Br- bract;  
C- cone-shaped silica deposit;  
D and Du- sand dunes;  
EpC- epidermal cell with cone-shaped silica deposit;  
Fi and Fn- indigenous forests;  
Fy- fynbos;  
Gr(Figures)- grasslands;  
HSS- hypodermal sclerenchymatous strand;  
KS and KBS- Kranz sheath;  
Ma(Figures)- in marshes;  
Me- mesophyll cell;  
MS- mestome sheath;  
NC- no cone shaped silica deposit;  
P- phloem;  
PE- papillate epidermal cell;  
PxL- protoxylem lacuna;  
RT- riverine thicket;  
Sc- sclerenchyma;  
St- stoma;  
Su- subsidiary cell;  
TP- translucent parenchyma;  
X- xylem.

2- second row of bundles;  
5- fifth row of bundles;  
Ab- abaxial epidermis;  
AdL- adaxial large bundle;  
BP- border parenchyma;  
Bu- bulliform epidermal cell;  
C- cavity;  
Da- in dams;  
Es- in estuaries;  
Fi- forest margin;  
G- girder;  
Gr(Plates)- vascular bundle groupings;  
Hy- hypodermis;  
H- horn shaped lignin deposit;  
L- large bundle;  
Ma(Plates)- marginal bundle;  
MEp- marginal epidermal cell;  
MS2- lignified cell resembling the mestome sheath cells;  
O- in open areas, with no vegetation;  
Pa- parenchymatous cells;  
PP- palisade parenchyma;  
Ri- in rivers or streams;  
S(Figures)- streams and rivers;  
Si- silica deposit;  
Stc- sub-stomatal cavity;  
Tr- trichome;  
OT- outer periclin wall (tangential);  
Pbr- parenchymatous bridge;  
PS- parenchymatous sheath;  
RM- radiating chlorenchyma;  
S(Plates)- small bundle;  
StP- stellate parenchyma;  
Th- thicket;  
VB- vascular bundle(s);  
Fo- forests, no designation;  
Ga- guard cell;  
H- horn shaped lignin deposit;  
I- intermediate bundle;  
Li- lignified cell;  
Md- midrib bundle;  
Mixed- mixed vascular tissue;  
MX- metaxylem vessels;  
OT- outer periclin wall (tangential);  
Pbr- parenchymatous bridge;  
PS- parenchymatous sheath;  
RM- radiating chlorenchyma;  
S(Plates)- small bundle;  
StP- stellate parenchyma;  
Th- thicket;  
VB- vascular bundle(s);  

Species abbreviations:

A-C3- C₃ Ascolepis species;  
A6- A. ovata;  
Am- A. mollis;  
Be- B. contexta;  
Bhu- B. humilis;  
Bs- B. schoenoides;  
Ca- C. aethiopica;  
C-C3- C₃ Cyperus species;  
C-C4- C₄ Cyperus species;  
Cm- C. mossii;  
Cz- C. zuluensis;  
Cz- C. zuluensis;
Fc- F. complanata;  
K-C4- C₄ Kylinga species;  
P-C4- C₄ Pyreus species;

Fd- F. dichotoma;  
M-C4- C₄ Mariscus species;  
Rba-C4- R. barrosiana, C₄ species;

Sbr- S. bracteosum;  
Sn- S. natalensis;  
Ssp- S. sparteum.

Sm- S. melanomphala;

Sse- S. schweikerdtii;

Genera abbreviations:

B- Bolboschoenus;  
Cy- Cyathocoma;  
Fu- Fuirena;  
Sch- Schoenoplectus;

Ca- Carpha;  
E- Eleocharis;  
I- Isolepis;  
Sci- Scirpus;

Cl- Cladium;  
Fi- Ficinia;  
S- Schoenus;  
T- Tetraria.
Chapter 1, General Introduction

1.1 General Introduction

The Cyperaceae is a cosmopolitan family of monocotyledonous plants, consisting of about 5000 species (Reznicek 1990; Bruhl 1995; Plunkett et al. 1995; Simpson et al. 2003). This makes them extremely important ecologically, particularly in wet habitats at almost all latitudes. Interest in the Cyperaceae is encountered in all botanical disciplines due to the occurrence of both the C\textsubscript{3} and C\textsubscript{4} photosynthetic pathways within the family (Bruhl 1995). Furthermore, the Cyperaceae and the Poaceae are the only two monocotyledonous families that can be divided anatomically into species with C\textsubscript{3} and C\textsubscript{4} photosynthetic types (Soros and Dengler 1998).

It is therefore of concern that for many years the Cyperaceae have been treated as pests or weeds and much time has been dedicated to the removal or control of these plants (see Holt and Orcutt 1991; Grichar 1992; Grichar et al. 1992; Kleifeld et al. 1992; Richburg et al. 1993 & 1994; Harrison and Peterson 1991 & 1994; Heide 1997). Within the Cyperaceae, *Cyperus esculentus*, *C. longus* and *C. rotundus* were considered to be problematic in the agricultural sector (Reznicek 1990). The ecology and nutrient cycling within the habitats occupied by the Cyperaceae is of great importance in their control, as well as their conservation. Teeri et al. (1980), Lieffers and Shay (1981), Auclair (1982), Collins and Jones (1986), Dykyjova (1986), Bernard (1990), Jönssödttir and Callaghan (1990), Karagatzides and Hutchinson (1991), Aerts et al. (1992), Aerts and De Caluwe (1994A and B), Anderson et al. (1996) and Erschbamer (1996) to name but a few, have reported on these subjects.

Not only is the control, ecology, and conservation of species important, but there has also been an increased interest in their morphology, fungal infection, chemotaxonomy, and phylogeny. Oten-Yeboah (1975), as well as Nijalingappa and Goetzhebcur (1990) have reported on the morphological characteristics of some genera within the Cyperaceae. Whilst Clay et al. (1985), Vánky and McKenzie (1990), Adebajo (1993A), Massicotte et al. (1998), Miller et al. (1999), Muthukumar and Udaian (2000), as well as Piepenbring (2000 and 2001) have investigated fungal and microbial infections within the Cyperaceae. A number of important chemotaxonomic publications have appeared namely those by Harborne et al. (1982 and 1985), Manhart (1990), Komani et al. (1991), Lucoño and Castroviejo (1991 and 1993), Adebajo (1993B), Mahmout et al. (1993), Omokawa et al. (1994), Von Perger et al. (1994), Dolmazon et al. (1995), Bum et al. (1996 and 2001), Garo et al. (1996), Morimoto et al. (1997), Seabra et al. (1997 and 1998), Lee et al. (1998), Raab et al. (1998), Abdel-Mogib et al. (2000), Bell et al. (2000), Meng et al. (2001), as well as Sonwa and Konig (2001). There has been increased interest in their chemotaxonomy and research because many of their natural plant compounds have medicinal uses.

subsequently also further investigated the phylogenetic relationships of the Cariceae. Roalson and Friar (2000) have focussed on the genus Eleocharis. Vanzela et al. (1998) have investigated multiple locations of the rDNA sites in the genus Rhynchospora. Muasya et al. (2001) focussed on the genus Isolepis. Muasya et al. (2000) investigated a number of genera including Trichophorum, Scirpoides and Ficinia. Simpson et al. (2003) investigated the phylogenetic relationships in the Cyperaceae Subfamily Mapanioideae. Very few workers have focussed on the Cyperaceae as a whole, with Plunkett et al. (1995) and Muasya et al. (1998), publishing on this subject. These data sets are important in the classification of the family.

Despite the wealth of taxonomic data that has been published each year, no structured classification of the Cyperaceae existed until recently. Goetghebeur (1985), then subsequently Bruhl (1995) were amongst the first to generate structured classifications. However, neither used data generated from molecular origins. Goetghebeur (1985) made use of cladistic data sets, in which the morphology and micromorphology of the inflorescence, as well as a few structural characteristics of the leaves and culms were used. Bruhl's (1995) classification focussed mainly on Australian species but included a few species with a world-wide distribution. Bruhl's 1995 work remains important in that it was amongst the first to give attention to anatomical structures and was the first to generate the classification using the programme DELTA. DELTA was developed as an aid to classify the grasses by Dalwitz (1980) in South Africa. The phylogenetic classification carried out by Muasya et al. in 1998 supports the classification of Bruhl (1995). Bruhl (1995) classified the Cyperaceae into two subfamilies, namely the Cyperoideae and the Caricoideae. These two sub-families were further divided into twelve tribes and 122 genera. These twelve tribes were as follows: the Abildgaardieae; Arthostylideae; Bisboekelereae; Cariceae; Cryptangieae; Cypereae; Hypolytreae; Rhynchosporeae; Schoeneae; Scirpeae; Sclerieae and Trilepideae. Bruhl (1995) highlighted the need and importance of the inclusion of anatomical data sets in the classification of the Cyperaceae.

Plowman (1906) used anatomical characters in an attempt to classify the Cyperaceae and generate a phylogeny. Pfeiffer (1927) also attempted to classify the Cyperaceae using the anatomical structure of leaves. The extensive anatomical work by Metcalfe (1969, 1971) was however, the most detailed of these three studies of the anatomy of the Cyperaceae. At the same time that Metcalfe published the “Anatomy of the Cyperaceae”, Govindarajalu (1966; 1968A & B; 1969; 1974A & B; 1975A & B; 1976; 1978; 1979; 1981A & B; 1982; 1985) was publishing extensive surveys of the anatomy of the Indian Cyperaceae. Govindarajalu’s work has unfortunately been largely ignored, with few researchers being aware of his work. Shepard (1976), Standley (1987 & 1990), as well as Starr and Ford (2001) have focussed extensively on Carex in Canada. Koyama (1967), Metcalfe (1971), Govindarajalu (1966-85) and Bruhl (1995) have highlighted the importance of the inclusion of anatomical structures as aids in the classification of the Cyperaceae.

The Cyperaceae may be classified physiologically into C₃ and C₄ species, in terms of their anatomy (Soros and Dengler 1998). In addition the C₄ species may be further divided into four types based on the vascular sheath presence and arrangement (Bruhl and Perry 1995; Soros and Dengler 1998 & 2001). The arrangements of the sheath layers in the leaves, bracts and culms, where applicable are summarised in Figure 1.
Figure 1: Shows the vascular bundle structure of the C_3 and C_4 anatomical groups within the Cyperaceae. Abbreviations are as follows: (BP) border parenchyma sheath; (KS) Kranz sheath or PCR sheath; (MS) mestome sheath; (MX) large metaxylem vessels; (PS) parenchymatous sheath and (RM) radiate chlorenchyma/mesophyll. The lines of differing colour are as follows: (Dark green) cells with Primary Carbon Assimilating chloroplasts; (Light green) cells with Primary Carbon Reducing chloroplasts; (Blue) parenchymatous sheath walls; (Orange/brown) cells of the border parenchyma and (Red) lignified/suberised walls.
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The rhynchosporoid group are surrounded by two vascular sheaths (Fig. 1A: Takeda et al. 1980 & 1985; Ueno and Koyama 1987; Bruhl and Perry 1995; Soros and Dengler 2001) and outer radiating mesophyll (Takeda et al. 1980 & 1985; Ueno and Koyama 1987) or PCA tissue (primary carbon assimilating). The outer, or parenchymatous sheath, is often hard to distinguish from the radiating mesophyll and is incomplete in some species (Takeda et al. 1980 & 1985; Ueno et al. 1986 & 1988A; Ueno and Koyama 1987). The radiating mesophyll at the poles of these vascular bundles may sometimes be in direct contact with the inner bundle sheath (Takeda et al. 1980; Ueno and Koyama 1987). The inner sheath is described as the Kranz sheath (Takeda et al. 1980 & 1985; Ueno et al. 1986 & 1988A; Ueno and Koyama 1987) or the PCR (primary carbon reducing) sheath (Bruhl and Perry 1995; Soros and Dengler 2001). The PCR sheath is in the position of the mestome sheath (Soros and Dengler 2001). This Kranz sheath is lignified in the inner and outer tangential walls (Ueno et al. 1989). Species with the rhynchosporoid type have been identified to be present only in the C₄ genus *Rhynchospora* (rhynchosporoid type) and *Syntrinema* of the *Rhynchosporoideae* tribe of the Cyperaceae (Bruhl 1993 & 1995).

The fimbristyloid type is characterised by the presence of three sheaths surrounding leaf-blade vascular bundles (Fig. 1B: Johnson and Brown 1973; Carolin et al. 1977; Gilliland and Gordon-Gray 1978; Takeda et al. 1980 & 1985; Ueno et al. 1986 & 1988A; Bruhl and Perry 1995; Soros and Dengler 2001). The outer sheath is parenchymatous (PS) and is encircled by a layer of radiating mesophyll (RM). The PS may contain chloroplasts. The middle sheath has been described as a mestome sheath (MS) and the inner sheath is the Kranz sheath (Carolin et al. 1977; Takeda et al. 1980 & 1985; Ueno et al. 1986 & 1988A) or PCR sheath (Bruhl and Perry 1995; Soros and Dengler 2001). In the larger vascular bundles this Kranz sheath (PCR sheath) is interrupted by large metaxylem vessels, which are in direct contact with the MS (Ueno et al. 1988A & 1989; Bruhl and Perry 1995; Soros and Dengler 2001). The MS has suberised lamellae in the radial walls that are present between the MS cells (Soros and Dengler 2001). The fimbristyloid anatomical type is believed to be only present in the tribe *Abildgaardieae* (Bruhl 1993 & 1995; Soros and Dengler 2001), within the *Abildgaardieae, Bulbostylis, Crosslandia, Fimbristylis, Nemum* and *Nelmesia* genera (Bruhl 1993 & 1995).

The chlorocyperoid type is characterised by the presence of two vascular sheaths, which surround the vascular bundles (Fig. 1C: Johnson and Brown 1973; Laetsch 1974; Brown 1975; Takeda et al. 1985; Ueno and Koyama 1987; Ueno et al. 1988A). The outermost sheath is described as the mestome sheath, which is encircled by the radiating mesophyll/chlorenchyma (Brown 1975; Carolin et al. 1977). The innermost sheath is termed the Kranz sheath (Brown 1975; Carolin et al. 1977; Hesla et al. 1982; Ueno et al. 1986 & 1988A; Ueno and Koyama 1987) or PCR sheath (Soros and Dengler 2001). In the larger vascular bundles, the Kranz sheath (PCR sheath) is interrupted by large metaxylem vessels and the metaxylem vessels in these vascular bundles are in direct contact with the mestome sheath (Brown 1975; Carolin et al. 1977; Hesla et al. 1982; Ueno et al. 1986 & 1988A; Ueno and Koyama 1987; Soros and Dengler 2001). Similar to the fimbristyloid anatomical type, suberised lamellae are present in the radial walls between the MS cells (Ueno et al. 1989). The chlorocyperoid type has been reported to be present in the *Cyperoideae and Rhynchosporoideae* tribes, in the genera *Ascolepis*, *Cyperus* subgenus *Cyperus*, *Kyllinga*, *Liphocarpa*, *Mariscus*, *Monandrus*, *Pycreus*, *Queenslandiella*, *Remirea*, *Rhynchospora* (chlorocyperoid types), *Rikitiella*, as well as *Sphaerocyperus* (Bruhl 1993 & 1995).

In the tribe *Scirpeae*, the fourth anatomical type is present in the genus *Eleocharis*. This genus has a unique anatomical structure similar to the C₄ chlorocyperoid type (Fig. 1D). This variant has an entire Kranz sheath, which displaces the metaxylem vessels within the vascular bundles of the culms of these species. This fourth structural
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type is referred to as the eleocharoid type. The eleocharoid anatomical type is characterised by the presence of two vascular sheaths (Bruhl et al. 1987; Ueno and Samejima 1989; Ueno et al. 1989; Bruhl and Perry 1995; Soros and Dengler 2001). The outer sheath is the MS, which is thick-walled (Bruhl et al. 1987) and has suberin lamellae that are present in all the walls (Ueno and Samejima 1989). The inner sheath is the Kranz sheath (Ueno and Samejima 1989; Ueno et al. 1989) or PCR sheath (Bruhl et al. 1987; Bruhl and Perry 1995; Soros and Dengler 2001). This Kranz sheath (PCR sheath) is thus not interrupted by the metaxylem vessels (Bruhl et al. 1987; Ueno and Samejima 1989; Ueno et al. 1989; Bruhl and Perry 1995; Soros and Dengler 2001) and lies adjacent the large metaxylem vessels (Bruhl et al. 1987).

Not only does the genus *Eleocharis* have a unique anatomical structure, but it also has a different photosynthetic subtype to the rest of the *C₄* Cyperaceae. The *C₄* *Eleocharis* species are all NAD-Me (Bruhl et al. 1987; Ueno and Samejima 1989; Soros and Dengler 1998). However, until recently all the Cyperaceae were believed to be NADP-Me (Brown 1975; Carolin et al. 1977; Ueno et al. 1986; Bruhl et al. 1987; Ueno and Samejima 1989). Clearly this is not true with all the *C₄* *Eleocharis* species being NAD-Me. Also results are being published, which may indicate that *Cyperus fastigiatus* is either NAD-Me or PCK (Sonnenberg 1989; Sonnenberg and Botha 1992). The distribution of the *C₄* subtypes within the *C₄* Cyperaceae anatomical groups is poorly understood and needs further investigation.

The *C₃* species may be divided into two groups based on presence or absence of a vascular parenchyma sheath and are all characterised as non-Kranz. In the first *C₃* group of the Cyperaceae the vascular bundles are surrounded by two bundle sheaths. These two sheaths were an outer parenchymatous sheath and an inner mestome sheath (Fig. 1E: Brown 1975; Gilliland and Gordon-Gray 1978; Takeda et al. 1980; Ueno and Koyama 1987; Ueno et al. 1989; Bruhl 1995; Bruhl and Perry 1995; Soros and Dengler 2001). Additionally some species may have a sheath of vascular parenchyma present inside the mestome sheath, within the outer portions of the xylem and phloem (Fig. 1F). These cells are also referred to as border parenchyma (Bruhl and Perry 1995; Soros and Dengler 2001). The chloroplasts within the sheath of border parenchyma contain grana and have large numbers of mitochondria similar to or in greater numbers than the mesophyll (Bruhl and Perry 1995; Botha pers. comm. 2001). The cells of the vascular (border) parenchyma, may range from small poorly developed cells or NK-S, to medium sized or NK-M, to relatively large or NK-L (Ueno et al. 1989).

It has been suggested in the past that the *C₄* PCR tissue within the Cyperaceae was derived from the vascular parenchyma (Ueno and Samejima 1989; Ueno et al. 1989; Ueno 1996) or border parenchyma (Bruhl and Perry 1995; Soros and Dengler 2001). In the Cyperaceae this derivation of PCR and PCA tissue from procambial or ground meristem, has been an issue that has been debated for many years. Within the grasses there are two vascular bundle arrangements, with two differing origins for the PCR tissue. In the first, which Hattersley and Watson (1976) defined as XyMS-, where the PCA tissue abuts the PCR tissue bundle mestome sheath. The second is defined as XyMS+, where a mestome sheath exists internal to the PCR it abuts the metaxylem vessels. In the XyMS- grasses, the PCR of the is in close association with the radiating mesophyll or PCA tissue and derived from the procambium. However, in the XyMS+, the PCA and PCR tissues are still in close association, but are separated from the vascular tissues by the mestome sheath. It is argued that the mestome sheath in the XyMS+ is derived from the outer procambium tissues and the PCR from the ground meristem. Hattersley and Watson (1976), Dengler et al. (1985), Nelson and Langdale (1989), Nelson and Dengler (1992) refer to this PCR tissue as the "bundle sheath". This had lead to many authors describing the PCR tissue in the Cyperaceae as the "Kranz bundle sheath", see Takeda et al. (1980 & 1985), Bruhl et al. (1987), Ueno et al. (1988A & 1989), Li and Jones (1994), as well as Bruhl and Perry...
Within the Cyperaceae the PCR tissue is formed endarch to the mestome sheath and or parenchymatous sheath (where present). In 1998 Soros and Dengler suggested that the PCR tissues within the leaf blade bundles of the Cyperaceae may be derived from the procambium. Later in 2001 Soros and Dengler confirmed this supposition, stating that PCR tissues are always derived from procambium and the PCA from the ground meristem. All in all, the anatomy of vascular bundles remains complex as do the origins of the various tissue types.

Ueno et al. (1989) have hypothesised that the evolution of the C₄ photosynthetic structure within the Cyperaceae is thought to have started with the C₃ species with small vascular parenchyma cells giving rise to large vascular parenchyma cells, which in turn gave rise to the Kranz sheath and species with fimbristyloid anatomy. This Kranz species with fimbristyloid anatomy in turn giving rise to sub-fimbristyloid, to sub-chlorocyperoid and finally to chlorocyperoid anatomy. They believe that the C₄ syndrome was sequentially developed in an evolutionary sequence of events from a primitive ancestral form to an advanced form. This sequential step approach is supported by the multiple evolutionary development of the rhynchosporoid and chlorocyperoid anatomical types within the Rhynchosporeae. It is hypothesised that the C₄ syndrome within flowering plants evolved at least 31 times (Soros and Dengler 2001) and at least four different times in the grasses (Ellis 1974; Brown 1975; Ehleringer and Monson 1993; Kellogg 2000; Soros and Dengler 2001) and four different times within the Cyperaceae (Bruhl and Perry 1995; Soros and Dengler 2001). Soros and Dengler (2001) hypothesise that each evolutionary event within the Cyperaceae marked a separate evolutionary assemblage, that each of these four evolutionary events occurred in separate tribes, with the exception of the Rhynchosporeae, where both the rhynchosporoid and chlorocyperoid anatomical types were present and that the remaining three anatomical types; the chlorocyperoid anatomical type in the Cyperaeae, the fimbristyloid in the Abildgaardieae and the eleocharoid in the Scirpeae.


The Cyperaceae are mostly absent in arid areas (with an annual rainfall of less than 250 mm), especially for the southern African Mariscus species (Vorster 1983) and the genus Rhynchospora (Ueno and Koyama 1987). Most Cyperaceae species occur in areas with a maximal winter rainfall (Takeda et al. 1985; Ueno and Takeda 1992). The C_3 Cyperaceae tend to be more numerous in habitats with high rainfall and temperate conditions (Takeda et al. 1985). Here these species are widespread from tropical, through sub-tropical to temperate and partially sub-Antarctic (Ueno and Koyama 1987). The distribution of the C_3 Cyperaceae of Japan occurs in wet shade habitats (Ueno and Takeda 1992). The genus Carex of Canada occurs in cool and temperate habitats (Crins and Ball 1990).

The C_3 Rhynchospora species occurs in habitats with an abundant water supply, such as marshes, swamps and river-banks (Ueno and Koyama 1987). The range of habitats for the C_4 Cyperaceae is narrower than for the C_3 species (Ueno and Koyama 1987; Ueno and Takeda 1992). C_4 Cyperaceae tend to show effective photosynthetic ability under conditions of high light intensity and high leaf temperature, but these plants may experience intermittent water stress (Ueno and Takeda 1992). The distribution of the C_4 Cyperaceae is associated with increasing temperature (Teeri et al. 1980; Hesla et al. 1982; Ueno and Takeda 1992; Li 1993A). These species would decrease in abundance with a decrease in temperature (Teeri et al. 1980; Li 1993A). Though the C_4 Cyperaceae species of Europe have been shown to occur in cool habitats (Li 1993A), the C_3 species of Japan (Ueno and Takeda 1992), the South African Mariscus species (Vorster 1983), as well as American C_4 species (Teeri et al. 1980) increase in abundance with increasing rainfall. Furthermore the C_4 Cyperaceae mostly occur within summer rainfall areas, especially in Australia (Takeda et al. 1985) and in the southern African genus Mariscus (Vorster 1983). However, the species of genus Mariscus in southern Africa are absent in desert habitats (Vorster 1983), whilst the C_4 Rhynchospora species are abundant in savannah grasslands (Ueno and Koyama 1987). It appears that the C_4 Cyperaceae are mostly abundant where there is an alternation of wet and dry seasons, especially in the genus Rhynchospora (Ueno and Koyama 1987). The majority of East African (Kenyan) C_4 species seem to occur in the drier habitats of the tropics and subtropics (Hesla et al. 1982; Ueno and Koyama 1987).

Given the wealth of literature that exists detailing the Cyperaceae taxa, it is surprising that so few exist in which emphasis is placed upon their unique anatomy. In the Eastern Cape, only a few studies have been taken, namely Mpikelelli (1982), Sonnenberg (1989, 1992) and Thamae (1991). These were mostly in the form of Honours and Masters theses at the Universities of Forth Hare and Rhodes. This is indeed disturbing since, the family Cyperaceae within the Eastern Cape region of South Africa is one of the plant families that has been virtually ignored by investigators (Lubke et al. 1988A & B).

1.2 The Eastern Cape Study area

Within the Eastern Cape it has been estimated that there are 4-6000 species within the Province, compared with the 2050 or so species of Great Britain (Gledhill 1981). The Eastern Cape has not been extensively collected and the flora is still poorly understood. Likewise, ecological studies have been confined to isolated areas and consequently an
understanding of the interrelationships, as well as the dynamics of plant communities with the region is incomplete. In the Eastern Cape four different phytochoriological regions (Afromontane, Cape, Tongoland-Pondoland and Karoo-Namib) meet, and this region is thus immensely complex (Lubke et al. 1988A). Summer and winter rainfall regions overlap here as well (Kopke 1988).

The Eastern Cape has an unpredictable temperate climate (Lubke et al. 1988A & B). The winter rainfall predominates on the western border (Gledhill 1981). The largest part of the Eastern Cape has a pronounced double maximum, with dry periods in mid-summer and mid-winter. The portion along the coast and the Zuurveld area has a pronounced spring maximum, whilst the area extending down the valleys of the main rivers to the land below the Winterberg escarpment experiences a pronounced autumn maximum. The spring rains come from the west with the passage of cold fronts, whilst the autumn rains occur mainly in March and come from the east (Kopke 1988). In this area topography plays a major role in the rainfall patterns (Gledhill 1981; Kopke 1988). The area from Komga (near King Williams Town) in the east to the Katberg in the west, stands out with a higher than average rainfall of between 750 and 2000mm, most of the mountains receive over 1000mm (Kopke 1988).

The changing landscape and climate is accompanied by an equally variable vegetation (Gledhill 1981). Due to the variable climatic conditions, the Eastern Cape is a transitional region where a wide variety of floras (Tongoland-Pondoland, Cape, Afromontane or grassland and Karoo-Namib) and other vegetation types converge (Bruton and Gess 1988; Lubke et al. 1988A & B). In parts of the Eastern Cape the representatives of the floras are so intermingled that not one type can be said to predominate (Gledhill 1981).

Vegetation and geographic boundaries were used in this investigation to delimit the boundaries of the study area. The demarcations used were those proposed by Bruton and Gess (1988). They suggested that the limits of the region were the Great Kei river in the east and the Kromme-Gamtoos river system in the west. The northern limits were defined as the Sneeuberg-Winterberg-Stormberg escarpment (Fig. 2).

1.3 Objectives

Cyperaceae were under collected in southern Africa, and the material upon which this thesis is based, forms the single largest regional collection in southern Africa. The variability in climate, unpredictable rainfall pattern and rapid changes in vegetation, are linked to the convergence of four phytochoriological zones within the region as well (Lubke et al. 1988B).

The principal objective of this study was to make a collection focussing on the anatomy of the leaves, bracts and culms from the broadly defined Eastern Cape region. Other collectors (Ueno et al. 1988 & 1989; Brühl and Perry 1995; Soros and Dengler 1998 & 2001), have made extensive collections elsewhere, which could be referred to once the primary objective in this thesis (the anatomical study) was completed, at some stage in a future study.

The second objective of this research was to examine the collection for unique anatomical structures or forms. Thirdly, it was hoped that the species collected would provide sufficient information to allow classification into C₃, C₄ or C₃-C₄ forms, based on their vascular bundle anatomy.
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From the introduction and the objectives already listed it was felt that there were a few interesting questions relating to the Cyperaceae in general as well as to the Eastern Cape Cyperaceae in particular that needed to be addressed. These may be divided into two broad categories based upon structural and distributional data.

In the first category:
1. How many C_3 and C_4 anatomical types are present in the Eastern Cape.
2. Were all the C_4 anatomical types represented (rhynchosporoid, fimbristyloid, chlorocyperoid and eleocharoid types)?
3. Were there more than one C_4 anatomical type present within a specific genus?
4. Were the anatomical types collected (in the Eastern Cape) in close agreement with those already described in the literature?

In the second category:
1. Was there evidence in support of microclimate affecting the distribution of species/genera?
2. Did the C_3 and C_4 anatomical types occur in definite habitats, and could these habitats be diagnostically significant?
3. How did the specific habitats of the C_3 and C_4 Cyperaceae species of the Eastern Cape compare to the Cyperaceae investigated elsewhere?

Given that the C_4 species are generally accepted to be water use efficient, a working hypothesis for the thesis is that: distribution of the Cyperaceae within the broad region defined as the Eastern Cape would be influenced by rainfall pattern. It was therefore expected that C_3 species would predominate in more mesic environments and habitats; C_4 species in drier less favourable habitats.
Figure 2: Illustrates the major towns, rivers, mountains and boundaries (stippled line) of the Eastern Cape region of South Africa, where the inset shows the location of the region within the country.
2.1 Materials and Methods

2.1.1 Species Collection

A list of known localities of Cyperaceae genera and species within the Eastern Cape was compiled from the National Herbarium in Pretoria (PRE) Precis database and from specimens housed in the Schönländ Herbarium in Grahamstown (GRA). This list was used for establishing most common habitat types to facilitate the collection of species (List housed in GRA, as a hard copy and one on CD). Collections were made during the flowering period from November to late January, 1993-1997.

Where possible six to seven specimens of each species were collected. In many instances populations were too small for more specimens to be removed. Depending on the physical size of the species one to two of the duplicates were used for the anatomical investigations. One was used for the field herbarium (housed in the ecology Department at Pretoria University) and one was placed in the Schönländ herbarium (GRA) as a voucher specimen. One was sent for confirmation of identification by Professor Kathleen Gordon-Gray and Jane Browning to the University of Natal herbarium (UN) and one of the remaining specimens was sent to the Missouri Botanical Gardens (MBG). Most of the remaining specimens were distributed to herbaria which asked for duplicates during the investigation, such as the University of New England Herbarium (UNE). The naming system used was according to Gordon-Gray (1995) and Arnold & de Wet (1993). All plants were classified according to Bruhl (1995). The specimens, species, Herbaria, including the habitat information, districts collected from and collection numbers of the author are detailed in Appendix I.

A few of the species were not recollected, these were the hydrophytic species of the various genera namely, Cyperus, Ficinia, Isolepis and Tetraria. This totals of 53 hydrophytic species or 29 percent of the species in the region. In the three years prior, as well as for four years during the this investigation the Eastern Cape experienced one of its worst droughts. Species rich areas such as Wite Els and Assagai Bosch forestry areas had not received any rainfall for six years prior to the authors collection there. Similarly neither had the Hogsback or Kentani districts. Both these districts did receive rainfall during the initial collections of the area and were resampled one year after the drought in those areas had been broken. Very few additional species were added to the initial collections of the areas. It was suspected by the author that many of these water loving species many have been eradicated from these areas.

2.1.2 Preparation in the field

Fresh material was used so that all structural features would be dehydrated and imbedded in exactly the same way. Three-one-cm-long segments were taken from the mature leaves, inflorescence bracts and culms of the specimens to be used for anatomical determinations (in the field). For the leaves and bracts these segments were removed from the mid-lamina regions. Segments were also removed from the mid-culm regions where possible. In species that were larger than 1.5 m, segments were removed 50 cm from the inflorescence (these culms were extremely lignified and sections could not be cut from the mid-culm regions).
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The segments were immediately placed in a 50 percent Formyl Acetic Alcohol (FAA) solution (500ml H₂O, 500ml 100 percent ETOH, 25ml glacial acetic acid, 60ml formalin). The specimens remained in the FAA until they could be put through a serial dehydration in the laboratory.

2.1.3 Slide preparation

2.1.3.1 Dehydration and Staining

According to the methods of Johansen (1968), each segment was placed into a separate vial and sequentially dehydrated in an ethyl and butyl alcohol series (chemicals from Merk, Port Elizabeth). Finally after the last alcohol step, hot (65°C) paraplast wax (Merk, Port Elizabeth) was added and the specimen was placed overnight in an Memmert B30 oven (Schwabach, West Germany) at 65°C. Two overnight washes of the wax were applied to the specimens, which were then embedded in an upright position (at right angle to the blocking face), with the specimen position marked on the block (by melting away sufficient wax with a blunt metal implement in order to see the specimen within the wax).

The wax blocks containing the specimens were sectioned using a Lietz Wetzlar Minot Microtome (Wetzlar, Germany) at 10 μm-20 μm, and a 20° angle. The ribbons of sections were water bath floated onto the glass slides (Chance Proper Ltd., Warley, England), that had a coating of Haupts mounting medium (made according to Johansen’s 1968 formulation, chemicals from Merk, Port Elizabeth) smeared on the surface. The glass slides were all pre-cleaned using chloroform (100 percent mixture, Merk, Port Elizabeth). The slides with wax ribbons were placed in slide baskets (Chance Proper Ltd., Warley, England) in an oven (Memmert B30, Schwabach, Wets Germany) at 40°C over open trays containing 2-5ml of 10 percent Formalin (Merk, Port Elizabeth) for two days. Sections were stained with safranin (BDH, Poole, England) and fast green cfc (Hopkins & Williams, Essex, England) according to the methods of Johansen (1968). Sections were left in safranin for 24 hours and in fast green for 1 minute. All chemicals used were made up according to the methods outlined in Johansen (1968) and came from Merk, Port Elizabeth.

2.1.3.2 Sectioning of hardened culm material

The culms of *Rhynchospora brownii* presented many problems when sectioning. The culms were so hardened that in all of the sections, it appeared that many of the vascular tissues were damaged in the sectioning process. The culm material was soaked in the softening agent Mollifex (BDH Chemicals Ltd., Poole, England) for periods varying from one week to two months to see if these tissues would remain after sectioning. After using duplicate material it was thought that these tissues may have degenerated during growth.

Hand sectioning was also attempted, but no viable sections could be cut from this hardened culm tissue. Freeze sectioning according to the methods described in Johansen (1968) were also attempted, but these too failed. Because of the extremely lignified nature of the tissues, this sectioning method destroyed the section altogether. Thus with a lack of material, there was a difficulty with many of the determinations of phloem tissues, xylem and border parenchyma.
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2.1.4 Photography and Developing

Sections were viewed and photographed using a Zeiss Standard Junior 18 microscope (Carl Zeiss, Oberkochen, Germany) fitted with a 360° revolving stage. A Zeiss MC-63 mounted camera (Carl Zeiss, Oberkochen, Germany) was used to photograph selected specimens, using Agfa Pan APX 25 ASA black and white film (Agfa, Leverkusen, Germany). Standard Agfa film and paper developing techniques were used. Negatives and prints were developed using Agfa multi-contrast developer (Agfa, Leverkusen, Germany) and Agfa multi-contrast fixer (Agfa, Leverkusen, Germany). The photographic paper used was premium multicontrast MPC-310RC, glossy B/W RC-paper (Agfa, Leverkusen, Germany).

2.1.5 Anatomical characteristics examined

Appendix 2 lists the anatomical characteristics that were investigated. Initially a test of how many specimens should be used in the investigation was made with one to five different specimens that were collected from different habitats, where it was possible. Within an 80 percent confidence level (using a Students T-testing of means: De Muth 1999) all one to five specimens were similar in all measurements, except when the morphology of the specimen differed. Thus one species was described in most cases due to time constraints, with over 106 species collected, that is with over 500 specimens and over 5000 blocks of material imbedded. However, where species from different habitats varied morphologically, sections were made from these morphologically distinct specimens and compared. If the anatomical characteristics varied significantly (at an 80 percent confidence level) then both were described. In this thesis, only one species, Ficinia lateralis (Vahl) Kunth was described twice and the different forms were defined as F. lateralis inland and F. lateralis coastal. Definition of adaxial and abaxial epidermis, is according to Metcalfe (1971) and Esau (1977).

2.1.5.1 Descriptions of shape or outline

Descriptions of leaf, bract and culm shape were in accordance with the shapes of structures that were described on pages 8-12 and 26-27 of Metcalfe (1971). The outline of sclerenchymatous structures within the leaves, bracts and culms were in accordance with the descriptions on pages 18-19 of Metcalfe (1971). The outlines/shapes of all other tissues and cell types were the same as the outline/shapes of sclerenchymatous structures on the pages of Metcalfe (1971) mentioned above. Additional outlines were added to these outline/shape classes, were trapeziform for trapezoidal shaped structures and semicircular or crescentiform for sub-hemispherical.

2.1.5.2 Calculation of size parameters

The magnification was calibrated using a standard Zeiss micrometer (Carl Zeiss, Oberkochen, Germany). A number of calculations were made of the various structures sizes (height) using a precalibrated system and this was verified from comparisons with photomicrographs, using the fact that when a object is magnified to 1000x, then 1mm on the print, represents 1μm (1000x = 1mm on the print = 1μm). No significant difference (α = 0.20 or 80 percent level of significance) could be detected between the height of the structure determined from the calibrated system and the photomicrographs.
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The epidermal cell heights of the leaves, bracts (adaxially and abaxially), and culms were calculated as follows. The cell height of the epidermal cells was calculated every fourth cell along the epidermis, where possible. This exercise was repeated 20 times (in the case where there were less than 20 cells, the height of all the epidermal cells was calculated). This was repeated on five random slides of the same species, from the duplicates of each of the specimens that were placed in FAA in the field. The epidermal cell height recorded in the Tables is the mean of the cell height, with its standard error (using the Student's T-test). The same method for calculating epidermal height was used for the following structures: hypodermal sclerenchymatous strands (HSS); girders; the midrib (where one was present) was calculated at the median of the midrib bundle; sub-stomatal cavity and lamina cavity (calculated on the sides and middle of each cavity). The thickness of the lamina for the leaves and inflorescence bracts was calculated every four epidermal cells along the lamina as a height (perpendicular to the epidermal surface); culm thickness was calculated along the epidermis at random or where possible every four cells of the epidermis (perpendicular to the epidermal surface). The length of the trichomes was calculated for the length of the structure, along the long-axis of the trichome structure.

Spacing of vascular bundles of the leaf lamina and inflorescence bracts was calculated as follows: the cells of the mesophyll between the outer sheaths of the various vascular bundles were counted and recorded. The hypodermal cell thickness was calculated by counting the individual cells along the hypodermis, of each slide and section. The vascular bundle numbers, HSS and girder numbers were calculated by counting these structures in the slides of each specimen used.

2.1.6 Distribution and habitat definitions

2.1.6.1 Distribution

The distribution of habitats is defined in the following way. The demarcation of "coastal" is the area within 1 km of the coast where plants have to endure continual salt stress conditions, whilst the inland regions are not under the influence of salt spray (Lubke et al. 1988B). In other words, the coastal regions were the areas where halophytic conditions would prevail.

2.1.6.2 Habitat

The types of habitats are defined in the following way. "Fynbos habitat" is defined to be within the global concepts of heathlands or plant communities characterised by heathlands, with Mediterranean type climates. In this area Ericaceae, Restionaceae, Proteaceae and Rutaceae are dominant. "Thicket" or "Subtropical thicket" is dense woody vegetation with a closed canopy, composed predominantly of trees and shrubs.

Thickets are typically composed of savannah and forest margin species. Typical genera are Rhus, Maytenus, Cassine, Olea, Crassula, Aloe and Euphorbia (Lubke et al. 1988A). Riverine thickets are simply the thickets that are associated with rivers in the region.

Within "grasslands" there is a mixture of tussock grasslands, sour grasslands (dominants are Themeda triandra and Eragrostis capensis), coastal mixed grassveld (dominants are Themeda triandra, Pentaschistis angustifolia and
Merxmeullera disticha), mountain mixed grassveld (dominants include Themeda triandra, Penniseta sphacelatum, and Tetrachne dregei) and sweet grassveld (dominants include Themeda triandra, Eragrostis chloromelas and Cymbopogon plurindos).

"Forest" (indigenous) include Montane, Alexandria and Knysna types. Montane habitats are present in the mountainous regions, where the tree stature, size and extent varies. In the Amatole mountains, forests are species rich. Alexandra forests have high rainfall, the trees have distinct strata and there is an abundance of tree species. The Knysna forest type has trees with the greatest stature of any trees in South Africa, but is not as rich in species diversity as the other two forests (Lubke et al. 1988A). Forests with no designation (Fo) refers to forests within the collection list referred to in 2.1.1 (housed in the Schönland Herbarium) that were not referred to as either indigenous or as exotic. "Exotic forests" are the forestry plantations of SAFCOL found in the region, which are predominantly composed of Eucalyptus sp. and Pinus species. "Forest margins" (Fm) are the margins of forests where forest species, and a few grassland species, would have to endure climatic ecoclines.

"Banks" refers to the communities present on the banks of streams or rivers and on the margins of dams. "Dams" refers to plants that are aquatic or semi-aquatic and are found in the water of dams or pans. "Marshes" are communities where a large number of wetland species dominate on wet soils, that are predominantly clay based. These soils are wet throughout most of the year and are only dry in prolonged periods of drought. In "rivers or streams" refers to plants that are either aquatic or semi-aquatic are found in streams or rivers and/or plants that were present on the dried river or stream beds.

"Dunes" refers to the plant communities present on the coastal sand dunes, including dune slack communities. "Estuary" is the area of the river that is under tidal influence and would be subjected to fluctuating levels of salinity, where plants would have to be salt tolerant to endure or halophytic in nature.

"Open areas", are defined as areas with little or no vegetation in areas that had been either mechanically cleared of vegetation or had become denuded by climate (not human induced).

"Substratum type" in all cases the is the A horizon layer (the first 30cm of the soil) where the plants were rooted. The descriptive of sand, clay, stone, shale and humus refers to the dominant composition of the soil type in question.

The "soil moisture condition" of the habitat substratum was defined as either wet or dry. This definition was subjective, whether the soil appeared to be wet or dry in the herbarium specimens and in the author's case, whether the soil oozed water when a handful of soil was pressurised. The author took dry to mean no visible moisture present in the soil, within the first 30cm.
3.1. Introduction to the *Abildgaardieae*


3.1.1 The genus *Abildgaardia*

Most of the *Abildgaardia* are believed to be C₄, anatomically fimbristyloid and biochemically NADP-Me (Bruhl 1993). There are only two C₃ species, *Abildgaardia hygrophila* (Gordon Gray) K.Lye and *A. variegata* (Gordon Gray) K.Lye. There are 15 *Abildgaardia* species present in the world. These species are present in eastern Asia, Africa, Australia, the Pacific, North America, South and Central America, New Guinea and the West Indies. The most common habitat is an open habitat, with a hydrophytic to mesophytic environment (Bruhl 1993). Metcalfe (1971) investigated only one species that was collected from Zambia (*A. hygrophi/a*, by KD.Gordon-Gray). Bruhl (1993) investigated the anatomy of two Australian species (*A. ovata* and *A. vaginata*) and one from South Africa (*A. trifolia*).

3.1.2 The genus *Bulbostylis*

*Bulbostylis* is similar to *Abildgaardia* in that members are most common in open habitats that range from helophytic to mesophytic conditions. There are over 100 species that are distributed in eastern Asia, Africa, Australia, the Pacific, North America, South and Central America, New Guinea and the West Indies. Within the subcontinent of southern Africa, seventeen species are recognised (Bruhl 1993). Habitats within Africa are dry and most species are annuals. Many species are now becoming extinct, with the annual species *B. humilis* becoming more abundant (Gordon-Gray 1971).

Bruhl (1993) suggested that all these species are Fimbristyloid, though they approach Eleocharoid anatomy in *B. paradoxa* and are biochemically NADP-Me. However, the species that Bruhl (1995) investigated (*B. lanata* and *B. paradoxa*), were collected in Australasia. The species examined by Govindarajalu (1966), Gordon-Gray (1971) and Metcalfe (1971) all have three-layered bundle sheaths present around the vascular bundles confirming the research of Bruhl (1993) that states the genus *Bulbostylis* is anatomically fimbristyloid. Metcalfe (1971) described nine species, eight of which were collected from Africa north of Zimbabwe. *Bulbostylis capillaris* (L.) C.B.Clarke was collected in America. Prior to this thesis Gordon-Gray (1971) is the only researcher who has investigated southern African species. Gordon-Gray (1971) briefly described the leaf and culm anatomy of *B. contexta*, *B. hispidula*, *B. humilis* and *B. schoenoides*. Metcalfe (1971) suggested that the genera *Abildgaardia*, *Fimbristylis* and *Nelmesia* are closely related to the genus *Bulbostylis*.
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3.1.3 The genus Crosslandia

*Crosslandia* is monotypic (*Crosslandia setifolia* W.V.Fitzgerald). *Crosslandia setifolia* is reported to have a three-layered vascular bundle sheath (Metcalfe 1971; Bruhl 1993) and is anatomically Fimbristyloid. The biochemical type still has to be determined (Bruhl 1993). *Crosslandia setifolia* is common in open mesophytic habitats on quartz soils and is endemic to Australia (Metcalfe 1971; Bruhl 1993). Metcalfe (1971) suggests that *Crosslandia* may be closely related to the genera *Abildgaardia*, *Bulbostylis* and *Fimbristylis*.

3.1.4 The genus Fimbristylis

The vascular bundles in *Fimbristylis* have three-layered sheaths present surrounding the bundles (Gordon-Gray 1971; Metcalfe 1971; Sharma and Mehra 1972; Govindarajulu 1981A & 1982). Anatomically *Fimbristylis* is Fimbristyloid and biochemically NADP-Me. This genus consists of over 300 species. The distribution is as follows: eastern Asia; Africa; the Pacific; North, South and Central America; Australia and New Guinea (Bruhl 1993). The *Fimbristylis* species are common in open, halophytic habitats (Gordon-Gray 1971; Bruhl 1993). In Africa only *F. complanata* is tolerant of saline conditions. *F. dichotoma* and *F. ferruginea* are more abundant in the marshy areas of tropical Africa. Gordon-Gray (1971) briefly described the leaf and culm anatomy of, *F. complanata*, *F. dichotoma* and *F. ferruginea* in southern Africa. Metcalfe (1971) described four species, none from Africa. Metcalfe (1971) has suggested that *Fimbristylis* may be related to the genera *Abildgaardia*, *Bulbostylis* and *Nelmesia*.

3.1.5 The genus Nelmesia

*Nelmesia* like *Crosslandia* is monotypic with one species, *Nelmesia melansostachya* Van der Veken. This species is limited to northern Zaire in tropical Africa, (Metcalfe 1971). The habitat of this species is described as West African Rainforest (Bruhl 1993). The bundle sheath is three-layered (Metcalfe 1971; Bruhl 1993), suggesting this species is anatomically fimbristyloid. The biochemical type has still to be determined (Bruhl 1993).

3.1.6 The genus Nemum

This genus is described as anatomically fimbristyloid, but approaches the anatomical features of the eleocharoid group. The biochemical type has yet to be identified. There are 10 species, which are limited to Africa. These species are distributed from the north to the south of Africa (Bruhl 1993).

3.1.7 The genus Tylocarya

Metcalfe (1971) lists one only species, *T. cylindrostachya*, stating that it is distributed within Thailand and may be associated with the genus *Fimbristylis*. Bruhl (1995) suggest that the anatomical structure of this species approaches that of the fimbristyloid type, and that there may be a relationship between the genera *Tylocarya* and *Fimbristylis*. 
3.2. RESULTS

3.2.1 Species collected in the Eastern Cape

Three genera from this tribe are present in the Eastern Cape region. These genera are as follows: _Abildgaardia_ Vahl, _Bulbostylis_ Kunth ex C.B.Clarke and _Fimbristylis_ Vahl. There are a total of eight _Abildgaardieae_ species present within the eastern Cape. The genus _Abildgaardia_ is represented by only one species _A. ovata_ (Burm.f.) Kral (refer to Appendix 1 for specimens collected). _Bulbostylis_ has four species, _B. contexta_ (Nees) Bodard (Appendix 1), _B. hispidula_ (Vahl) R.W.Haines (Appendix 1), _B. humilis_ Kunth (Appendix 1) and _B. schoenoides_ (Kunth) C.B.Clarke (Appendix 1). _Fimbristylis_ has three species. These species are as follows: _F. complanata_ (Retz.) Link (Appendix 1), _F. dichotoma_ (Linnaeus) Vahl (Appendix 1) and _F. ferruginea_ (Linnaeus) Vahl (Appendix 1).

3.2.2 Distribution and habitats of the _Abildgaardieae_

Based on the records in PRE and GRA, as well as collections, most of the _Abildgaardieae_ are common within inland habitats, with the exception of _F. dichotoma_ and _F. ferruginea_, which were more common in coastal regions (Fig. 3). _B. schoenoides_ was absent from coastal habitats (Fig. 3).

![Figure 3](image)

Figure 3: Shows the distribution of habitats of the _Abildgaardia_ species within the Eastern Cape. The species symbols are as follows: (Ao) _A. ovata_; (Be) _B. contexta_; (Bhi) _B. hispidula_; (Bhu) _B. humilis_; (Bs) _B. schoenoides_; (Fc) _F. complanata_; (Fd) _F. dichotoma_ and (Ff) _F. ferruginea_.

The _Abildgaardia_ and _Bulbostylis_ species both are more common on dry soils (Fig. 4). _A. ovata_, _B. contexta_, _B. hispidula_ and _B. schoenoides_ have only been collected from dry soil habitats. _Fimbristylis_ species are however, only found to be present in wet soils (Fig. 4). The substratum within the habitats is predominantly sandy, with the exception of the habitats of _B. contexta_ and _F. ferruginea_ (Fig. 5).
Figure 4: Condition of the soil in the habitats of the Abildgaardieae species within the Eastern Cape. The species symbols are as follows: (Ao) A. ovata; (Bc) B. contexta; (Bhi) B. hospidula; (Bhu) B. humils; (Bs) B. schoenoides; (Fc) F. complanata; (Fd) F. dichotoma and (Ff) F. ferruginea.

Figure 5: Shows the substratum types of the Abildgaardieae habitats, within the Eastern Cape. The species symbols are as follows: (Ao) A. ovata; (Bc) B. contexta; (Bhi) B. hospidula; (Bhu) B. humils; (Bs) B. schoenoides; (Fc) F. complanata; (Fd) F. dichotoma and (Ff) F. ferruginea.
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The substratum of the habitats of *B. contexta* is mostly sand and stone, with a few specimens present in shale soils. Most of the specimens of *F. ferruginea* collected are present equally on sand and rocky substratum. Most of the *Abildgaardieae* are present in many habitats. (Fig. 6), where the most common habitat is grassland. Only *A. ovata* and *B. hispidula* are habitat specific. *A. ovata* is also present in river habitats, but is mostly present in grassland habitats. *B. hispidula* is only present in grassland habitats (Fig. 6). Even though the *Fimbristylis* species are only present in wet soil substratum, both *F. dichotoma* and *F. ferruginea* have been collected from sand dune habitats in the Eastern Cape Province, from dune slack and estuarine communities.

![Figure 6](image-url)

*Figure 6.* Shows the distribution of habitats in which the *Abildgaardieae* species have been collected from in the Eastern Cape. The species symbols are as follows: (Ao) *A. ovata*; (Bc) *B. contexta*; (Bhi) *B. hispidula*; (Bhu) *B. humilis*; (Bs) *B. schoenoides*; (Fe) *F. complanata* and (Fd) *F. dichotoma*; (Ff) *F. ferruginea*. Habitat symbols are as follows: (Ba) banks of dams, estuaries, marshes, rivers or streams; (Du) dunes; (En) in estuaries; (Fe) exotic forests; (Fn) natural or indigenous forests; (Fy) fynbos; (Gr) grasslands; (Ma) in marshes; (Ri) in rivers and (Th) thickets.
3.2.3 **Leaf Characteristics within the Abildgaardieae**

Leaf outline is variable in the genus *Bulbostylis* ranging from thickly crescentiform (*B. contexta*) to V-shaped (*B. hispidula*). In the genera *Fimbristyli* and *Abildgaardia*, all the leaves are crescentiform. There are no trichomes present in the leaves of the Abildgaardieae.

Most of the leaves are thin (Table 1, Appendix 3), ranging from 63μm (*Bulbostylis humilis*) to 208μm (*F. dichotoma*) in the lamina, with the exception of *Fimbristyli* ferruginea (240-345μm). Midribs are generally thicker than the lamina, with the exception of *B. hispidula*. No distinguishable midribs are present in the hexagonal, *B. humilis* and the crescentiform, *F. dichotoma*. Details of the leaf anatomical characteristics are detailed in Table 1 of Appendix 3.

The adaxial epidermal cells are larger than the abaxial epidermal cells (Table 1 [Appendix 3], Plate 1.1). The adaxial epidermal cell height ranges from 5μm (*B. humilis*) to 105μm (*F. ferruginea*). Abaxial epidermal cell height ranges from 5μm (*B. schoenoides*) to 54μm (*F. ferruginea*). The outer periclinal wall of the epidermal cells are two to three times thicker than the inner periclinal and anticlinal walls (Plate 1.2). Generally adaxial and abaxial epidermal cells are oval to rectangular in shape. The epidermal cells in *B. contexta* and *B. humilis* are circular to square. Most adaxial and abaxial epidermal cells lack cone-shaped silica deposits, which sometimes are present in the epidermal cells that abut the hypodermal sclerenchymatous strands (HSS, Plate 1.2).

With the exception of *B. humilis* and *F. complanata* (slightly raised stomata, Plate 1.3), stomata are generally flush within the abaxial epidermal surfaces (Plate 1.4). The thickening of the guard cells walls of the stomata is variable (Plate 1.3-4, Appendix 4). Sub-stomatal cavities are small (Plate 1.5) and range from absent (*B. hispidula* and *B. humilis*) to 72μm (*F. ferruginea*).

HSS are composed of small, oval to square, highly lignified cells (Plate 1.2 and 1.6-9). The HSS are present adjacent the adaxial hypodermis in *F. ferruginea* (Plate 1.6) and adjacent the large bundles in *B. humilis*. The HSS are present adjacent the adaxial and abaxial epidermis (Plate 1.2 and 1.7-10, Appendix 4). HSS outline is variable (Plate 1.2 and 1.7-10, Appendix 4). HSS are present adjacent all vascular bundles in the leaf and/or with large, intermediate, as well as marginal bundles (Plate 1.9). The adaxial HSS are mostly smaller than the abaxial HSS, with the exception of *B. schoenoides* and *F. complanata* (Table 1, Appendix 3). The variability in the numbers of HSS is illustrated in Table 1 (Appendix 3).

The number of HSS present adjacent the midrib is variable. Both *B. hispidula* and *F. dichotoma* (Plate 1.10) have an adaxial HSS present above the midrib. No abaxial HSS are present adjacent the midrib bundle in *B. hispidula*. One abaxial HSS is present adjacent the midrib bundle in *A. ovata, B. contexta, B. schoenoides, F. complanata* and *F. dichotoma*. There are two abaxial HSS present adjacent the midrib bundle in *F. ferruginea*.
Plate 1. Shows structural details of the leaf blades of the *Abildgaardieae* in transverse section, including the structure, arrangement and distribution of cone-shaped silica deposits; adaxial and abaxial epidermis; adaxial, abaxial and marginal hypodermal sclerenchymatous strands; hypodermis; lamina cavities; silica deposits on epidermal surfaces; stomata and sub-stomatal cavities; vascular bundle arrangement and vascular bundle spacing, as well as vascular tissues.

(1.1) Shows the adaxial and abaxial epidermis of *Fimbristylis complanata*, which is thick-walled in the outer periclinal wall. The adaxial epidermal cells are larger than the abaxial epidermal cells. The adaxial hypodermis is thin-walled. The midrib vascular bundle is surrounded by radiating chlorenchyma and three vascular sheaths. The outer sheath is parenchymatous, the second sheath is a lignified mestome sheath and the inner sheath is the Kranz sheath, which is interrupted by two large metaxylem vessels. A large protoxylem lacuna is present at the xylem pole. (1.2) *Abildgaardia ovata* showing part of the abaxial epidermis and an abaxial hypodermal sclerenchymatous strand. Note the cone-shaped silica deposit in the abaxial epidermal cell that abuts the hypodermal sclerenchymatous strand. The cells of the epidermis are thick-walled in the outer periclinal wall. (1.3) A raised abaxial stoma in *F. complanata*, with lignified guard cells, un lignified subsidiary cells and a small sub-stomatal cavity. (1.4) Shows the flush abaxial stoma of *A. ovata* with lignified guard cells and subsidiary cells. Note that the sub-stomatal cavity in this species is small. The epidermal cells that are adjacent the stoma are thick-walled in the outer periclinal wall. (1.5) A flush abaxial stoma in *Bulbostylis schoenoides*, where the sub-stomatal cavity is continuous with the lamina cavity. Note particularly the translucent "blue" parenchyma that is present in the cavity. The abaxial epidermal cells that are adjacent to the stoma are thick-walled in the outer periclinal walls. (1.6) An adaxial hypodermal sclerenchymatous strand in *F. ferruginea* that is present abutting the hypodermis. (1.7) An abaxial hypodermal sclerenchymatous strand exists in *F. complanata*, and the abutting epidermal cell has numerous, small, cone-shaped silica deposits. Note particularly that the epidermal cell abutting the hypodermal sclerenchymatous strand is also smaller than the adjacent epidermal cells. (1.8) Details of the margin in *F. ferruginea* showing a marginal hypodermal sclerenchymatous strand and abutting epidermal layers. The abaxial stoma has lignified guard cells and relatively thin-walled subsidiaries, with sub-stomatal cavity. Epidermal cells are thick-walled in the outer periclinal wall. (1.9) Shows a portion of the lamina in *F. ferruginea*, where the abaxial epidermis is thick-walled in the outer periclinal wall. The adaxial hypodermis has large cells that are relatively thin-walled. Note that there are adaxial and abaxial hypodermal sclerenchymatous strands present adjacent the large vascular bundle. The large vascular bundle has a protoxylem lacuna. Vascular bundles have lamina cavities present between each vascular bundle and around the smaller vascular bundles. (1.10) A portion of the lamina in *F. dichotoma* with large adaxial hypodermis cells. The cells of the adaxial epidermis have thickened outer periclinal wall. The midrib vascular bundle has an adjacent adaxial and abaxial hypodermal sclerenchymatous strands. The midrib vascular bundle also has a large protoxylem lacuna. (1.11-12) *F. complanata* with indistinct silica deposits on abaxial epidermal surface. The outer periclinal wall of the epidermal cells are thick-walled.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (B) translucent "blue" parenchyma; (C) cone-shaped silica deposit; (Ca) lamina cavity; (HSS) hypodermal sclerenchymatous strand; (Hy) hypodermis; (L) large vascular bundle; (Md) midrib vascular bundle; (MX) metaxylem vessels; (PxL) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (Si) silica deposit; (St) stoma; (Stc) sub-stomatal cavity; (Su) subsidiary cell and (T) tannin idioblast. Bars = 10 µm.
Plate 1. Legend on facing page.
Lamina cavities are mostly absent in this tribe, whilst in *B. schoenoides* and *F. ferruginea* lamina cavities are present (Plate 1.9). The lamina cavities are present between the vascular bundles. The lamina cavities in *B. schoenoides* are triangular in outline, whilst *F. ferruginea* has oval-shaped cavities (Appendix 4). Translucent tissue (translucent "blue" parenchyma because of the cell contents absorbing the fast green stain, Plate 1.5) is present within the lamina cavities of *B. schoenoides* and stellate parenchyma in *F. ferruginea*. Lamina cavities are small (Table 1, Appendix 3), ranging from 9 μm (*B. humilis*) to 64 μm (*B. schoenoides*).

Tannin is usually present within thin-walled cells, which are mostly scattered throughout the mesophyll (Plate 1.10). Generally few of these cells were observed in most species. *B. contexta* however, has many tannin idioblasts scattered throughout the mesophyll of its leaves. Silica is present in the form small bulbiform to baculiform deposits on the surfaces of the adaxial and abaxial epidermal cells in *F. complanata* (Plate 1.11-12).

All species have an adaxial hypodermis (Plate 2.1-3), except *B. humilis*. The hypodermal cells are thin-walled and translucent. The hypodermis thickness ranges from 1-6 cells in *F. dichotoma* to 1-2 cells in *B. contexta* (Table 1, Appendix 3). The shape of these cells ranges from oval to rectangular and may be squashed in appearance.

The mesophyll in most of the species is composed of thin-walled, chlorenchymatous parenchyma that appear to radiate (the long axis of the chlorenchyma is present at right angles to the outer sheath of the vascular bundles) around the vascular bundles (Plates 1.1, 1.9 and 2.3-4). The chloroplasts in the radiate mesophyll cells (RM) are small and numerous. In addition to the RM, *B. humilis* also has non-lignified, translucent parenchyma (TP) present in its leaves. The TP in this species is present on the xylem pole of the large vascular bundles, where it interrupts the RM, and extends to the centre of the leaf. The cells of the TP are triangular to rectangular in shape, thin-walled and squashed in appearance.

All the vascular bundles are present in one row within the leaf (Plates 1.9 and 2.1-2). The maximal cell distal count between the vascular bundles of all the *Abildgaardieae* species is less than three cells (Table 1, Appendix 3), with the exception of *B. schoenoides* (where the maximal cell count is 4 cells).

A number of species lack certain vascular bundles (Table 1, Appendix 3). *B. humilis* and *F. dichotoma* have no midrib bundle. *A. ovata*, *B. contexta*, *B. hispidula* and *B. schoenoides* lack large bundles (Table 1, Appendix 3). Intermediate bundles are absent in *B. schoenoides*. Small bundles are absent in the leaves of *B. contexta*, *B. hispidula* and *B. schoenoides*. *B. humilis* has no marginal bundles.

Three sheaths surround all vascular bundles, an outermost thin-walled parenchymatous sheath (PS), a middle lignified mestome sheath (MS) and an inner Kranz sheath (KS, Plate 2.4-12). The cells of the PS are generally small, thin-walled and chlorenchymatous (Plate 2.4-12). The cells of the MS are generally small, lignified and are approximately similar to the PS cells in size (Plate 2.4-12). The lignification within the MS cells of the *Abildgaardieae* is variable (Appendix 4), but is mostly thicker in the radial and inner tangential walls. The lignification within the MS cells in *B. hispidula* and *B. schoenoides* is similar in all the walls. The MS walls in *F. complanata* are lignified as in *B. hispidula* and *B. schoenoides*, but with the lignification being more pronounced abutting the large metaxylem vessels (MX).
Plate 2. Shows structural details of the leaf blades of the *Abildgaardieae* in transverse section, including the arrangement and distribution of adaxial and abaxial epidermis, hypodermis, lamina cavities, mesophyll structure, including translucent parenchyma, radiating chlorenchyma structure, vascular bundle arrangement, vascular bundle spacing and vascular sheath organisation, as well as vascular tissues.

(2.1) Shows *Fimbristylis complanata* with thick-walled outer periclinal wall in the adaxial and abaxial epidermal cells. The cells of the adaxial epidermis are larger than the abaxial epidermis. Note particularly the thin-walled adaxial hypodermis. The abaxial hypodermal sclerenchymatous strands are present adjacent the intermediate and midrib vascular bundle. (2.2) The large celled adaxial hypodermis in *F. ferruginea*. The adaxial epidermal cells are larger than the abaxial epidermal cells. An abaxial hypodermal sclerenchymatous strand is present adjacent the large vascular bundle. Lamina cavities are present between the vascular bundles. (2.3) Shows *Bulbostylis hispida* where the hypodermis extends to the radiating chlorenchyma of vascular bundles. The adaxial epidermal cells are larger than the abaxial epidermal cells. The cells of the epidermis are thick-walled in the outer periclinal wall. Vascular bundles are one to three cells apart. (2.4) The midrib vascular bundle in *F. complanata* with radiating chlorenchyma and three vascular sheaths, an outer chlorenchymatous sheath of parenchyma, a middle lignified mestome sheath and inner Kranz sheath. Both the parenchymatous sheath and Kranz sheath are thin-walled. Note that the Kranz sheath is interrupted by two large metaxylem vessels. There is also a large protoxylem lacuna present at the xylem pole of the vascular bundle. (2.5) Shows a large vascular bundle in *F. complanata*. There are three vascular sheaths, the outer sheath is parenchymatous, the middle sheath is the mestome sheath and the inner sheath is the Kranz sheath. Both the outer and inner sheaths are thin-walled, whilst the mestome sheath is thick-walled. The Kranz sheath is interrupted by four metaxylem vessels. The chloroplasts of the Kranz sheath are large and almost fill the whole cell. The protoxylem lacuna of this large vascular bundle is small. (2.6) An intermediate vascular bundle in *F. complanata* where radiating chlorenchyma abuts the vascular bundle. There are three sheaths, an outer parenchymatous sheath, a middle mestome sheath and an inner Kranz sheath. Note that the Kranz sheath is interrupted by two small metaxylem vessels. The chloroplasts of the Kranz sheath are so large that they almost fill the cell. (2.7) A small vascular bundle in *F. complanata*, where radiating chlorenchyma surrounds the vascular bundle. There are three vascular sheaths, an outer parenchymatous sheath, a middle mestome sheath and an inner Kranz sheath. The protoxylem lacuna of this large vascular bundle is small. (2.8) A marginal vascular bundle in *F. complanata*, where radiating chlorenchyma abuts the vascular bundle. There are three vascular sheaths, an outer parenchymatous sheath, a lignified middle mestome sheath and an inner Kranz sheath. The Kranz sheath is interrupted by two large metaxylem vessels. The Kranz sheath chloroplasts are large. There is also a large protoxylem lacuna present in this vascular bundle. Abaxial epidermal cells are thick-walled in the outer periclinal wall. (2.9) The midrib vascular bundle in *B. schoenoides*, with three vascular sheaths, an outer parenchymatous sheath, a lignified middle mestome sheath and an inner Kranz sheath. Radiating chlorenchyma abuts the parenchymatous sheath. Note in particular that the metaxylem vessels do not interrupt the Kranz sheath. The chloroplasts of the Kranz sheath are large and almost fill the cell. There is also a large protoxylem lacuna present within the vascular bundle. (2.10) The marginal vascular bundle of *B. schoenoides*, where radiating chlorenchyma surrounds most of the vascular bundle. There are three vascular sheaths, an outer parenchymatous sheath, a lignified middle mestome sheath and an inner Kranz sheath. Note also that no large metaxylem vessels interrupt the Kranz sheath. The Kranz sheath chloroplasts are large and almost fill the cell. (2.11) Shows a large vascular bundle in *B. humilis*. Abutting the xylem pole of the vascular bundle is translucent parenchyma, whilst radiating chlorenchyma is present abutting the rest of the vascular bundle. Four vascular sheaths are present in this large vascular bundle, a partial outer parenchymatous sheath, a lignified mestome sheath, an inner partial Kranz sheath on the phloem side of the vascular bundle and an inner partial sheath of border parenchyma, which is present on the xylem side of the vascular bundle. Separating the sheath of border parenchyma and the Kranz sheath are two large metaxylem vessels. Present within the vascular bundle is a large protoxylem lacuna. (2.12) The chlorenchyma in *B. humilis* extends from the epidermis to the xylem pole of the small vascular bundles and the phloem side of the large vascular bundles. The chlorenchyma is thin-walled and radiate in appearance. Endarch to the chlorenchyma is thin-walled translucent parenchyma. Lamina cavities occur between vascular bundles. Abutting the epidermis are hypodermal sclerenchymatous strands that occur adjacent to each vascular bundle. Epidermal cells have thickened outer periclinal walls.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (Ca) lamina cavity; (Ep) epidermal cell; (Hy) hypodermis; (I) intermediate vascular bundle; (KS) Kranz sheath; (L) large vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (PS) parenchymatous sheath; (Pl) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10µm.
Plate 2. Legend on facing page.
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The KS is bisected by MX in the midrib, large, intermediate and marginal bundles, with the exception of *B. schoenoides*. In *B. schoenoides* the KS of the midrib and marginal bundles is not interrupted by the MX (Plate 2.9-10). The walls of the KS are generally thin-walled. The chloroplasts in the KS are usually so large that they fill the entire cell, with the exception of *B. hispidula* and *B. humilis*, where large and small chloroplasts are present. In all cases the chloroplasts were centrifugal in position. The KS is absent on the xylem half of the large bundles in *B. humilis*, where it was replaced by thin-walled, border parenchyma (Plate 2.5 and 2.12.).

The outline of the phloem is variable, but less so than with the xylem (Appendix 4). The midrib bundle, the large and marginal bundles mostly have V-shaped xylem. There is variability in the outline of the xylem in the intermediate and small bundles (Appendix 4). Other than the large bundles, protoxylem lacunae (PxL) mostly occur in all cases. The KS is absent on the xylem half of the large bundles in *B. humilis*, where it was replaced by thin-walled, border parenchyma (Plate 2.5 and 2.12.).

### 3.2.4 Bract Characteristics within the tribe *Abildgaardieae*

Apart from *B. hispidula*, which did not have bracts, there are four bract shapes recognisable within this tribe, namely semi-circular (*A. ovata, B. contexta* and *F. ferruginea*), V-shaped (*B. humilis* and *F. complanata*), triangular (*B. schoenoides*) and rectangular (*F. dichotoma*). There are no trichomes present in the bracts of the *Abildgaardieae*. Bracts range in thickness from 72µm (*B. contexta* and *F. complanata*) to 413µm (*B. humilis* [Table 2, Appendix 3]).

Adaxial cell thickness is variable, ranging from 5µm (*B. humilis*) to 49µm (*F. dichotoma*). Generally abaxial epidermal cells were smaller (Table 2, Appendix 3), with the exception of *B. humilis*. The abaxial epidermal cells in *B. humilis* are larger than the adaxial epidermal cells. Abaxial epidermal cell thickness ranges from 5µm (*B. contexta* and *B. schoenoides*) to 27µm (*F. ferruginea*). Bulliform cells are absent in the *Abildgaardieae* bracts. The epidermal cells are thin-walled in the inner periclinal and anticlinal walls (Plate 3.1), whilst the outer periclinal wall is significantly thicker and lignified.

Cone-shaped silica deposits in the epidermal cells that abut the HSS occur in both the adaxial and abaxial epidermis (Plate 3.2-4). In both *B. schoenoides* and *F. ferruginea* there are more cones in the adaxial epidermal cells than the abaxial epidermal cells.

The stomata in the genera *Abildgaardia* and *Bulbostylis* are generally flush with the epidermal surfaces (Plate 3.1). *F. complanata* and *F. dichotoma* have slightly raised stomata. *F. ferruginea* has slightly sunken stomata. Lignification within the guard cells is detailed in Appendix 4. The sub-stomatal cavities in this tribe are small, ranging from no cavities (*B. schoenoides* and *F. ferruginea*) to 45µm (*B. contexta* [Table 2, Appendix 3]).

The HSS thickness/height is small (Table 2, Appendix 3), ranging from 4µm (*B. schoenoides*) to 29µm (*F. dichotoma*). Abaxial HSS are smaller than the adaxial, with the exception of *B. humilis* and *F. ferruginea*. Abaxial HSS range from 7µm (*B. contexta*) to 24µm (*F. ferruginea*). The HSS number and distribution is illustrated in Table 2 (Appendix 3) and Plate 3. All the HSS are thick-walled, lignified and variable in outline (Appendix 4, Plate 3.2-6).
Plate 3. Shows structural details of the bract blades of the Abildgaardieae, in transverse section, including the structure and arrangement of the adaxial and abaxial epidermis, cone-shaped silica deposits, hypodermis, hypodermal sclerenchymatous strands, lamina cavities, silica deposits, stomata and sub-stomatal cavities, tannin idioblast structure and arrangement, vascular bundle arrangement and spacing.

(3.1) Shows the abaxial epidermis of B. schoenoides with a flush stoma. The outer periclinal wall of the epidermis is thick-walled. The subsidiary cell of the stoma and the guard cells are relatively thin-walled. The sub-stomatal cavity of the stoma is small. (3.2) An adaxial hypodermal sclerenchymatous strand in F. complanata with abutting cone-shaped silica deposit. (3.3) An adaxial hypodermal sclerenchymatous strand in B. humilis with abutting cone-shaped silica deposit. (3.4) The margin in F. dichotoma with marginal adaxial and abaxial epidermal cells. Note particularly the thick-walled outer periclinal wall of the epidermis. The marginal hypodermal sclerenchymatous strand has an abutting cone-shaped silica deposit. (3.5) An adaxial hypodermal sclerenchymatous strand with abutting hypodermis in F. complanata. Tannin idioblasts also but the hypodermal sclerenchymatous strand. (3.6) Shows the adaxial epidermal cells in B. contexta, which are larger than the abaxial epidermal cells. The outer periclinal wall of the epidermal cells are relatively thick-walled. The adaxial hypodermis is crushed in appearance. Lamina cavities are present between the vascular bundles. (3.7) Shows the thick-walled adaxial epidermal cells in A. ovata with abutting hypodermis. Radiating chlorenchyma abuts the parenchymatous sheath of a large vascular bundle. (3.8) Midrib vascular bundle in adaxial row in B. humilis. Adaxial hypodermis imbedding adaxial row of vascular bundles. Adaxial epidermal cells larger than abaxial epidermal cells. Tannin idioblasts present in radiating mesophyll of vascular bundles. (3.9) The adaxial hypodermis in B. humilis extends to the radiating chlorenchyma of the vascular bundles. The abaxial epidermis is thick-walled in the outer periclinal wall. Tannin idioblasts are scattered at random within the radiating mesophyll. Vascular bundles are one to three cells apart. There are two rows of vascular bundles, where the midrib is present above the abaxial row of vascular bundles and is surrounded by the adaxial hypodermis. (3.10) The cells of the lamina adaxial hypodermis are large in size and thin-walled in B. humilis. There are two rows of vascular bundles in the lamina. (3.11) Indistinct silica deposits are present on the adaxial surface of the lamina in F. complanata. (3.12) The lamina in B. schoenoides where the adaxial and abaxial epidermal cells have thick-walled outer periclinal wall. The vascular bundles sheaths and vasculature are mixed.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (C) silica cone; (Ca) lamina cavity; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (RM) radiating mesophyll; (S) small vascular bundle; (Si) silica deposit; (St) stoma; (Stc) sub-stomatal cavity and (T) tannin idioblast. Bars = 10μm.
Plate 3. Legend on facing page.
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The location of the HSS within the bracts is variable between the genera (Appendix 4), with the exception of the midrib region. The bundles in B. schoenoides are not present adjacent to HSS. The abaxial HSS are present adjacent to all the bundles in B. humilis. The midrib vascular bundle in all species generally has one adjacent abaxial HSS. F. dichotoma had an additional adaxial HSS present adjacent to the midrib bundle. Both adaxial and abaxial HSS are present adjacent the large, as well as intermediate bundles in F. dichotoma. Adaxial HSS are present adjacent to the marginal bundles in A. ovata and B. contexta. The large bundles in F. complanata are present adjacent the abaxial HSS. The intermediate bundles in A. ovata, B. contexta, F. complanata and F. ferruginea all have adjacent abaxial HSS. Abaxial HSS are present adjacent the marginal bundles in F. dichotoma.

B. contexta is the only species, that has lamina cavities within the bracts (Plate 3.6). The cavities occurred between the vascular bundles, were continuous with the sub-stomatal cavities (Table 2, Appendix 3).

An adaxial hypodermis ranging from 1 to 7 cells in thickness is present within the bracts of the Abildgaardieae (Table 2 [Appendix 3], Plate 3.6-10). Hypodermal cells are generally thin-walled, oval to rectangular in shape and in many, the cells appear squashed. None of the bracts in the Abildgaardieae species have an abaxial hypodermis.

Tannin is present in small, thin-walled cells. The tannin idioblasts are generally few and randomly scattered within the mesophyll. However, tannin idioblasts in B. humilis are present only in the RM surrounding the vascular bundles (Plate 3.8 and 3.10). In A. ovata and F. dichotoma there are many scattered tannin idioblasts. Silica deposits other than the cone-shaped silica deposits are present in the epidermal cells of F. complanata, where small irregular shaped deposits of silica are present on the adaxial and abaxial epidermal surfaces (Plate 3.11).

The mesophyll is generally composed of thin-walled RM (Plate 3.7 and 3.10). Additionally within the mesophyll of the genus Bulbostylis there are a few rounded translucent parenchyma cells that are scattered throughout the mesophyll. Especially in B. humilis where these cells are present abutting the sub-stomatal cavities.

Generally vascular bundles occur in one row within the lamina of the bracts (Plate 3.9). The bundles in B. humilis occur within two rows, in an adaxial and an abaxial row (Plate 3.8 and 3.10). The adaxial row consists of the midrib bundle, the intermediate and marginal bundles, whilst the abaxial row consists entirely of small bundles.

The maximal cell distal count is generally zero or one cell (Table 2, Appendix 3), with the exception of B. contexta (2-4 cells). The number and presence of bundles is variable (Table 2, Appendix 3). A midrib bundle is present in all species. Large bundles are absent in A. ovata, the genus Bulbostylis and F. complanata. Intermediate bundles are absent only in B. schoenoides. Small bundles are absent in A. ovata, B. contexta and B. schoenoides.

Most bundles are characterised by the presence of three vascular bundle sheaths and an abutting RM, with the exception of B. humilis and B. schoenoides. B. humilis, which lacks the outer sheath (Plates 3.8, 3.10 and 4.1-5). B. schoenoides lacks RM (Plate 4.6). The outer sheath is a parenchymatous sheath (PS, Plate 4.6-8), the middle sheath is a lignified mestome sheath (MS, Plate 4.6-8) and the inner sheath is a non-lignified Kranz sheath (KS, Plate 4.1-8). The sheaths in the midrib bundle and marginal bundles are mixed with the vasculature in B. schoenoides (Plates 3.12 and 4.6-7), where the sheaths are only distinctive at the xylem and phloem poles (Plate 4.6). In one of the
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Plate 4. Shows structural details of the bract blades of selected Abildgaardieae species in transverse section, detailing the abaxial epidermis structure, radiating chlorenchyma arrangement and structure, vascular sheath and vascular tissue structure.

(4.1) Shows the midrib vascular bundle in B. humilis with abutting radiating chlorenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner thin-walled Kranz sheath. The Kranz sheath is interrupted by two large metaxylem vessels. There is a small protoxylem vessel present at the xylem pole of the vascular bundle. (4.2) An intermediate vascular bundle in the lamina of B. humilis, with abutting radiating chlorenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner thin-walled, Kranz sheath. The Kranz sheath has one metaxylem vessel interrupting the sheath. (4.3) Another intermediate vascular bundle in B. humilis, where two metaxylem vessels interrupt the Kranz sheath. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. Radiating mesophyll surrounds the mestome sheath. The chloroplasts of the Kranz sheath are so large that they fill the cell. (4.4) Shows a small vascular bundle in the lamina of B. humilis with abutting radiating chlorenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner thin-walled Kranz sheath. Note that the Kranz sheath is not interrupted by xylem vessels. The chloroplasts of the Kranz sheath are large in size. (4.5) A marginal vascular bundle in B. humilis with abutting radiating chlorenchyma. There are also two vascular sheaths, where the outer lignified sheath is the mestome sheath and the inner sheath is the Kranz sheath. The Kranz sheath is not interrupted by xylem vessels. The chloroplasts of the Kranz sheath are also large in size. (4.6) The midrib vascular bundle in B. schoenoides with a partial sheath at the adaxial and abaxial pole of the vascular bundle. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner Kranz sheath. The vascular tissues are mixed in appearance. The abaxial epidermis also has a lignified outer periclinal wall. (4.7) The intermediate vascular bundles in F. dichotoma. (4.8) An intermediate vascular bundle in the lamina of F. ferruginea with three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner Kranz sheath. The Kranz sheath is interrupted by two metaxylem vessels. and that these chloroplasts are smaller than those of F. dichotoma. Note in particular the centrifugal location of the chloroplasts in the Kranz sheath. (4.9) The marginal vascular bundle in B. schoenoides and abaxial epidermis. The abaxial epidermis has a thick-walled outer periclinal wall. The marginal vascular bundle has no sheaths and the vascular tissues are mixed in appearance.

Symbols are as follows: (Ab) abaxial epidermis; (Ca) lamina cavity; (Hy) hypodermis; (KS) Kranz sheath; (Mixed) mixed vascular tissues; (MS) mestome sheath; (MX) metaxylem vessels; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle and (T) tannin idioblast. Bars =10μm.
marginal bundles of *B. schoenoides* the sheaths and vasculature are mixed so that no one tissue can determined (Plate 4.9).

Plate 4. Legend on facing page.

The cells of the PS are thin-walled, with few small chloroplasts. In *F. complanata* and *F. dichotoma* however, many chloroplasts are present in the PS. In most instances the PS and MS cells are similar in size, except in *A. ovata* where PS cells are much larger than the MS cells. MS cells are small, translucent and lignified. Generally thick-walls are present within the inner tangential and radial walls of the MS. The lignification in the MS cells in *F. complanata* is similar in all walls. Plate 4 shows examples of the lignification of the MS in the vascular bundles in
the *Abildgaardieae* bracts, these differences are highlighted in Appendix 4. Generally the KS surrounds the whole bundle. In both *B. contexta* and *B. schoenoides* the KS is absent in the midrib bundle on the phloem side of the bundle. Additionally the KS is also absent in the marginal bundles of *B. schoenoides* (Plate 4.9). Border parenchyma (BP) is present in *B. contexta*, abutting the MS and the MX. The KS cells contain large centrifugal chloroplasts (1-3 cells on average (Plates 3.7 and 4.9). Chloroplast position was often difficult to determine especially when the chloroplasts were large (see Plate 4.2-5 and 4.7).

The xylem in the midrib bundle of *B. schoenoides* is mixed in outline, as well as the phloem and xylem of the marginal bundles (mixed: no discernible shape, Plate 4.7). The outline of the xylem and phloem is detailed in Appendix 4. Protoxylem lacunae (PxL) are present in the midrib bundles in *B. contexta, B. humilis, F. complanata* and *F. dichotoma* (Plate 4.1). PxL are also present in the marginal bundles of *F. dichotoma*.

### 3.2.5 Culm Characteristics within the tribe *Abildgaardieae*

Generally the culm outline of the *Abildgaardieae* is circular to oval, with a wavy outline. *B. contexta* has acutely triangular culms and *B. schoenoides*, triangular with a wavy outline (the waviness of the outline is present adjacent the HSS, Plate 5.1-2). There are no trichomes present in the culms of the *Abildgaardieae*. Culm size ranges from 51µm (*B. schoenoides*) to 799µm (*F. ferruginea*, Table 3, Appendix 3).

The epidermal cell shapes are oval to rectangular. The height of the epidermal cells abutting the HSS is smaller than the epidermal cells abutting the HSS, with the exception of *B. contexta* (Plate 5.2). The outer periclinal walls of the epidermal cells are thicker than the inner periclinal and anticlinal walls (Plate 5.1-6). The epidermal cell height is small (Table 3, Appendix 3), ranging from 4µm (*F. complanata*) to 30µm (*F. ferruginea*).

The stomata in most of the species are flush with the epidermal surface (Plate 5.5), with the exception of *F. ferruginea*, which has sunken stomata. The sub-stomatal cavity size varies (Table 3, Appendix 3), ranging from 11µm (*F. complanata*) to 45µm (*B. hispidula, B. humilis* and *F. ferruginea*). No sub-stomatal cavities are present in *A. ovata*.

Hypodermal sclerenchymatous strands (HSS) occur in all species, where the thickness/height is small (Table 3, Appendix 3), ranging from 6µm (*F. complanata*) to 69µm (*F. dichotoma*). The number of HSS is the largest in the species with the biggest culms (*F. dichotoma*). HSS outline is variable (Appendix 4). SS are present on the xylem poles of the large bundles in *B. contexta, B. humilis* and *F. dichotoma* (Plate 5.7-8), as well as the xylem pole of the intermediate vascular bundles in *B. contexta*.

Cavities are present in only *B. contexta, B. schoenoides* and *F. complanata*. The cavities are present just inside the outer row of vascular bundles (Plate 5.4), as well as being present in the central regions of the culm in *B. contexta* (Plate 5.2). Present within the cavities of *B. schoenoides* and *F. complanata* are cells of thin-walled, translucent "blue" parenchyma. The size of the outer cavities range from 22µm (*B. schoenoides*) to 92µm (*F. complanata*). The central cavity in *B. contexta* is much larger than the outer cavities, ranging from 255µm to 311µm (Table 3, Appendix 3).
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Plate 5. Shows structural details of the culms of a few selected Abildgaardiae in section, illustrating the arrangement and distribution of the epidermis; ground tissue structure; hypodermal sclerenchymatous strands and abutting cone-shaped silica deposits; sclerenchymatous strands; stomatal structure; vascular bundle arrangement; and vascular sheath structure, as well as vascular tissues.

(5.1) Shows A. ovata with thick-walled outer periclinal wall of epidermis. One row of vascular bundles is present close to the epidermis. Surrounding these vascular bundles is radiating chlorenchyma, which is absent both on the xylem pole of the large vascular bundles and on a few intermediate vascular bundles. Hypodermal sclerenchymatous strands are to adjacent all vascular bundles. Abutting the radiating chlorenchyma and xylem pole of the larger vascular bundles is translucent parenchyma. The translucent parenchyma extends to the centre of the culm. (5.2) The epidermal cells in B. contexta are thick-walled in the outer periclinal wall. Hypodermal sclerenchymatous strands are present adjacent to the inner row of vascular bundles and a few of the outer row of small vascular bundles. Cavities are present between the outer row vascular bundles and in the central translucent parenchyma region. Radiating chlorenchyma surrounds the outer row of vascular bundles and abuts the phloem side of the second row of large vascular bundles. Translucent parenchyma abuts the chlorenchyma and extends to the centre of the culm. (5.3) The epidermis in B. contexta where the cell abutting the hypodermal sclerenchymatous strand is smaller than the adjacent cells and contains a cone-shaped silica deposit. The epidermal cells abutting the cell containing the silica deposit are thick-walled in the outer periclinal wall, whilst the cell with the silica is thin-walled in the outer periclinal wall. (5.4) Shows that the outer periclinal wall of the epidermal cells in B. schoenoides are thick-walled. Hypodermal sclerenchymatous strands are present adjacent to all vascular bundles. Radiating chlorenchyma abuts the vascular bundles, but is absent at the xylem pole of the vascular bundles. Thin-walled chlorenchyma is present between the vascular bundles, the hypodermal sclerenchymatous strands and the epidermis. Abutting the xylem pole of the vascular bundles is translucent parenchyma, which extends to the centre of the culm. Cavities are present between the vascular bundles. (5.5) Illustrates the epidermis of A. ovata, where the outer periclinal wall of the cell is lignified. Stoma have lignified guard cells and small sub-stomatal cavities. Note the hypodermal sclerenchymatous strand with abutting small epidermal cells and larger adjacent epidermal cells. (5.6) Shows the epidermis in B. schoenoides with lignified outer periclinal wall. Note the smaller epidermal cells abutting hypodermal sclerenchymatous strand and the larger epidermal cells adjacent to the strand. (5.7) An outer large vascular bundle in F. dichotoma with abutting sclerenchymatous strand. The abutting radiating chlorenchyma is present on the phloem side of the vascular bundle. Translucent parenchyma is present on the xylem side of the vascular bundle. There are four vascular sheaths present, the outer sheath is the parenchymatous sheath, the second sheath of lignified cells is the mestome sheath and the inner sheath on the phloem side of the vascular bundle is the Kranz sheath. The inner sheath on the xylem side is composed of border parenchyma. The parenchymatous sheath, Kranz sheath and sheath of border parenchyma are chlorenchymatous. Separating the Kranz and border parenchymatous sheath are two large metaxylem vessels. Both the sheath of border parenchyma and the Kranz sheath are chlorenchymatous. The chloroplasts of the border parenchyma are small, whilst those of the Kranz sheath are large and almost fill the cell. There is a large protoxylem lacuna that does not interrupt the sheath of border parenchyma at the xylem pole of the vascular bundle. (5.8) An inner large vascular bundle in F. dichotoma with abutting sclerechymatous strands and translucent parenchyma surrounding the xylem side of the vascular bundle. The arrangement of sheaths and protoxylem lacuna is the same as for the outer large vascular bundles. (5.9) An outer large vascular bundle in F. ferruginea with radiating chlorenchyma abutting the phloem side of the vascular bundle. The arrangement of sheaths and protoxylem lacuna is the same as for the outer large vascular bundles of F. dichotoma, except that the chloroplasts of the Kranz sheath are small. (5.10-11) Outer intermediate vascular bundles in F. ferruginea with radiating chlorenchyma. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner Kranz sheath. The chloroplasts of the parenchymatous sheath are small, whilst those of the Kranz sheath are large. The chloroplasts of the Kranz sheath are centrifugal in location. The Kranz sheath is interrupted by two metaxylem vessels. (5.12) An outer large vascular bundle in B. hispidula with abutting radiating chlorenchyma, which is absent at the xylem pole of the vascular bundle. There are four sheaths present in the vascular bundle, an outer parenchymatous sheath, the middle sheath mestome sheath, an the inner partial Kranz sheath and an inner partial sheath is composed of border parenchyma. The parenchymatous sheath has small chloroplasts and is absent at the xylem pole of the vascular bundle. The mestome sheath is composed of lignified cells and surrounds the whole vascular bundle. The Kranz sheath is present on the phloem side of the vascular bundle. The sheath of border parenchyma is limited to the xylem side of the vascular bundle. Separating the sheath of border parenchyma and the Kranz sheath are two large metaxylem vessels. Both the Kranz sheath and sheath of border parenchyma are chlorenchymatous. The chloroplasts of the sheath of border parenchyma are small, whilst the chloroplasts of the Kranz sheath are large and centrifugal in location. A protoxylem lacuna is present near the xylem pole of the vascular bundle, where it does not interrupt the sheath of border parenchyma.

Symbols are as follows: (BP) border parenchyma; (C) cone-shaped silica deposit; (Ca) cavity; (HSS) hypodermal sclerenchymatous strand; (Ep) epidermal cell; (I) intermediate vascular bundle; (KS) Kranz sheath; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (OT) outer periclinal wall; (PS) parenchymatous sheath; (Pxl) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (St) stoma; (SS) sclerenchymatous strand and (TP) translucent parenchyma. Bars = 10 µm.
Plate 5. Legend on facing page.
Chapter 3, Abildgaardieae

With the exception of vascular tissues and the vascular bundle sheaths, there are two types of cells that make up the bulk of the tissues in the culm, namely RM and translucent parenchyma (TP). RM is present abutting the outer row of vascular bundles (Plates 5.7-12 and 6.1-2). This RM extends from the epidermis to the xylem pole of the outer row large vascular bundles and some of the outer intermediate vascular bundles (Plate 5.1-2 and 5.4). RM surrounds the small vascular bundles (where present). The RM cells are thin-walled and chlorenchymatous. TP abuts the RM and extends to the centre of the culm. At the xylem poles of the large vascular bundles and a few intermediate bundles there was no RM (Plates 5.1-2, 5.4, 5.9 and 6.1-5). In a few instances sclerenchymatous strands abutted these vascular bundles at the xylem poles of the vascular bundles (Plate 5.7-8). The translucent parenchyma cells have small intercellular spaces close to the vascular bundles, and larger intercellular spaces closer to the centre of the culm. Apart from B. contexta and F. dichotoma, all species have a few thin-walled tannin idioblasts scattered in the RM of the vascular bundles (Plate 6.1).

Most vascular bundles are present in one row (Plate 5.4), whilst two rows are present in B. contexta (Plate 5.2), F. dichotoma and F. ferruginea. In these species the outer row of bundles is present near the epidermis in the RM and the second row is present in the TP region (Plate 5.2). Large, intermediate and small bundles in B. contexta, F. dichotoma and F. ferruginea are present in the outer row. The inner row is composed only of large and intermediate bundles. The numbers of vascular bundles is varied (Table 3, Appendix 3). A. ovata is the only species in the tribe that lacks small bundles, whilst B. humilis and F. complanata are the only species that lack intermediate vascular bundles.

As in the leaves and bracts, most bundles have three vascular bundle sheaths, namely an outer parenchymatous sheath (PS, Plates 5.7-12 and 6.1-2), a partially lignified mestome sheath (MS, Plates 5.7-12 and 6.1-6) and an inner non-lignified Kranz sheath (KS, Plates 5.7-11 and 6.1-6). However, both B. humilis and B. contexta lack the outer sheath (Plate 6.3-6). On the xylem side of the large bundles in A. ovata, B. hispidula, B. schoenoides and the genus Fimbristylis, there is a KS. At this position there is an additional sheath of border parenchyma (BP, Plates 5.7-9, 5.12 and 6.2-3).

The PS is thin-walled and chlorenchymatous. The chloroplasts within the PS are mostly small and few in number, with the exception of B. schoenoides. In B. schoenoides chloroplasts are absent in the PS at the xylem pole of the large and intermediate bundles (Plate 6.2). Generally MS cells are more thick-walled in the radial and inner tangential walls of the cells, especially on the phloem side, as well as abutting the MX of the large bundles (Plates 5.7-8, 6.1 and 6.3-6). The walls of the cells of the MS in B. hispidula (Plate 5.12), B. schoenoides (Plate 6.2) and F. ferruginea (Plate 5.9-11) are similarly thickened in all bundles, especially on the phloem sides of the bundle and abutting the MX. The thickening within the walls of the MS is detailed in Appendix 4. The KS of the intermediate bundles in A. ovata, the genus Bulbostylis, F. dichotoma and F. ferruginea are interrupted by the MX (Plates 5.10-11 and 6.5). The KS in the small bundles surrounds the vascular tissue (Plate 6.6). The chloroplast(s) of the KS are large (Plates 5.7-8 & 6.1-6) and centrifugal in position (Plates 5.10-12).

The phloem outline of the bundles is variable (Appendix 4). The outline of the xylem in this tribe is not as variable as the phloem outline (Appendix 4). The large bundles in the Abildgaardieae have protoxylem lacunae present at the xylem pole of the bundle (Plate 5.7-9, 5.12 and 6.1-4).
Chapter 3, Abildgaardieae

Plate 6. Shows structural details of the culms of a few selected Abildgaardieae in section, illustrating the ground tissue structure, and vascular sheath and vascular tissue structure and arrangement.

(6.1) Shows an outer large vascular bundle in B. humilis with translucent parenchyma on the xylem side of the vascular bundle and radiating chlorenchyma on the phloem side of the vascular bundle. There are four sheaths present in the vascular bundle, the outer sheath is a chlorenchymatous sheath of thin-walled parenchyma, the middle sheath is lignified mestome sheath, an inner sheath Kranz sheath (on the phloem side of the vascular bundle) and an inner sheath of border parenchyma (on the xylem side of the vascular bundle). The parenchymatous sheath, the Kranz sheath and the sheath of border parenchyma are chlorenchymatous. The Kranz sheath has large chloroplasts. A small protoxylem lacuna is present inside the sheath of border parenchyma at the xylem pole of the vascular bundle.

(6.2) An outer large vascular bundle in B. schoenoides with abutting radiating chlorenchyma. Translucent parenchyma abuts the xylem pole of this vascular bundle. There are four sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath, with inner partial sheaths of border parenchyma and Kranz sheath. Note that the sheath of border parenchyma and Kranz sheath are not separated by metaxylem vessels, but that the border parenchyma is limited to the xylem pole of the vascular bundle extending to adjacent to the large metaxylem vessels. The chloroplasts of the Kranz sheath are large and fill the cell, whilst the chloroplasts of the sheath of border parenchyma and the parenchymatous sheath are small. A protoxylem lacuna is present at the xylem pole of the vascular bundle inside the sheath of border parenchyma.

(6.3) An inner large vascular bundle in B. contexta with abutting sclerenchymatous strand. Radiating chlorenchyma is present at the phloem pole of the vascular bundle. Surrounding the vascular bundle is translucent parenchyma. There are three vascular sheaths present, an outer lignified mestome sheath, an inner partial sheath of border parenchyma (on the xylem side of the vascular bundle) and an inner partial Kranz sheath (on the phloem side of the vascular bundle). Separating the sheath of border parenchyma and the Kranz sheath are two large metaxylem vessels. Both the Kranz sheath and the sheath of border parenchyma are chlorenchymatous. The sheath of border parenchyma has small chloroplasts, whilst the Kranz sheath has large chloroplasts. There is a large protoxylem lacuna present at the xylem pole of the vascular bundle, inside the sheath of border parenchyma.

(6.4) An outer large vascular bundle in B. contexta with translucent parenchyma surrounding the xylem side of the vascular bundle. Note in particular the group of large sclerenchymatous strands on the xylem side of the vascular bundle. The sheaths surrounding the vascular bundle and the protoxylem lacuna arrangement within the vascular bundle is the same as it was for the inner large vascular bundle.

(6.5) An outer intermediate vascular bundle in B. contexta with abutting sclerenchymatous strands and chlorenchymatous tissues. Translucent parenchyma is endarch to the chlorenchyma. There are two sheaths, an outer lignified mestome sheath and an inner Kranz sheath. The Kranz sheath has large chloroplasts and is interrupted by two metaxylem vessels.

(6.6) An outer small vascular bundle in B. contexta with abutting chlorenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner Kranz sheath. Note particularly that the Kranz sheath is not interrupted by metaxylem vessels and that the chloroplasts are large.

Symbols are as follows: (BP) border parenchyma; (Ep) epidermal cell; (KS) Kranz sheath; (MS) mestome sheath; (MX) metaxylem vessel; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (SS) sclerenchymatous strands; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10µm.
Plate 6. Legend on facing page.
4.1. Introduction to the Cariceae

The tribe Cariceae has six genera: Carex Linnaeus; Cymophyllus Mackenzie; Kobresia Willdenow; Schoenoxiphium Nees; Uncinia Persoon and Vesicarex Steyermark (Bruhl 1995). Over 2100 species are present in these genera, constituting almost half the species of the family (Reznicek 1990). Carex alone has over 2000 species making this genus the largest of the Cyperaceae (Shepard 1976; Reznicek 1990; Standley 1990). Schoenoxiphium has 17 species (Reznicek 1990). Little if no information has been produced on the other genera and thus definite species numbers of the other genera are not known.

Carex is cosmopolitan in distribution, but the great majority of species occur in the northern and southern temperate regions, as well as the montane tropics (Shepard 1976; Reznicek 1990). The genus Schoenoxiphium is restricted to southern and eastern Africa, as well as Madagascar (Kukkonen 1983; Reznicek 1990). The extreme northern limit of the genus is in Ethiopia (S. lehmannii and S. sparteum). The rest of the species with the exception of S. madagascariense and S. gracile, which occur in Madagascar, are all distributed in habitats near the eastern seaboard below the Zambezi (Kukkonen 1983).

In terms of anatomy, Carex is the most studied of the genera within the Cyperaceae. Metcalfe (1971) listed 404 species for which some anatomical information was published prior to 1970, numerous species have been treated subsequently. Most of these investigations have been presented as regional surveys of leaf anatomy. The most extensive of these surveys completed to date is by Shepard (1976), who investigated the use of anatomical characteristics in the intrageneric classification of Carex. Some of the more recent studies use anatomical data as a set of additional phenotypic characteristics, within the context of a systematic study, or as anatomical aids for identification (Standley 1990). However, few investigators have investigated the anatomy of members of the Cariceae that occur only in Africa. Only one Carex species, Carex spico-paniculata (collected by Cheadle No. 662 from Natal) and four Schoenoxiphium: S. caricoides; S. ecklonii; S. lanceum and S. rufum (Moll No. 3036, Karkloof, Natal; Cheadle no. 919, Cape; Anon, Kirstenbosch; Cheadle no. 683, Natal, respectively) were investigated by Metcalfe (1971). Metcalfe in his 1971 publication states that many of the species investigated were grown at Kew from material collected from an unspecified locality. Shepard in his (1976) investigation did investigate southern African Cariceae and Bruhl in his 1995 publication looked at only one, Schoenoxiphium sparteum (specifically the leaves).

4.2 Results

4.2.1 Species collected in the Eastern Cape

In all, 10 Cariceae species were found to be present, and collected, four Carex Linnaeus and six Schoenoxiphium Nees. The four Carex species are as follows: Carex aethiopica Schurk (refer to Appendix 1 for specimens collected); C. glomerabilis V.I.Krecz. (Appendix 1); C. mossii Nelmes (Appendix 1) and C. zuluensis C.B.Clarke (Appendix 1). The six Schoenoxiphium species are as follows: Schoenoxiphium basutorum Turrill (Appendix 1); S. bracteosum Kukkonen (Appendix 1); S. lehmannii (Nees) Steud. (Appendix 1); S. rufum Nees (Appendix 1); S. schweikerdtii Merx and Podlech. (Appendix 1) and S. sparteum (Vahl) Kük. (Appendix 1).
4.2.2 Distribution and habitats of the Cariceae

Most of the Cariceae occur in inland habitats, with the exception of *S. schweikerdtii* (Fig. 7), which is almost equally present in coastal and inland habitats. *C. mossii, C. zuluensis, S. bracteosum* and *S. rufum* are absent in coastal habitats, whilst *S. schweikerdtii* is absent inland (Fig. 7).

![Figure 7: Shows the distribution of the Cariceae species collected in the Eastern Cape. The species are as follows: (Ca) C. aethiopica; (Cg) C. glomerabilis; (Cm) C. mossii; (Cz) C. zuluensis; (Sbr) S. bracteosum; (Sl) S. lehmannii; (Sr) S. rufum; (Sse) S. schweikerdtii and (Ssp) S. sparteaum.]

The Cariceae occur in a wide range of habitats (Fig. 8), the majority were collected from the banks of rivers, streams, dams and marshes. These bank habitats are predominantly present in forests, as well as to a lesser extent in grasslands and on the slopes of the inland mountains (Fig. 8). What is interesting to note is that only *C. aethiopica* and *C. glomerabilis* were collected from the xeric habitats of coastal sand dunes. Not only is *C. aethiopica* present in xeric environment of coastal dunes, but also in the xeric environments dominated by pioneer plants of bare ground areas. *S. lehmannii* is present in areas devoid of vegetation and is also present in the xeric ecocline environments of forest margins. Also present in the xeric ecocline environments of forest margins is *C. mossii*. Most species occur on a wide range of substratum from clay based, through sandy to stone based soils (Fig. 9), with the exception of *C. mossii* and *S. rufum*. Both *C. mossii* and *S. rufum* are present only on clay based soils. Generally species were collected from habitats that had wet soils (Fig. 10). *C. glomerabilis* and *S. lehmannii*, were collected from dry soil.
Figure 8: Shows the habitats types that the Cariceae species were collected from in the Eastern Cape. The species are as follows: (Ca) C. aethopicus; (Cg) C. glomerabilis; (Cm) C. massii; (Cz) C. zuluensis; (Sbr) S. bracteosa; (Sl) S. lehmannii; (Sr) S. rufum; (Ssc) S. schweinfurtt and (Ssp) S. spartum. Habitat symbols are as follows: (Ba) on the banks of a marsh, river or stream; (D) on sand dunes; (Fo) exotic forests; (Fi) indigenous forests; (Fm) forest margin; (Fo) forests, no designation; (Fy) fynbos; (Gr) grasslands; (Ma) in a marsh; (O) in open areas, with no vegetation; (Rf) in a river or stream and (Th) in Thickets.
4.2.3 Leaf Characteristics within the tribe Cariceae

The majority of the Cariceae examined in this study have flanged V-shaped leaves and a few with V-shaped leaves without flanges (S. rufum and S. sparteum). The only species that is an exception to this is Carex zuluensis, which has a V-shaped midrib, with inversely crescentiform laminae. There are no trichomes present in the leaves of the Cariceae. The laminae of the leaves are mostly thin (Table 4, Appendix 3), ranging from 14μm (S. rufum) to 280μm.
(C. aethiopica). The midrib of the leaves is generally thicker than the lamina, except in the area of the leaf where the flanges occur.

The outer periclinal walls of the adaxial and abaxial epidermal cells are thick-walled (Plate 7.1-12), whilst the inner periclinal and anticlinal walls are comparatively thin-walled (Plates 7.1-12 and 8.1-12). All species have adaxial and abaxial epidermal cells of variable shape (Appendix 4). Most of the abaxial epidermal cells of the genus Carex are irregularly shaped (with rectangular to triangular protrusions or papillae) on the outer periclinal walls (Plate 7.3-4 and 7.8), with the exception of C. zuluensis, which had smooth walls, that are oval to rectangular in shape. The abaxial epidermis cell walls in S. rufum has protrusions of lignin abutting the middle lamellae, a feature which is not present in any other of the Cariceae (Plate 7.5). In all cases the adaxial epidermal cells are larger than the corresponding abaxial epidermal cells. The adaxial epidermal cell size ranges from 8 μm (C. mossii) to 57 μm (C. aethiopica). The abaxial epidermal cell size ranges from 5 μm (C. glomerabilis) to 17 μm (C. mossii). Bulliform cells are present in the adaxial epidermal cells of the midrib of both genera (Plate 7.2), with the exception of C. aethiopica, S. sparteum and S. schweikerdtii.

Cone-shaped silica deposits occur in the epidermal cells adjacent to the abaxial hypodermal sclerenchymatous strands (HSS, Plate 7.12). Cone-shaped deposits abut the HSS in the adaxial epidermal cells in the genus Schoenoxiphiun. S. rufum and S. schweikerdtii are the only species in the tribe that lacked silica deposits in the adaxial epidermal cells.

Within the two genera stomata are generally hypostomatous, within abaxial stomata. Whilst in S. bracteosum stomata are amphistomatous. Within the genus Carex and S. rufum, stomata are sunken (Plate 7.8). The stomata in C. zuluensis and most of the Schoenoxiphiun species are flush with the epidermis (Plate 7.6-7). Only S. lehmannii has raised stomata (Plate 7.9). The thickening in the walls of the guard cells of the stomata is variable (Plate 7.5 and 7.7-8, Appendix 4). The sub-stomatal cavities are small (Table 4, Appendix 3), ranging from 2 μm (C. mossii) to 25 μm (S. lehmannii).

The cells of the epidermis abutting the HSS, sclerenchymatous strands (SS), as well as girders are small and lignified (Plates 7.10-12, and 8.1-3). The HSS, as well as girders are present adjacent to the adaxial and abaxial epidermal cells in all species within this tribe. The shape of the HSS and the girders varies between the genera and the species (Appendix 4, Plates 7.10-12, 8.1, 8.3-4 and 8.6-9). There were few HSS and many girders present in the leaves of the Cariceae (Table 4 [Appendix 3]).

The location of HSS or girders adjacent to or abutting the vascular bundles for the genus Carex is variable. There are only two species with HSS present in the laminae of the Cariceae (C. glomerabilis and S. schweikerdtii). Not all the large or intermediate vascular bundles in C. glomerabilis are present adjacent to HSS. HSS are present abutting the adaxial epidermis in S. schweikerdtii, where the HSS are present adjacent to the large, intermediate and small vascular bundles (Plate 8.4), as well as present in the margins (Plate 8.3).
Plate 7. Shows structural details of the leaf blades of the Cariceae in section, including details of the arrangement and distribution of adaxial and abaxial epidermis; bulliform and papillate epidermal cells; hypodermal sclerenchymatous strands, girders and associated cone-shaped silica deposits; hypodermis; lamina cavities; mesophyll tissue structure and arrangement; sclerenchymatous strands; and stomata, as well as sub-stomatal cavities and vascular sheath arrangement.

(7.1) Shows the thin-walled adaxial epidermis in Carex aethiopica. Tannin idioblast consists of small rounded cells. (7.2) The midrib in C. zuluensis with enlarged adaxial bulliform cells. The abaxial epidermal cells have a lignified outer periclinal wall. A thin-walled adaxial hypodermis is present abutting the bulliform cells. The midrib vascular bundle has both adaxial and abaxial girders. (7.3) Shows the abaxial epidermis in Schoenoxiphium rutum has papillate epidermal cells with lignified outer periclinal wall. (7.4) The abaxial epidermal cells in C. aethiopica also have papillate epidermal cells with lignified outer periclinal walls. (7.5) Shows the abaxial epidermis in S. rutum with lignified outer periclinal wall, especially adjacent to the middle lamellae of the abutting cells. Within the abaxial epidermis are stomata, which have subsidiary cells with lignified outer periclinal wall. The sub-stomatal cavities of these stoma are small. (7.6) The abaxial epidermis in S. spartum also has cells with lignified outer periclinal wall. The flush stoma, also has subsidiary cells that have lignified outer periclinal walls. The sub-stomatal cavities of the stoma are also small. (7.7) Shows the abaxial epidermis in S. schweikerdtii, where the outer periclinal wall is lignified. The flush stoma have subsidiary cells that are lignified in both the periclinal walls. Note that the sub-stomatal cavity of this species is continuous with the lamina cavity. (7.8) The abaxial epidermis in C. aethiopica with papillate epidermal cells abutting a stoma. This stoma is sunken and has small subsidiary cells. The sub-stomatal cavity of this stoma is small. (7.9) Shows S. lehmannii where the adaxial epidermal cells are larger than the abaxial epidermal cells. Both the adaxial and abaxial epidermal cells have a lignified outer periclinal walls. The stoma are slightly raised above the abaxial epidermal surface. The subsidiary cells are slightly lignified in all walls. Note particularly that the sub-stomatal cavity of this stoma is continuous with the lamina cavity. The mesophyll is composed of non-radiating chlorenchyma. Tannin idioblasts are present scattered within the chlorenchyma. (7.10) The abaxial epidermal cells in C. zuluensis are lignified in the outer periclinal walls. The mesophyll is composed of non-radiating chlorenchyma. Between each of the lamina vascular bundles, is a lamina cavity. Note that the large vascular bundle in the picture has a large abaxial girders. This large vascular bundle has two vascular sheaths, an outer translucent parenchymatous sheath and an inner lignified mestome sheath. The lignification of the mestome sheath is thickest in the inner tangential and radial walls. (7.11) The adaxial epidermis of C. zuluensis where the outer tangential is lignified. The epidermal cells abutting the adaxial girders of large vascular bundle depicted in 7.10 are smaller than the adjacent adaxial epidermal cells. The mesophyll tissues are composed of non-radiating chlorenchyma. (7.12) Shows the abaxial epidermis abutting the girders of a large vascular bundle in S. lehmannii where one of these cells has a cone-shaped silica deposit. Note that the cell containing the deposit of silica is thin-walled in the outer periclinal wall compared with the adjacent epidermal cells.

Symbols are as follows: (Ab) abaxial epidermal cell; (Ad) adaxial epidermal cell; (Bu) bulliform epidermal cell; (C) cone-shaped silica deposit; (Ca) lamina cavity; (G) girders; (Hy) hypodermis; (L) large vascular bundle; (Md) midrib vascular bundle; (OT) outer periclinal wall (tangential); (PE) papillate epidermal cell; (S) small vascular bundle; (St) stoma; (Stc) sub-stomatal cavity; (Su) subsidiary cell and (T) tannin idioblast. Bars = 10 μm.
Plate 7. Legend on facing page.
Plate 8. Shows structural details of the leaf blades of a few selected Cariceae in section, illustrating the arrangement and distribution of adaxial, abaxial and marginal epidermal structure; hypodermal sclerenchymatous strands, sclerenchymatous strands and girders; hypodermis; lamina cavities and translucent "blue" parenchyma; mesophyll structure; tannin arrangement; vascular bundle arrangement and spacing; and vascular sheaths, as well as vascular tissues.

(8.1) Shows the adaxial epidermal cells of *S. rutum* are larger than the abaxial epidermal cells, where the outer periclinal wall of these cells is lignified. Adaxial and abaxial girders are present on the lamina's large vascular bundles. The mesophyll is composed of non-radiating chlorenchyma. Scattered within the mesophyll are tannin idioblasts. Between the large vascular bundles are the lamina cavities, which are present on the abaxial side of the intermediate and small vascular bundles. (8.2) A lamina intermediate vascular bundle in *S. sparteum* with abutting adaxial and abaxial sclerenchymatous strands. The mesophyll tissues are composed of non-radiating chlorenchyma. There are two vascular sheaths, an outer parenchymatous sheath composed of thin-walled translucent cells and an inner lignified mestome sheath. (8.3) The margin in *S. schweikerdtii*, where the epidermal cells have lignified outer periclinal walls. Note in particular that the marginal epidermal cell is far larger than the abutting adaxial and abaxial epidermal cells. The marginal hypodermal sclerenchymatous strand is large. (8.4) The adaxial epidermal cells in *S. schweikerdtii* are larger than the abaxial epidermal cells and are thick-walled in the outer periclinal wall. Note that the small lamina vascular bundle has an abutting adaxial gider and an adjacent abaxial hypodermal sclerenchymatous strand. Lamina cavities are present between the vascular bundles. The mesophyll is composed of non-radiating chlorenchyma. (8.5) Shows the translucent "blue" parenchyma is present within the lamina cavities in *S. lehmannii*. (8.6) The adaxial epidermal cells in *C. aethiopica* are larger than the abaxial epidermal cells. Lamina cavities are present between the vascular bundles. Note that the tannin idioblasts are mostly present at the edges of the cavities. (8.7) The adaxial epidermal cells in *S. sparteum* are larger than the abaxial epidermal cells, where the outer periclinal wall is thick-walled. Adaxial and abaxial girders abut a few of the lamina large vascular bundles. Abaxial giders and adaxial sclerenchymatous strands abut a few of the large vascular bundles. The lamina cavities are present between the vascular bundles. (8.8) The abaxial epidermis in *S. sparteum* has a lignified outer periclinal wall. Note that the intermediate vascular bundle in the picture has an abutting abaxial gider and adaxial sclerenchymatous strand. This vascular bundle has three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath composed of border parenchyma. The sheath of border parenchyma is interrupted by two metaxylem vessels. (8.9) The midrib in *S. schweikerdtii* where the adaxial and abaxial epidermal cells are similar in size and lignified in the outer periclinal walls. A hypodermis is present in the midrib abutting the adaxial epidermis. Note that the midrib has both adaxial and abaxial giders. (8.10) The midrib in *C. zuluensis* with enlarged bulliform epidermal cells. Note the large thin-walled hypodermis, which is present abutting these bulliform cells. The mesophyll is composed of non-radiating chlorenchyma. (8.11) The mesophyll in *S. sparteum* is composed of non-radiating chlorenchyma, which has many chloroplasts and a few large tannin idioblasts. (8.12) The mesophyll in *C. zuluensis* is also composed of non-radiating chlorenchyma with many chloroplasts. Lamina cavities are characterised by the presence of "blue" parenchyma.

Symbols are as follows: (Ab) abaxial epidermal cell; (Ad) adaxial epidermal cell; (B) translucent "blue" parenchyma; (Bu) bulliform cell; (Ca) lamina cavity; (G) gider; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (I) intermediate vascular bundle; (L) large vascular bundle; (Md) midrib vascular bundle; (Me) mesophyll cell; (MeP) marginal epidermal cell; (MS) mestome sheath; (PS) parenchymatous sheath; (S) small vascular bundle; (St) stoma; (SS) sclerenchymatous strands and (T) tannin idioblast. Bars = 10μm.
Plate 8. Legend on facing page.
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The midrib bundles of all the Cariceae species have an abutting abaxial girder. Girder position and distribution within the Cariceae leaves is variable. Adaxial and abaxial girders are present abutting the midrib bundle (C. aethiopica [Plate 8.6], C. zuluensis [Plate 7.2] and S. schweikerdtii [Plate 8.9]), the intermediate bundles (C. glomerata, C. zuluensis, S. lehmannii and S. schweikerdtii), a few of the small bundles (C. glomerata and S. schweikerdtii [Plate 8.4]) and marginal bundles (C. zuluensis). In a few species abaxial girders abut the large bundles (C. mossii and S. bracteosum), the intermediate bundles (C. aethiopica [Plate 8.6], C. mossii, and S. sparteum [Plate 8.8]) and the small bundles (S. lehmannii). Adaxial girders abut the marginal bundles of C. aethiopica and S. sparteum.

Many of the species examined have more adaxial than abaxial girders, with the exception of C. aethiopica; S. lehmannii and S. sparteum (Table 4, Appendix 3). The adaxial girders are large ( Plates 7.10, 7.11 and 8.1, Table 4 [Appendix 3]), ranging from 5μm (S. lehmannii) to 65μm (S. rufum). Abaxial girders are generally smaller than adaxial girders (Table 4, Appendix 3), ranging from 5μm (S. sparteum) to 72μm (C. aethiopica).

Sclerenchymatous strands (SS) are present abutting the adaxial poles of the midrib bundles, where girders were absent. The presence of SS, other than on the adaxial poles of the midrib bundle is confined to C. glomerabilis and the genus Schoenoxiphium. SS are present on the adaxial poles of some large (C. glomerabilis, S. lehmannii and S. sparteum [Plate 8.7]), intermediate (C. zuluensis and S. sparteum [Plate 8.2 and 8.8]), small (C. zuluensis and S. sparteum) and marginal bundles (S. sparteum). SS are also present on the abaxial pole in some of the intermediate (C. glomerabilis, S. lehmannii, S. schweikerdtii and S. sparteum [Plate 8.2]), small (C. glomerabilis, S. lehmannii, S. schweikerdtii and S. sparteum) and marginal bundles (S. sparteum).

Lamina cavities are present in all members of this tribe ( Plates 7.7, 7.9-10, 8.1, 8.4-7, 8.9, 8.12 and 9.1-3), except in C. glomerabilis. Generally the lamina cavities are found between the vascular bundles in the lamina ( Plates 8.7 and 9.1-2). The cavities in C. aethiopica are present only between the large and intermediate bundles (Plate 8.6). The lamina cavities in S. rufum are present between the median row of bundles and below the abaxial row of bundles (Plate 8.1). The cavities in S. schweikerdtii are absent between the last three vascular bundles closest to the margins. Lamina cavities vary in shape (Appendix 4). Present within the lamina cavities of the Cariceae similar to the Abildgaardieae, is translucent "blue", lobed-parenchyma (Plate 8.5 and 8.12). Generally lamina cavities are large (Table 4, Appendix 3), whilst in S. lehmannii the cavities are small. Lamina cavity size ranges from 15μm (S. lehmannii) to 133μm (S. rufum).

Tannin idioblasts are absent in S. schweikerdtii (Plate 8.4 and 8.9). There are few tannin idioblasts present in the leaves of C. mossii, C. zuluensis and the genus Schoenoxiphium. In C. aethiopica and S. sparteum (Plate 8.7) there are numerous tannin idioblasts, which are mostly present abutting the lamina cavities. Generally, the tannin idioblasts in the genus Carex and S. rufum (Plate. 8.1) seem to be randomly scattered within the mesophyll tissue. As with C. aethiopica, most of the tannin idioblasts in the genus Schoenoxiphium are present abutting the lamina cavities.
Plate 9. Shows structural of the leaf blades of a few selected Cariceae in section, including the arrangement and distribution adaxial and abaxial epidermis; hypodermal sclerenchymatous strands, girders and sclerenchymatous strands; lamina cavities; mesophyll structure; vascular bundle arrangement; vascular bundle spacing; and vascular sheaths, as well as vascular tissues.

(9.1) Shows that the adaxial epidermal cells in C. aethiopica are larger than the abaxial. The lamina cavities are present between the vascular bundles. Tannin idioblasts are present mostly surrounding the vascular bundles. (9.2) The adaxial epidermal cells in S. lehmannii are larger than the abaxial epidermal cells. Lamina cavities are present between the vascular bundles. (9.3) The adaxial epidermal cells are larger than the abaxial epidermal cells in S. rufum. The lamina cavities are present between the large vascular bundles, where the small and intermediate vascular bundles are almost surrounded by the cavity. Adaxial and abaxial girders abut the large vascular bundles. Tannin idioblasts are present scattered within the mesophyll. (9.4) Shows the midrib vascular bundle in S. rufum with abutting adaxial and abaxial girders. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner sheath composed of non-lignified border parenchyma. The mestome sheath cells are lignified in the inner tangential and radial walls. The border parenchyma is composed of small cells that are interrupted by two large metaxylem vessels and the protoxylem lacuna. There is a large protoxylem lacuna present at the xylem pole of the vascular bundle, which abuts the mestome sheath. (9.5) The large vascular bundle in the flange of S. rufum has both adaxial and abaxial girders. This vascular bundle has the same three sheaths present in the same arrangement as in the midrib vascular bundle. (9.6) The large vascular bundle in the lamina of S. rufum has the same arrangement of girders, sheaths and protoxylem lacuna. The only difference is that the protoxylem lacuna of this vascular bundle is small. (9.7) Shows an intermediate vascular bundle in S. rufum present near the margin. This intermediate vascular bundle has adaxial and abaxial girders. There are also the same three vascular sheaths present. The only difference is that the sheath of border parenchyma is interrupted by three large metaxylem vessels. There is no protoxylem lacuna. (9.8) An intermediate vascular bundle in the lamina of S. rufum. This vascular bundle is mostly surrounded by a layer of non-radiating chlorenchyma with many chloroplasts. There are three vascular sheaths present, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The mestome sheath is lignified in the inner tangential and radial walls. The shear of border parenchyma is interrupted by two metaxylem and protoxylem vessels. (9.9) Shows the margin in S. rufum where the adaxial and abaxial epidermal cells have a lignified outer periclinal wall. Between the marginal and adjacent vascular bundle is the last cavity of the lamina. The mesophyll is composed of non-radiating chlorenchyma, with many small chloroplasts. Similar to the lamina intermediate vascular bundle, the same three sheaths are present in the same arrangement. The shear of border parenchyma is also interrupted by the same number of metaxylem and protoxylem vessels. (9.10) A large lamina vascular bundle in S. schweikerdtii with abutting adaxial and abaxial girders. The lamina cavities are present on either side of the vascular bundle. The mesophyll is composed of non-radiating chlorenchyma, with few chloroplasts. There are three vascular bundles sheaths present, an outer translucent sheath of parenchyma, a middle lignified mestome sheath and a distinctive inner sheath composed of border parenchyma. The mestome sheath cells have similar lignification in all walls. (9.11) A small vascular bundle of the lamina in S. schweikerdtii, where hypodermal sclerenchymatous strands are present adjacent to the vascular bundle, and there are no girders. The lamina cavities are present on either side of the vascular bundle. The mesophyll is also composed of non-radiating chlorenchyma, with few chloroplasts. The small vascular bundle has the same three vascular sheaths in the same arrangement. The only difference is that the sheath of border parenchyma, is only interrupted by a few metaxylem vessels. (9.12) Shows the marginal vascular bundle in S. schweikerdtii, which is surrounded by non-radiating chlorenchyma, with few chloroplasts. Similar to the marginal vascular bundle of S. rufum, the same three sheaths are present in the same arrangements. The lignification within the mestome sheath is similar in all the walls of the cell.

Symbols are as follows: (Ab) abaxial epidermal cell; (Ad) adaxial epidermal cell; (B) "blue" parenchyma; (BP) border parenchyma; (Ca) lamina cavity; (G) girders; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (L) large vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (PS) parenchymatous sheath; (Pxl) protoxylem lacuna; (S) small vascular bundle and (SS) sclerenchymatous strands. Bars = 10 μm.
Plate 9. Legend on facing page.
An adaxial hypodermis is present in *C. mossii*, *C. zuluensis* (Plates 7.1 and 8.10) and *S. Schweikerdtii* (Plate 8.9, Table 4, Appendix 3). The adaxial hypodermis in the leaf of *C. zuluensis* (Plates 7.2 and 8.10) and *S. Schweikerdtii* (Plate 8.9) is present only in the midrib. The hypodermis in *C. mossii* is present along the entire leaf. The cells of the hypodermis are composed of thin-walled, translucent cells. An abaxial hypodermis is absent in the *Cariceae*.

The mesophyll is composed of thin-walled, variably shaped chlorenchymatous cells (Plates 7.2, 7.6, 7.8-11, 8.2, 8.4-5, 8.8 and 8.10-12). In *C. zuluensis* the mesophyll is quite unusual in that the arrangement of the tissue appears to be similar to that of a dicot leaf (Plate 8.12). The shape of the mesophyll closest to the adaxial epidermis is rectangular (similar to palisade parenchyma), whilst the mesophyll closest to the abaxial epidermis is triangular to rounded (similar to spongy parenchyma).

Most of the vascular bundles occur within one median row in the leaf mesophyll (Plates 8.6-7 and 9.1). *S. rufum* has two rows of vascular bundles within the mesophyll, one adaxial and one median (Plates 8.1 and 9.3). The adaxial row is composed of small and a few intermediate bundles, whilst the median row consisted of the midrib, large, marginal and a few intermediate bundles. All species have a midrib bundle present. The maximal cell distal count of vascular bundles is over seven cells (Table 4, Appendix 3). Cell distal counts most commonly range from 8-10 cells.

There is no apparent pattern of the arrangement of vascular bundles in the leaves of *C. glomerabilis*, *C. zuluensis* and the genus *Schoenoxiphium*. In the laminae of *C. aethiopica* and *C. mossii*, one small bundle is present between the large and intermediate bundles in the lamina. The numbers of large, intermediate and small bundles within the lamina is variable (Table 4, Appendix 3).

Vascular bundles in all cases are surrounded by three vascular sheaths (Plate 9.4-9). The outer sheath is a parenchymatous sheath (PS), the middle sheath a lignified the mestome sheath (MS) and the inner sheath is composed of border parenchyma (BP). The BP is a partial or interrupted sheath (Plate 9.4-12).

Generally most of the PS cells are larger than the abutting MS (Plates 7.10, 8.2, 8.8 and 9.4-12). The PS cells in *C. mossii* are the same size as the adjacent mesophyll cells. Generally the cells of the PS are characterised by the presence of a few, small chloroplasts (Plate 9.8 and 9.12). In *C. aethiopica* the chloroplasts are larger than the other species, and in *S. bracteosum* there appears to be more chloroplasts in the PS than the other species.

The radial and inner tangential walls of the MS are thick-walled (Plates 7.10 and 9.4-8). The cell walls of the MS in the genus *Carex* and *S. lehmannii* are thicker on the phloem side of the bundle and opposite the large metaxylem vessels in all the bundles that have large metaxylem vessels (midrib and large bundles [Plate 7.10]). In *S. bracteosum* the lignification in the MS is more pronounced on the phloem side of the bundle. In *S. rufum* and *S. Schweikerdtii* (Plate 9.10-12) the lignification of the MS is similar in all the cells of the MS. *S. sparteum* mostly has thin-walled MS (Plate 8.2 and 8.5).

The position of the BP in the genera *Carex* and *Schoenoxiphium* is varied. The BP is bisected by the large metaxylem vessels in the midrib bundle (*S. bracteosum*, *S. rufum* [Plate 9.4], *S. Schweikerdtii* and *S. sparteum*), large (*C. aethiopica*, *C. glomerabilis*, *C. mossii*, *S. bracteosum*, *S. lehmannii*, *S. rufum* [Plate 9.5-6], *S. Schweikerdtii* [Plate 9.10] and *S. sparteum*), intermediate (*C. aethiopica*, *C. glomerabilis*, *S. bracteosum*, *S. lehmannii*, *S. rufum* [Plate 9.7-8], *S. Schweikerdtii* and *S. sparteum* [Plate 8.8]) and marginal bundles (*S. bracteosum*, *S. rufum* [Plate 9.9])
and *S. spartenum*). The BP is also interrupted by the protoxylem lacunae in the midrib bundle (*S. rufum* [Plate 9.4] and *S. schweikerdtii*), and large bundles (*S. rufum* [Plate 9.5-6] and *S. schweikerdtii* [Plate 9.10]). Protoxylem lacunae interrupt the BP in a few of the marginal bundles of *S. rufum* (Plate 9.9). The BP in *C. zuluensis* is limited to the xylem side of all the vascular bundles. In the small bundles of *S. bracteosum* the BP is limited to the xylem side of the bundle. The BP in *S. lehmannii* is also limited to the xylem side of the bundle in the midrib bundle and marginal bundles. In the small bundles of *S. schweikerdtii* the BP is limited to the phloem side of the bundle (Plate 9.11). In both *C. aethiopica* and *C. glomerabilis* the BP is limited to the phloem side of the marginal bundles. The BP cells are variable in size, ranging from small (NK-S) in the genus *Carex* to medium sized (NK-M) in the genus *Schoenoxiphium* (Plate 9.4-12).

The outlines of the phloem tissue are not easy to group into general classifications (Appendix 4). The outlines of xylem from the different genera and species are slightly easier to group because of a few more similarities (Appendix 4). All midrib bundle and large bundles of the tribe *Cariceae* have protoxylem lacunae present at the xylem pole of the bundle (Plate 9.4-6, and 9.10).

### 4.2.4 Bract Characteristics within the tribe *Cariceae*

Bracts are variable in shape (Appendix 4), generally the *Cariceae* have V-shaped bracts. The bracts of *S. lehmannii* are V-shaped to inversely W-shaped. *C. zuluensis* has a V-shaped midrib, with an inversely crescentiform lamina. Only the bracts of *C. aethiopica* have large multi-cellular trichomes, that are curved-lanceolate in shape (Table 5, Appendix 3) and present at the adaxial mid-lamina regions (Plate 10.1). These trichomes occur between the mid-lamina large and intermediate vascular bundles, and have a continuous hypodermis with the midrib.

Bracts are variable in thickness (Table 5, Appendix 3), ranging from 46μm (*C. glomerabilis*) to 233μm (*S. schweikerdtii*). The midrib thickness for the species is thicker than in the lamina, with the exception of *C. mossii* and *S. rufum* (Table 5, Appendix 3).

All species have distinct adaxial and abaxial epidermal cells. Generally the outer periclinal walls of the adaxial and abaxial epidermis cells are thick-walled (Plate 10.2-10). The shapes of the adaxial and abaxial epidermal cells are variable. The abaxial epidermal cells in *C. aethiopica*, *C. mossii* and *S. spartenum* are irregular in outline on the outer periclinal walls (rectangular to triangular protrusions, or papillate), to rectangular (Plate 10.6). Bulliform cells are present within the adaxial epidermal cells of the midrib of the *C. zuluensis* (Plate 10.3) and the genus *Schoenoxiphium* (Plate 10.8), with the exception of *S. bracteosum* and *S. spartenum*. Generally the adaxial epidermal cells are significantly larger than the abaxial epidermal cells (Table 5 [Appendix 3], Plate 10.2 and 10.7-9). The cells of the adaxial and abaxial epidermis are small, the adaxial epidermal cell size ranges from 8μm (*C. glomerabilis* and *S. bracteosum*) to 46μm (*C. zuluensis*), whilst abaxial epidermis cell size ranges from 2μm (*C. mossii*) to 16μm (*C. aethiopica*).

Cone-shaped silica deposits similar to those in the leaves occur in all the *Cariceae*, with the exception of *C. mossii* (Plate 10.5) and *S. lehmannii*, which lack these deposits. The cone-shaped silica deposits are present in the epidermal cells that abut the HSS in both the adaxial and the abaxial epidermal cells (Plate 10.4).
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Plate 10. Shows structural details of the bract blades of the Cariceae in section, illustrating the arrangement and distribution of bulliform epidermal cells; adaxial and abaxial epidermis structure; girders with abutting cone-shaped silica deposits; hypodermis; lamina cavity arrangement and structure; mesophyll structure; multilocular trichome structure; sclerenchymatous strands; tannin arrangement; vascular bundle arrangement and spacing; and vascular sheaths, as well as vascular tissues.

(10.1) Shows the adaxial epidermal cells in Carex aethiopica, which are larger than the abaxial epidermal cells. A large mid-lamina trichome is present in this species. The adaxial hypodermis, which extends from the midrib is continuous within the trichome. The hypodermis extends to the lamina cavity adjacent to the trichome. The lamina cavities are present between the vascular bundles. (10.2) The adaxial epidermal cells of Schoenoxiphium spartum are larger than the abaxial epidermal cells. The intermediate vascular bundle has an abutting abaxial girder and adaxial sclerenchymatous strands. The mesophyll is composed of non-radiating chlorenchyma. There are two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath has a few tiny chloroplasts. (10.3) The midrib in C. zuluensis with enlarged bulliform cells. The adaxial hypodermis, which abuts the bulliform cells is composed of large, thin-walled cells. The midrib vascular bundle has both adaxial and abaxial girders. (10.4) The adaxial epidermal cells in S. bracteosum are larger than the abaxial epidermal cells. Present within the epidermal cells that abut the girders of the intermediate vascular bundle are cells that contain cone-shaped silica deposits. The intermediate vascular bundle in this picture has both adaxial and abaxial girders. The lamina cavities are present between the vascular bundles. The mesophyll of this species is composed of non-radiating chlorenchyma, with many chloroplasts. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is chlorenchymatous and has a few tiny chloroplasts. (10.5) The abaxial epidermal cells in C. mossii have a lignified outer periclinal wall. (10.6) The adaxial epidermal cells in C. aethiopica are similar in size as the abaxial epidermal cells. The abaxial epidermal cells have a few papillate epidermal cells. Intermediate vascular bundles have abutting abaxial girders. The adaxial hypodermis is composed of thin-walled cells that have a crushed appearance. The lamina cavities are present between the large vascular bundles and are present above the intermediate vascular bundles. The mesophyll is composed of non-radiating chlorenchyma with few chloroplasts. Tannin idioblasts are scattered in the mesophyll tissues. (10.7) The adaxial epidermal cells in S. rufum are larger than the abaxial epidermal cells and are lignified in the outer periclinal walls. The large vascular bundles have both adaxial and abaxial girders. Lamina cavities similar to the leaves, are mostly present between large vascular bundles. These cavities are present between the small and intermediate vascular bundles. Vascular bundles have three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath may contain a few small chloroplasts. The sheath of border parenchyma is interrupted by two meta-xylem vessels and the protoxylem lacuna. The protoxylem lacuna is present inside the mestome sheath at the xylem pole of the vascular bundle. (10.8) The bulliform epidermal cells in S. lehmannii are present in the midrib. Adaxial epidermal cells are larger than abaxial epidermal cells. The lamina cavities are present between the vascular bundles. (10.9) The adaxial epidermal cells in C. glomerabilis are much larger than the abaxial epidermal cells. The large vascular bundles have both adaxial and abaxial girders. The lamina cavities are present between the vascular bundles. (10.10) Shows the adaxial epidermal cells of C. aethiopica, which are similar in size as the abaxial epidermal cells. The adaxial hypodermis is composed of thin-walled cells and is present in the lamina. The lamina cavities surround most of the small vascular bundles. The mesophyll is composed of non-radiating chlorenchyma, with few small chloroplasts. (10.11) The marginal vascular bundle in C. zuluensis with an abutting adaxial girder. There are two vascular sheaths present, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath is lignified in the inner tangential and radial walls. (10.12) A large lamina vascular bundle in S. schweikerdtii with both adaxial and abaxial girders. The lamina cavities are present between the vascular bundles. The mesophyll in this species is composed of non-radiating chlorenchyma, with few small chloroplasts. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is lignified in the inner tangential and radial walls. The sheath of border parenchyma is interrupted by meta-xylem vessels and the protoxylem lacuna. The protoxylem lacuna is present inside the mestome sheath at the xylem pole of the vascular bundle.

Symbols are as follows: (Ab) abaxial epidermal cell; (Ad) adaxial epidermal cell; (Bu) bulliform cell; (BP) border parenchyma; (C) cone-shaped silica deposit; (Ca) lamina cavity; (G) girder; (Hy) hypodermis; (I) intermediate vascular bundle; (L) large vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) meta-xylem vessel; (PE) papillate epidermal cell; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (S) small vascular bundle; (SS) sclerenchymatous strands; (T) tannin idioblast and (Tr) trichome. Bars = 10μm.
Plate 10. Legend on facing page.
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Generally the stomata are only present in the abaxial epidermis. The stomata in C. schweikerdtii are
amphistomatous. Raised stomata are present in the laminae of C. zuluensis, S. sparteum and S. schweiferdtii. C.
aethiopica, C. glomerabilis, S. bracteosum and S. lehmannii have flush stomata. The stomata in C. mossii and S.
rufum are sunken. The size of the sub-stomatal cavities is small (Table 5, Appendix 3), ranging from 2µm (S.
schweikerdtii) to 19µm (S. rufum). The thickening in the guard cell walls is variable (Appendix 4).

The cells that comprise the HSS, sclerenchymatous strands (SS) and the girders are generally small and lignified
(Plate 10.2-7, 0.9 and 10.11-12). There are few HSS present adjacent to the adaxial and abaxial epidermal cells of all
species of this tribe, whilst there are many girders (Plate 10.2-7). The adaxial HSS are mostly present in the margins
of the bracts of the tribe, as well as in the laminae adjacent a few of the intermediate (C. mossii and S.
schweikerdtii), small (C. aethiopica, C. glomerabilis, C. mossii and S. schweikerdtii) and marginal bundles (S.
schweikerdtii). In addition, abaxial HSS abut the marginal bundles in S. rufum. All species have one abaxial girder
abutting the midrib bundles (Plate 10.3). Adaxial girders are present abutting the large (C. aethiopica, C.
glomerabilis [Plate 10.9], C. mossii, C. zuluensis, S. bracteosum [Plate 10.4], S. lehmannii, S. rufum [Plate 10.7] and
S. schweikerdtii), the intermediate bundles (C. aethiopica, C. mossii, C. zuluensis, S. bracteosum, S. lehmannii, S.
rufum and S. schweikerdtii) and the small bundles (S. lehmannii). Abaxial girders are also present either abutting the
large bundles (C. aethiopica, C. mossii [Plate 10.5], C. zuluensis, S. bracteosum [Plate 10.4], S. lehmannii, S. rufum
[Plate 10.7], S. schweikerdtii [Plate 10.12] and S. sparteum), the intermediate bundles (C. aethiopica [Plate 10.6], C.
glomerabilis, C. mossii, C. zuluensis, S. bracteosum, S. lehmannii, S. rufum, S. schweikerdtii and S. sparteum [Plate
10.2]), or the small bundles (C. glomerabilis and S. schweikerdtii) and the marginal bundles (C. zuluensis [Plate
10.11]).

The shape of the HSS and girders varies between the genera and the species (Appendix 4). The midrib girders of the
Cariceae are generally crescentiform, while the midrib bundle girder in C. zuluensis is ascending crescentiform in
shape (Plate 10.3). The Cariceae have more adaxial HSS/girders than abaxial (Table 5, Appendix 3), with the
exception of C. aethiopica, S. bracteosum and S. sparteum. The adaxial HSS/girders are large, ranging from 8µm (S.
bracteosum) to 78µm (S. schweikerdtii), whilst the abaxial HSS/girders range from 7µm (C. glomerabilis) to 68µm
(S. schweikerdtii).

SS are mostly present abutting the adaxial poles of the midrib bundles of the tribe (Plate 10.3). They also abut the
xylem and phloem poles of various bundles in different species in the tribe (with the exception of S. lehmannii). The
SS in S. lehmannii abut the xylem and phloem pole of a few of the intermediate bundles. SS are present at the
adaxial poles of a few intermediate (S. schweikerdtii and S. sparteum [Plate 10.2]) and small bundles (S. sparteum.
S. rufum and S. schweikerdtii). SS are also present at the phloem poles of a few of the abaxial intermediate (C.
aethiopica and S. bracteosum), small (C. zuluensis, S. rufum, S. schweikerdtii and S. sparteum) and marginal
bundles (S. sparteum).

Laminal cavities are present in all the species of the tribe and occur between the vascular bundles in the lamina
(Plate 10.1, and 10.8-9). The shapes of the laminal cavities are variable (Appendix 4). The lamina cavities in S.
sparteum are greater in width than in height (Plate 10.8). Lobed translucent "blue" parenchyma are present within
most lamina cavities. The lamina cavities are large in relation to the lamina thickness (Table 5, Appendix 3), ranging
from 14µm (C. zuluensis) to 175µm (S. schweikerdtii).
The distribution and quantity of taniniferous cells within the mesophyll are variable. *C. glomerabilis* (Plate 10.9) and *S. schweikerdtii* lacked tannin idioblasts. Tannin idioblasts are numerous in the laminae of *C. aethiopica* (Plate 10.1), *C. mossii*, *S. rufum* and *S. sparteum*. *C. zuluensis*, *S. bracteosum* and *S. lehmannii* have few tannin idioblasts. Tannin idioblasts in *C. aethiopica*, *C. zuluensis*, *S. bracteosum* and *S. rufum* appear to be randomly scattered within the mesophyll (Plate 10.1), whilst those in *C. mossii* are mostly present abutting the vascular bundles. In *S. lehmannii* and *S. sparteum* the tannin idioblasts are mostly present abutting the lamina cavities.

Generally a hypodermis is absent in the bracts of the Cariceae (Table 5, Appendix 3). *C. aethiopica*, *C. mossii*, *C. zuluensis* and *S. schweikerdtii* have an adaxial hypodermis (Plate 10.1, 10.3, 10.6 and 10.10). The adaxial hypodermis in *C. mossii* and *C. zuluensis* is present only in the midrib (Plate 10.3), whilst the adaxial hypodermis in *S. schweikerdtii* extends from the margin to the midrib. The adaxial hypodermis in *C. aethiopica* extends from the midrib to the trichome and is continuous within the trichome (Plate 10.1). The cells of the hypodermis are composed of thin-walled translucent cells.

The mesophyll is composed of thin-walled, chlorenchymatous cells (Plates 10.2-4, 10.6-7, 10.10-12, 11.1-9) of variable shape. As with the leaves, the mesophyll in *C. zuluensis* resembles the appearance of a dicot leaf. Parenchymatous bridges (Pbr) are generally absent in the Cariceae tribe, with the exception of *C. aethiopica* and *S. rufum*. *C. aethiopica* has adaxial Pbr of mesophyll tissue, and thin-walled translucent parenchyma connecting some of the lamina intermediate and small vascular bundles, with the adaxial hypodermis. The Pbr in *S. rufum* are present on the adaxial poles of the intermediate and small bundles and composed of mesophyll tissue.

Only one row of vascular bundles is present (Plate 10.1). All species have a midrib vascular bundle, and large, intermediate, small and marginal bundles. The minimal cell lateral count of the vascular bundles of all species is more than three cells (Table 5, Appendix 3). Generally there is no recognisable pattern with respect to the distribution of the vascular bundles (Plate 10.1 and 10.8-9). In *S. bracteosum* and *S. rufum*, one small bundle is usually present between the large and intermediate bundles of the lamina.

Within the bracts of the entire Cariceae vascular bundles are generally characterised by the presence of three bundle sheaths, with the exception of *C. glomerabilis*, *C. zuluensis* and *S. sparteum*. The outer sheath is parenchymatous (PS), the middle a lignified mestome sheath (MS) and the inner sheath is a partial or an interrupted sheath of border parenchyma (BP). The outer sheath is partially absent in the marginal bundles of *C. glomerabilis* and *C. zuluensis* (Plate 10.11). Each of the marginal bundles has a sheath missing in *S. sparteum*, in one there is no PS and in the other no MS.

The cells of the PS are generally larger than the abutting MS cells (Plates 10.2, 10.4, 10.7, 10.10-12 and 11.1-9) and chlorenchymatous. The PS in *S. schweikerdtii* generally lacks chloroplasts.

Most of the walls of the MS are thick-walled in the radial and inner tangential walls (Plates 10.11-12, 11.1 and 11.3-9). The MS cells in *C. aethiopica*, *S. bracteosum*, *S. lehmannii* (except abutting the metaxylem vessels [Plate 11.2]) and *S. sparteum* have similar lignification in all the walls. An in depth discussion of the lignification within the walls of the MS of the vascular bundles is presented in Appendix 4.
Plate 11. Shows structural details of the bract blades of Carex zuluensis in section, namely Schoenoxiphium lehmannii, S. rufum and S. schweikerdtii illustrating the arrangement and distribution of the adaxial and abaxial epidermis, girder, sclerenchymatous strands, and vascular sheath, as well as vascular tissues.

(11.1) Shows a large lamina vascular bundle in C. zuluensis with three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. A few of the cells of the parenchymatous sheath contain small chloroplasts. The mestome sheath is lignified in the inner tangential and radial walls. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the protoxylem lacuna at the xylem pole of the vascular bundle. (11.2) A lamina intermediate vascular bundle in S. lehmannii with three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous. The sheath of border parenchyma is interrupted by two metaxylem vessels. The mesophyll is composed of non-radiating chlorenchyma. Tannin idioblasts are large. (11.3) Shows the midrib vascular bundle in S. schweikerdtii with both adaxial and abaxial girders. There are the same three sheaths present in the same arrangement. The sheath of border parenchyma are interrupted by metaxylem vessels and protoxylem lacuna. (11.4) The large vascular bundle of S. schweikerdtii has adaxial and abaxial girders. The sheath arrangement is also the same. (11.5) The midrib in S. rufum where the abaxial epidermal cells have a lignified outer periclinal wall. This midrib has both adaxial and abaxial girders. The same three sheaths are also present in the same arrangement as S. schweikerdtii. (11.6) The adaxial and abaxial epidermal cells have a lignified outer periclinal wall in S. rufum. The adaxial epidermal cells are also larger than the abaxial epidermal cells. The lamina large vascular bundles have both adaxial and abaxial girders. Similarly, there are the same three sheaths in the same structural arrangement. (11.7) A lamina intermediate vascular bundle in S. rufum with abutting adaxial and abaxial girders. There are also the same three sheaths present in the same arrangement as in the midrib and large vascular bundles. The only difference is that the sheath of border parenchyma is interrupted by two metaxylem and protoxylem vessels. (11.8) A lamina small vascular bundle in S. rufum with abutting adaxial sclerenchymatous strand. There are the same three sheaths as in the intermediate vascular bundle in the same arrangement. The sheath of border parenchyma however, is interrupted by two metaxylem vessels and one protoxylem vessel. (11.9) Shows a marginal vascular bundle in S. rufum with abutting sclerenchymatous strands. There are the same three vascular sheaths as in the small vascular bundle in the same arrangements.

Symbols are as follows: (Ab) abaxial epidermal cell; (Ad) adaxial epidermal cell; (BP) border parenchyma; (Ca) lamina cavity; (G) girder; (I) intermediate vascular bundle; (L) large vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (S) small vascular bundle; (SS) sclerenchymatous strands and (T) tannin idioblast. Bars = 10µm.
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With the exception of *C. mossii* (intermediate, small and marginal bundles), *C. zuluensis* (midrib bundles), *S. bracteosum* and *S. spartenum* (marginal bundles), border parenchyma (BP) is present in the vascular bundles of all species (Plate 11.3 and 11.5). Generally the BP is bisected by large metaxylem vessels (MX) in the midrib, and also in the large, intermediate and marginal bundles (Plates 10.12, 11.1-7 and 11.9). The MX in a few species did not interrupt the BP in the midrib bundle (*C. zuluensis* and *S. lehmannii*), intermediate (*C. mossii*) and marginal bundles (*C. mossii*, *S. bracteosum* and *S. spartenum*). The BP of the midrib bundle in *S. lehmannii* and the intermediate bundles in *S. spartenum* is limited to the xylem side of the bundle. The protoxylem lacunae of the *Cariceae* bract vascular bundles also interrupts the BP of the midrib bundle and large bundles (Plate 11.1 and 11.5-6). The BP of the small bundles in *C. aethiopica*, *C. zuluensis* and genus *Schoenoxiphium* surrounds the entire bundle, with the exception of *S. bracteosum* and *S. rufum*. The small bundles in *S. bracteosum* lack a BP, whilst the BP in *S. rufum* is limited to the phloem half on the small bundles. With the exception of *C. mossii*, where the BP cells are medium in size (NK-M), the BP cells of the *Cariceae* are small in size (NK-S, Plates 10.12 and 11.1-3).

Plate 11. Legend on facing page.
The outlines of most of the phloem and xylem tissue are variable (Appendix 4). Generally the midrib and large bundles of the tribe Cariceae have protoxylem lacunae present at the xylem pole (Plates 10.7, 10.12, 11.1 and 11.3-6), with the exception of a few of the large bundles in C. mossii.

4.2.5 Culm characteristics within the tribe Cariceae

The Cariceae is mostly homogeneous, with respect to culm outline. With the exception of S. bracteosum (circular [Plate 12.1]) and S. lehmannii (irregularly scutiform [Plate 12.2]), the Cariceae have triangular culms. Most of the triangular culm species are obtusely triangular (Plate 12.3), whilst C. mossii has acutely triangular culms (Plate 12.4). The culm sizes are large (Table 6, Appendix 3), ranging from 160μm (S. bracteosum) to 2626μm (S. schweikerdiitii). There are no trichomes present in the culms of the Cariceae.

Within the Cariceae the outer periclinal walls of the epidermis are thick-walled (Plate 12.5-8). As was noted in the bracts, the outer periclinal walls of the epidermal cells in S. lehmannii have circular to bulbous lignin deposits opposite the middle lamellae of each of the cells (Plate 12.6). The cells of the epidermis are small, ranging from 6μm (S. bracteosum and S. sparteum) to 17μm (C. aethiopica). The shapes of the epidermal cells vary. As with the leaves and bracts, the epidermal cells in C. mossii and S. rufum have cells that are irregular in outline (rectangular to triangular protrusions on the outer periclinal wall or are papillate in appearance, Plate 12.8).

Cone-shaped silica deposits occur in the epidermal cells abutting the HSS, in three species, namely C. aethiopica, S. bracteosum (Plate 12.5) and S. lehmannii. The cells of the epidermis abutting the HSS that did not have these cones, are mostly smaller than the epidermal cells abutting the HSS (Plate 12.5-7). The epidermal cells that contain the cone-shaped silica deposits in C. aethiopica are similar in size as the cells that abut them.

Stomata are generally flush with the epidermis (Plate 12.6). Sunken stomata are present in C. mossii (Plate 12.8) and S. bracteosum. Sub-stomatal cavities are small (Table 6, Appendix 3), ranging from less than 1μm (C. mossii) to 13μm (S. schweikerdiitii).

HSS cells are small and lignified (Plate 12.5-7). Few HSS are present adjacent to the epidermal cells (Plate 12.1), whilst there are many girders (Plate 12.2-3). The HSS in C. mossii and S. bracteosum are present at random along the epidermis (Plate 12.1). In S. lehmannii the HSS are present adjacent to a few of the outer row large bundles and at random along the epidermis (Plate 12.4). Girder and HSS outlines are variable (Appendix 4).

Girders abut the outer row large bundles in C. aethiopica (some), C. glomerabilis, C. mossii, C. zuluensis, S. lehmannii (some [Plate 12.2]), S. rufum, S. schweikerdiitii and S. sparteum (some [Plate 12.3]). In addition the intermediate bundles of the outer row in C. aethiopica (some), C. glomerabilis, C. zuluensis, S. lehmannii, S. rufum, S. schweikerdiitii and S. sparteum (some) are abutted by girders. The outer row of small bundles in C. aethiopica (some), C. glomerabilis (some), C. mossii (Plate 12.11), C. zuluensis, S. lehmannii, S. rufum (some), S. schweikerdiitii and S. sparteum (some) are abutted by girders. Girders abut a few of the second row of large bundles in C. zuluensis.
Plate 12. Shows structural details of the culms of a few selected Cariceae in section, illustrating the arrangement and distribution of cavities; epidermal structure and cone-shaped silica deposits; ground tissue structure including chlorenchymatous parenchyma and translucent parenchyma; hypodermal sclerenchymatous strands and girders; sclerenchymatous strands; stomatal structure; vascular bundle arrangement; and vascular sheaths, as well as associated vascular tissues.

(12.1) Shows S. bracteosum with hypodermal sclerenchymatous strands present at random along the epidermis. Ground tissues where the chlorenchyma is present close to the epidermis and translucent parenchyma is present in the centre surrounding the large vascular bundles. The small vascular bundles are present in the chlorenchyma. (12.2) A girder abuts the outer row of vascular bundles in S. lehmannii. The cavities are present between the outer row of vascular bundles. Translucent parenchyma is endarch to the cavities and the first row of vascular bundles. (12.3) The culm in S. sparteum is present inside an outer bract. The first row of vascular bundles have girders on the phloem side of the vascular bundle. Cavities are present between most of the vascular bundles. Translucent parenchyma extends from the cavities and the xylem side of most vascular bundles to the centre of the culm. (12.4) The chlorenchyma in C. mossii extends to the abaxial side of the outer cavities and the phloem side of the vascular bundles. The outer cavities are present endarch to the first row small and intermediate vascular bundles, where the cavities are present between the large vascular bundles. Translucent parenchyma abuts the xylem side of the first row of vascular bundles and is endarch to the cavities extending to the central cavity. The second row of vascular bundles are surrounded by the translucent parenchyma. (12.5) The epidermal cells in S. bracteosum are lignified in the outer periclinal wall. The cells of the epidermis abutting the hypodermal sclerenchymatous strand are smaller than the adjacent epidermal cells and have a cone-shaped silica deposit. (12.6) The epidermal cells of S. lehmannii are lignified in the outer periclinal wall, especially adjacent the middle lamellae of the epidermal cells. The flush stomata have un lignified subsidiary cells with small sub-stomatal cavities. Sub-stomatal cavities abut the outer cavities. The cells of the chlorenchyma have numerous small chloroplasts. (12.7) The epidermal cells in C. mossii have a lignified outer periclinal wall. The cells abutting the hypodermal sclerenchymatous strand have no cone-shaped silica deposits. (12.8) The epidermis in C. mossii has slightly sunken stoma, where the subsidiary cells are not lignified and the sub-stomatal cavities are small. The cells of the chlorenchyma have many small chloroplasts. (12.9) Shows an outer large vascular bundle in S. sparteum with abaxial girder and close proximity of outer cavity. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by both metaxytem and protoxytem vessels. (12.10) An outer large vascular bundle in C. mossii with abutting adaxial and abaxial sclerenchymatous strands. Outer cavities are present between the large vascular bundles. Chlorenchyma extends to the phloem side of the vascular bundle. Translucent parenchyma is present endarch to the cavity and abuts adaxial sclerenchymatous strand of the large vascular bundle. In this vascular bundle there are two clearly distinguishable vascular sheaths, an outer translucent parenchymatous sheath and an inner lignified mestome sheath. Present at the xylem pole of the vascular bundle inside the mestome sheath is a large protoxytem lacuna. (12.11) An outer small vascular bundle in C. mossii with abaxial girder and adaxial sclerenchymatous strand. This vascular bundle has three sheaths, an outer chlorenchymatous sheath of parenchyma, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is lignified in the inner tangential and radial walls. The sheath of border parenchyma is indistinct at the xylem pole of the vascular bundle. (12.12) Shows an outer large vascular bundle with adjacent small vascular bundles in C. mossii. Note particularly that the adaxial sclerenchymatous strands of the large vascular bundles extends and joins with the sclerenchymatous strand of the adjacent small vascular bundles. On the phloem side of these vascular bundles is chlorenchyma, whilst abutting the sclerenchymatous strands is translucent parenchyma. The large vascular bundle has two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by two large metaxytem vessels. A large protoxytem lacuna is present inside the border parenchyma at the xylem pole of the vascular bundle.

Symbols are as follows: (BP) border parenchyma; (Br) bract; (C) cone-shaped silica deposit; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (G) girder; (HSS) hypodermal sclerenchymatous strands; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxytem vessel; (PE) papillate epidermal cell; (PS) parenchymatous sheath; (PxL) protoxytem lacuna; (S) small vascular bundle; (SS) sclerenchymatous strands; (Stc) sub-stomatal cavity; (Su) subsidiary cell; (T) tannin idoblast and (TP) translucent parenchyma. Bars = 10μm.
Plate 12. Legend on facing page.
Distribution and shapes of girders are illustrated in Plate 12.2-3, 12.9 and 12.11, as well as being described in Appendix 4. The number of HSS and girders of the culms appears to correlate with the size of the culm (Table 6, Appendix 3), i.e. the larger the culm, the more HSS and girders.

Sclerenchymatous strand (SS) location and distribution vary in the Cariceae (Plates 12.10-12 and 13.1-6). SS are absent in S. bracteosum (Plates 12.1 and 13.1). SS are present abutting the xylem poles of: the outer row large bundles (C. mossii [Plate 12.12] and S. lehmannii [Plate 13.4]), the outer row of intermediate bundles (C. mossii and S. schweikerdtii), the outer row of small bundles (C. aethiopica, C. mossii [Plate 12.11], S. rufum and S. schweikerdtii [Plate 13.2]) and the inner row of large bundles (C. mossii [Plates 12.10 and 13.5], S. lehmannii, S. rufum, S. schweikerdtii [Plate 13.3 and 13.6] and S. sparteum). SS are also present abutting the phloem poles of: the outer row of large bundles (C. mossii [Plate 13.5], S. lehmannii, S. schweikerdtii and S. sparteum), the outer row of intermediate bundles (C. mossii, S. lehmannii and S. schweikerdtii), the outer row of small bundles (C. mossii, S. rufum and S. schweikerdtii) and the inner row of large bundles (S. lehmannii, S. rufum, S. schweikerdtii [Plate 13.2-3 and 13.6] and S. sparteum). In the culms of C. mossii, where small bundles are present in close proximity to the large bundles (1-3 cells away), the SS of each bundle joins (Plate 12.12).

Additional sclerenchyma is present in the culms of S. rufum, S. sparteum and S. schweikerdtii. The girders of the first row of bundles in S. rufum extend to form a sheath of lignified tissue that extends as far as the xylem pole of the second ring of bundles. This appears to take the form of a discontinuous ring of sclerenchyma around these outer vascular bundles. In some instances, fusion of SS occurs with the outer and inner row bundles in S. schweikerdtii (Plates 13.2-3). In some instances these fused SS bridge the outer culm cavities (Plate 13.2). In S. sparteum the SS abutting the xylem pole of the outer row of large bundles extends to join the adaxial SS of the second row of vascular bundles. This forms a layer of sclerenchyma that encircles the culm.

Within the genus Carex the culms are mostly characterised by the presence of cavities near the epidermis or margin (Plates 12.2-4 and 13.5-6) but some are more deeply-seated within the culm (Plate 13.5). The cavities near the margin are present between the outer row of vascular bundles that are closest to the epidermis (Plates 12.2-4 and 13.5-6). The more deeply-seated cavities are located near the centre of the culm (Plate 13.5). Outer cavities are only present in C. mossii, while the cavities in C. zuluensis are present only in the centre of the culm. The cavities of the genus Schoenoxiphium are generally present between the outer row of large bundles, extending above the outer rows of intermediate and small bundles (Plate 13.5). Cavities are absent in S. bracteosum (Plate 12.1). S. rufum has additional cavities present in the centre of the culm. The outlines of the cavities vary (Appendix 4). Translucent parenchyma ("blue" stellate to rectangular shaped) is generally present within the culm outer cavities, which are common in the cavities of leaves, and bracts. The central cavities of the genus Carex are hollow. The cavity size appeared to be related to the position of the cavity within the culm. The largest cavities are present in the central regions of the culm, whilst the smaller cavities are present near the margin (Table 6, Appendix 3).

There are a few tannin idioblasts present in the culms of the Cariceae, with the exception of S. schweikerdtii, where tannin idioblasts are absent (Plate 13.6). Most of the tannin idioblasts are scattered throughout the outer region of chlorenchyma (Plate 13.5), whilst in S. lehmannii and S. sparteum tannin idioblasts are present abutting the cavities.
Plate 13. Shows structural details of the culms of selected Cariceae in section, including the arrangement and distribution of cavities, epidermal cells, ground tissue arrangement and structure, hypodermal sclerenchymatous strand and girder arrangement, sclerenchymatous strands, vascular bundle arrangement, vascular sheath arrangement and structure, as well as vascular tissues.

(13.1) Shows a large vascular bundle in S. bracteosum with no sclerenchymatous strands. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle sheath mestome sheath and an inner sheath composed of border parenchyma. The sheath of border parenchyma is interrupted by metaxylem vessels. (13.2) The sclerenchymatous strand of first and second row vascular bundles in S. schweikerdtii join. Cavities are present on either side of the outer small vascular bundle. Endarch to the cavities and the small vascular bundle is translucent parenchyma. The second row large vascular bundle has a large protoxytem lacuna present at the xylem pole of the vascular bundle. (13.3) Shows the sclerenchymatous strands of outer row vascular bundles joining with the inner row of large vascular bundle in S. schweikerdtii, where adjacent inner row of vascular bundles sclerenchymatous strands also join. The outer cavity is exarch to the inner row of vascular bundles. The large vascular bundle has a protoxytem lacuna. (13.4) The chlorenchyma in S. lehmannii extends to the phloem side of an outer row of large vascular bundles and is present around the outer cavity. The chlorenchyma is thin-walled and has many small chloroplasts. Translucent parenchyma abuts the chlorenchyma and the xylem side of the outer large vascular bundle, extending to the centre of the culm. The cavities are present between the bridges of chlorenchyma extending to the large vascular bundle. Adjacent to the large vascular bundle is a hypodermal sclerenchymatous strand, whilst abutting the adaxial and abaxial sides of the vascular bundles are sclerenchymatous strands. The large vascular bundle has a protoxytem lacuna at the xylem pole of the vascular bundle. (13.5) Shows a few of the outer row large vascular bundles in C. mossii have abutting girders. The hypodermal sclerenchymatous strands are mostly present at random along the epidermis. The inner vascular bundles have abutting adaxial and abaxial sclerenchymatous strands. The chlorenchyma extends to the phloem side of the outer row of vascular bundles, where the outer cavities are present between most of the outer row of vascular bundles. Translucent parenchyma extends from the cavities and the xylem pole of most of the outer row vascular bundles to the central cavities. The second row of vascular bundles is present in the translucent parenchyma. (13.6) In S. schweikerdtii most of the outer row vascular bundles have abutting girders. The outer row vascular bundles with no girders have adjacent hypodermal sclerenchymatous strands. Sclerenchymatous strands abut the adaxial and abaxial sides of the inner row large vascular bundles. The cavities are present between the girders and hypodermal sclerenchymatous strands, extending to the layer of translucent parenchyma. Translucent parenchyma is endarch to the cavities and extends from the phloem side of the outer row large vascular bundles to the centre. (13.7) An outer row small vascular bundle in S. lehmannii surrounded by chlorenchyma, with cavities on either side. There are two recognisable sheaths present, an indistinct outer chlorenchymatous sheath of parenchyma and an inner translucent lignified mestome sheath. (13.8) An inner row of large vascular bundle in S. lehmannii with sclerenchymatous strands, surrounded by translucent parenchyma. There are two vascular sheaths, an outer mestome sheath and an inner sheath composed of border parenchyma. The sheath of border parenchyma is interrupted by two large metaxylem vessels and a small protoxytem lacuna. (13.9) An outer row intermediate vascular bundle in S. lehmannii with abutting girder. There are three vascular sheaths, an outer chlorenchymatous sheath of parenchyma, a middle mestome sheath and an inner sheath composed of border parenchyma. The cells of the mestome sheath are large and thin-walled. The sheath of border parenchyma is interrupted by metaxylem vessels and one protoxytem vessel.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (PS) parenchymatous sheath; (PXL) protoxytem lacuna; (S) small vascular bundle; (SS) sclerenchymatous strands; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10 μm.
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Ground tissues are composed of thin-walled, chlorenchymatous parenchyma that is variable in shape. The chlorenchyma extends from the epidermis to the outer row of bundles (Plates 12.4, 13.4-5 and 13.7). Thin-walled translucent parenchyma abuts the chlorenchymatous layer (Plates 12.2-4 and 13.5-6) and extends to the centre of the culm. In C. mossii the translucent parenchyma extends across the cavities in parenchymatous bridges (Plates 12.4 and 13.5) to the central TP region.

Plate 13. Legend on facing page.

The vascular bundles in the Cariceae are present in one (C. glomerabilis and S. bracteosum [Plate 12.1]), two (C. mossii [Plate 13.5], S. lehmannii [Plate 12.2] and S. spartium [Plate 12.3]), three (C. aethiopica) and four rows (C. zuluensis, S. rufum and S. schwikeradii). The outer row of bundles in the Cariceae consist of large, intermediate and small bundles, whilst the inner rows only have large bundles. The numbers of the different sizes of vascular bundles in the culms of the Cariceae is tabulated in Table 6 (Appendix 3). Only S. bracteosum has no intermediate bundles.
Most vascular bundles are characterised by the presence of three bundle sheaths (Plates 12.9, 12.11-12, 13.1 and 13.9), an outer parenchymatous sheath (PS), a middle lignified mestome sheath (MS) and an inner partial or interrupted sheath of border parenchyma (BP). Generally the PS is absent in the inner row bundles (Plate 13.3 and 13.8).

The cells of the PS sheath are small and thin-walled, but they are larger than the abutting MS cells (Plates 12.9-11, 13.1 and 13.7), with the exception of the PS cells of the small bundles in *S. spartea*, which are as large as the MS cells. The PS cells are chlorenchymatous, whilst chloroplasts are absent in the PS of *S. schweikerdtii* and *S. spartea*. The PS in *S. lehmannii* is only present on the xylem side of the outer row of bundles.

Most of the walls of the MS are thick-walled, especially the radial and inner tangential walls (Plates 12.11 and 13.1). *S. rufum* and *S. schweikerdtii* have the similar lignification in all the MS walls (Plate 13.3). The MS cells in *S. spartea* are thin-walled in the radial and inner tangential walls of the bundle sheath, in all bundles. An in depth discussion of lignification thickness and location is present in Appendix 4.

The BP in the *Cariceae* is bisected in the large and intermediate bundles by the large metaxylem vessels (Plates 12.9, 12.12, 13.1 and 13.8-9), with the exception of *S. lehmannii*, where a BP was absent (Plate 13.7). A partial BP is present in *C. mossii* (phloem side of the outer intermediate bundles [Plate 12.11]), *S. schweikerdtii* (on the xylem side of some large bundles) and *S. spartea* (phloem side of some small bundles). The exception is *S. bracteosum*, where the BP cells are medium sized. The BP cells of the *Cariceae* are small or NK-S.

Both phloem and xylem outlines vary (Appendix 4). Generally the large bundles in the tribe *Cariceae* have a protoxylem lacunae present at the xylem pole (Plates 12.10, 12.12, 13.2-4 and 13.8), with the exception of *S. bracteosum* (Plate 13.1).
5.1 Introduction to the *Cypereae*

The tribe *Cypereae* falls within the sub-family *Cyperoideae* and has seventeen genera. These seventeen genera are as follows: 
- *Alinula* J.Raynal;
- *Ascolepis* Nees ex Steudel;
- *Ascopholis* C.E.C.Fischer;
- *Courtoisia* Sojak;
- *Cyperus* Linnaeus subsp. *Cyperus*;
- *Cyperus* Linnaeus subsp. *Pycnostachys* C.B.Clarke;
- *Hemicarpha* R.Brown;
- *Mariscus* Vahl;
- *Monandrus* Vorster;
- *Pycreus* P.Beauvois;
- *Queenslandiella* Domin;
- *Remirea* Aublet;
- *Rikitella* J.Raynal;
- *Sphaerocyperus* Lye;

Bruhl's (1995) classification closely follows Raynal's (1973) classification. This classification differs slightly from the last classification of the *Cyperaceae*, based purely on anatomical characteristics, by Metcalfe in 1971. Metcalfe (1971) stated that there is a need for the inclusion of morphological data sets that would add clarity to the delimitation of groups and/or genera of species. Metcalfe classified the *Cypereae* into nine genera and 604 species. These genera were as follows: 
- *Courtoisia* Nees, now *Courtoisina* Sojak;
- *Cyperus* Linnaeus;
- *Juncellus* (Griesb.) C.B.Clarke, now *Cyperus*;
- *Kyllinga* Rottboel;
- *Mariscus* Vahl;
- *Pycreus* P.Beauvois;
- *Queenslandiella* Domin;
- *Remirea* Aublet and *Torulinium* Desv..<br>

In Bruhl's (1995) classification there is a total of 871 species classified as part of the *Cypereae* tribe.

Metcalfe (1971) classified the *Cypereae* into two basic groups based on bundle sheath structure. In his cladistic classification of *Cyperaceae*, Goetghebeur (1989) also divided the *Cyperaceae* into similar groups. Bruhl's (1995) computer generated classification closely supported Metcalfe's (1971) anatomical delimitation of the two groups. Goetghebeur (1989) defined these anatomical groups as the Eucyperoid and chlorocyperoid groups. The Eucyperoid group incorporates all plants without Kranz and the chlorocyperoid group plants with Kranz anatomy. Both Metcalfe (1971) and Bruhl (1995) followed a similar approach towards the definition of the two structural groupings. Metcalfe (1971) stated that the first group, or group A, has an outer parenchymatous sheath and an inner fibrous sheath, while the second group, or group B, has an outer fibrous sheath and an inner parenchymatous sheath. He also stated that group B has radiate chlorenchyma in association with the bundles. Instead of referring to the groups as group A and B, Bruhl (1995) separated the two groups into subgenera. Metcalfe's (1971) group A has similar structure to Bruhl's (1995) subgenus *Pycnostachys*. Bruhl (1995) stated that the *Pycnostachys* has an outer parenchymatous sheath, with a mestome sheath (Metcalfe's fibrous sheath) inside the parenchymatous sheath and an inner boundary layer separated by metaxylem. The parenchymatous sheath, with an inner mestome sheath is typical of plants with the C₃ photosynthetic pathway (Brown 1975; Gilliland and Gordon-Gray 1978; Takeda et al. 1980; Bruhl 1995; Bruhl and Perry 1995). Metcalfe's (1971) B group is similar to Bruhl's (1995) subgenus *Cyperus*, where an outer mestome sheath and inner Kranz sheath is interrupted by metaxylem vessels (Bruhl 1995). Radiate chlorenchyma in close association with vascular bundles is common in C₄ plants (Ueno 1996, Soros and Dengler 1998). The arrangement of mestome sheath in close association with outer radiate chlorenchyma and inner Kranz tissue separated by metaxylem vessels in larger bundles, is typical of the chlorocyperoid, C₄ anatomical group (Johnson and Brown 1973; Laetsch 1974; Brown 1975; Takeda et al. 1985; Ueno et al. 1988A; Bruhl 1990 & 1995; Soros and Dengler 2001).

Metcalfe (1971) argued that *Courtoisia* and *Cyperus* (in part) had group A anatomy. Similarly, Bruhl (1995) stated that the genera with the C₃ structure in the *Cypereae* were *Courtoisia* and *Cyperus* subgenus *Pycnostachys*. The second group, the C₄, chlorocyperoid group, was defined by Bruhl (1995) to be *Alinula, Ascolepis, Ascopholis, Cyperus* subgenus *Cyperus, Hemicarpha, Kyllinga, Lipocarpha, Mariscus, Monandrus, Pycreus, Queenslandiella,*
Remirea, Rikliella, Sphaerocyperus, Torulinium and Volkella. Metcalfe's (1971) separation of the group B was similar to Bruhl (1995).

Generally the Cypereae is a cosmopolitan tribe of species, where species have wide ranges of habitats. Alinula is present only in Africa, with Ascopholis present in East Asia and Africa. Courtoisina is present in East Asia and India (Madras). The Sphaerocyperus species are present in Africa and Australasia.

The genera Ascolepis, Cyperus (both subgenera), Kyllinga, Lipocarpha, Mariscus, Monandrus, Pycreus and Rikliella are cosmopolitan within Africa (Bruhl 1990 & 1995). All the genera of the Cypereae, with the exception of Ascopholis, Monandrus, Queenslandiella, Remirea, Sphaerocyperus and Torulinium occur in South Africa (Arnold and de Wet 1993).

The habitats of the Cypereae range from seasonally wet, to mesophytic. Species are less common in halophytic or helophytic habitats. Cyperus subgenus Pycnostachys has been directly correlated with damp shady habitats (Bruhl 1990 & 1995). Within South Africa Vorster (1983) has stated that Mariscus is absent from the West Coast and the Karoo desert regions (less than 250mm rainfall). The largest concentrations of Mariscus species are present in the warm summer rainfall areas of the eastern seaboard (Vorster 1983).

Metcalfe (1971) described only nine species from South Africa and Bruhl (1990 & 1995) five. With the exception of Vorster (1978, 1983 & 1990) there has been a general lack of anatomical investigation of the Cypereae present within South Africa.

5.2 Results

5.2.1 Cypereae species collected in the Eastern Cape

A total of five genera have been collected to date within the province thus far, namely Ascolepis Nees ex Stued., Cyperus Linnaeus, Kyllinga Rottboel, Mariscus Vahl and Pycreus P.Beauvois. Within these five genera a total of 57 species were collected in the past, whilst 42 of them were re-collected by the author.

Within the genus Ascolepis, A. capensis (Kunth) Ridley (refer to Appendix 1 for specimens collected) was re-collected. For the genus Cyperus 20 out of 25 species were re-collected, namely C. albostriatus Schrad. (Appendix 1), C. denudatus L.f. (Appendix 1), C. diformis Linnaeus (Appendix 1), C. distans L.f. (Appendix 1), C. esculentus Linnaeus (Appendix 1), C. fastigiatus Rottboel (Appendix 1), C. immensis C.B.Clarke (Appendix 1), C. laevigatus Linnaeus (Appendix 1), C. longus Linnaeus var. tenuiflorus (Rottboel) Boec. (Appendix 1), C. marginatus Thunb. (Appendix 1), C. natalensis Hochst. (Appendix 1), C. obtusiflorus Vahl (Appendix 1), C. pulcher Thunb. (Appendix 1), C. rubicundus Vahl (Appendix 1), C. rupestris Kunth var. rupestris (Appendix 1), C. semitrifidus Schrader var. semitrifidus (Appendix 1), C. sexangularis Nees (Appendix 1), C. sphaerospermus Schrader (Appendix 1), C. tenellus L.f. var. tenellus (Appendix 1) and C. textilis Thunb. (Appendix 1). A total of five out of seven Kyllinga species were re-collected, namely K. alata Nees (Appendix 1), K. brevifolia Rottboel (Appendix 1), K. elatior Kunth (Appendix 1), K. erecta Schumach. (Appendix 1) and K. pauciflora Ridley (Appendix 1). Ten out of 14 Mariscus species were re-collected, namely M. albomarginatus C.B.Clarke (Appendix 1), M. capensis (Steud.) Schrader
5.2.2 Distribution and habitats of the Cypereae

The distribution of the five genera is mostly inland (Fig. 11), with the exception of A. capensis. Only A. capensis is absent in coastal habitats. Generally coastal habitats are more water limiting with tolerance to damage by salt becoming important. Habitat type is distinctive when comparing the habitats of the C₃ and C₄ species (Fig. 12). The C₃ species seem to be present in more types of habitat than the C₄ species. A. capensis is habitat specific and was collected only from a marsh on the slopes of the central Hog of Hogsback.

Figure 11: Shows the distribution of habitats that the Cypereae genera were collected from in the Eastern Cape. Genera symbols indicate the following: (A-C₃) A. Ascolapis species; (C-C₃) C. Cyporus species; (C-C₄) C₄ Cyporus species; (K-C₄) C. Eelirgo species; (M-C₄) C. Mariscus species; (P-C₄) P. Pyenous species and (P-C₃) P. Pyenous species.

More C₃ species, than the C₄ species have been collected from hydrophytic to mesophytic habitats. The C₄ species were collected more frequently from grassland, marsh and river bank habitats. More C₄ species, than C₃ species occur in drier habitats, such as dunes, thickets and open ground areas. C₄ species were also more frequently collected, than C₃ species from halophytic environments (Fig. 12), which was supported by the fact that more C₄
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species, than *C*₃ species occurred in coastal habitats (Fig. 11). Neither the *C*₃ nor *C*₄ *Cyperaceae* were found in shady environments of forests within the region (Fig. 12) very often.

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**Figure 12:** Shows the distribution of habitats types that the *Cyperaceae* genera of the Eastern Cape were collected. Genera symbols are as follows: (A-C₃) *Acrolops* species; (C-C₃) *Cyperus* species; (C-C₄) *Cyperus* species; (K-C₃) *Kyllinga* species; (M-C₄) *Mertensia* species; (P-C₃) *Pycnosorus* species and (P-C₄) *Cyperus* species. Habitat symbols are as follows: (Da) on the banks of dams, rivers, streams; (Da) in dams; (Da) on sand dunes; (Ea) in estuaries; (Fo) in forests; (Fe) in exotic forests; (Fm) on forest margins; (Fm) in indigenous forests; (Fe) in fynbos; (Gr) in grasslands; (Ma) in marshes; (O) open areas with no vegetation; (Ri) in rivers or streams and (Th) in thickets.
More C3 species, than C4 species were collected from clay based soil types, indicative of their preference for colder damper habitats (Fig. 13). The C4 species, with the exception of the C4 Pycreus species were more frequently collected from habitats that have sandy and stony soils. Generally both the C3 and the C4 species, with the exception of the C4 Cyperus species have been collected from habitats with wet soils (Fig. 14). The C4 Cyperus species appear to be more frequently collected from habitats with dry soils. A. capensis was collected exclusively from marshes with wet soils. The C3 species have however, been collected from habitats with dry soils, indicative of the xeric habitats. Whilst the C3 species occur in wetter habitats than the C4 species.

Figure 13: Shows the substratum types of the habitats that the Cyperaceae genera were collected from in the Eastern Cape. Genera symbols are as follows: (A-C3) C, Ascolepis species; (C-C3) C, Cyperus species; (C-C4) C, Cyperus species; (K-C3) C, Kyllinga species; (M-C3) C, Marisca species; (P-C4) C, Pycreus species and (P-C3) C, Pycreus species.
5.2.3 Leaf structural characteristics of the Cypereae

The Cypereae tribe is mostly homogeneous, with respect to leaf outline. However, there are two species, *C. longus* var. *tenusflorus* and *C. marginatus*, which do not have leaves. Most of the species have V-shaped leaves, with three species being crescentiform (*C. seminatidus* var. *seminatidus*, *M. dubius* and *M. uitenhagensis*), one being inversely W-shaped (*Cyperus immensus*) and one being shallowly corrugate (*C. textilis*). The V-shaped species may be divided into three groups: the true V-shaped (*A. capensis*, *C. albostratus*, *C. esculentus*, *C. natalensis*, *C. obtusiflorus*, *C. pulcher*, *C. rubicundus*, *C. sexangularis*, *C. sphaerospermus*, *K. alata*, *K. brevifolia*, *K. pauciflora*, *M. albomarginatus*, *M. capensis*, *M. macrocarpus*, *M. sumatrensis*, *M. thunbergii*, *P. intactus*, *P. macranthus*, *P. nitidus* and *P. polystachyos* var. *polystachyos*), the flanged V-shaped (*C. denudatus*, *C. distans*, *C. fastigiatus*, *K. elatior*, *M. congestus*, *M. solidus*, *M. tabularis* subsp. *major* and *P. mundii*) and the thickly V-shaped (*C. dfferformis*, *C. laevigatus*, *C. rupestris* var. *rupestris*, *C. tennellus* var. *tennellus*, *K. erecta* and *P. cooperi*). *P. polystachyos* var. *polystachyos* is V-shaped with its margins curled inward. The flange in both *C. distans* and *P. mundii* is orientated so that the margins face inwards (towards the midrib region), not abaxial to the leaf, but adaxially (on top of the rest of the leaf tissues).

The leaf thickness in the different genera and species is variable (Tables 7 and 8A-D, Appendix 3). The thickness of the leaves in the genera *Cyperus*, *Mariscus* and *Pycreus* is similar, whilst that of the genus *Kyllinga* is the thinnest. Lamina thickness ranges from 60μm (*K. erecta*) to 548μm (*C. immensus*). Midrib regions are generally thicker than
the lamina, usually because of the large bulliform cells that are present in the midrib (Table 7 and 8A-D, Appendix 3), with the exception of A. capensis, C. immensis, C. natalensis, C. obtusiflorus, C. rupestris var. rupestris, C. tennellus var. tennellus, K. elatior, M. dawus, M. macrocarpus, M. sumatrensis, M. tabularis subsp. major, M. thunbergii, M. uitenhagensis and P. polystachios var. polystachios.

Generally all species have adaxial and abaxial epidermal cells, there are no circular or polygonal leaves. The outer periclinal wall of the adaxial and abaxial epidermis is mostly thick-walled when compared with the inner periclinal and anticlinal walls (Plate 14.1-5). The adaxial epidermal cells are mostly thin-walled in the genus Cyperus (Plate 14.6). The walls of the abaxial epidermal cells in A. capensis are thin-walled and similarly thickened. The adaxial and abaxial epidermal cell shape is variable. Bulliform cells are present in the midrib adaxial epidermal cells in the Cypereae (Plate 14.3 and 14.6), with the exception of A. capensis, C. laevigatus, C. rubicundus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus (Plate 14.7), C. sexangularis, C. tennellus var. tennellus, C. textilis, K. elatior, M. capensis, M. dawus, P. cooperi, P. macranthus and P. nitidus. The marginal epidermal cells in M. solidus are large and pear-shaped, whilst the adjacent epidermal cells are also far larger than the other epidermal cells. The marginal epidermal cells in M. uitenhagensis cover the last hypodermal sclerenchymatous strands (HSS) in such a way that the terminal epidermal cells fold over each other to form a point (Plate 14.5). P. intactus also has a large oval abaxial epidermal cell at the tip of the midrib V.

The adaxial epidermal cells are generally larger than those of the abaxial epidermal cells (Plate 14.3 and 14.5, Tables 7 and 8A-D [Appendix 3]). The abaxial cells in C. albostriatus (Plate 14.4), C. denudatus, C. difformis, C. distans, C. fastigiatus, C. immensis, C. laevigatus, C. obtusiflorus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus, C. tennellus var. tennellus, K. alata, M. tabularis subsp. major, M. thunbergii, P. cooperi, P. maracanthus and P. nitidus are larger than the adaxial (Tables 8A-D, Appendix 3). The adaxial epidermal cell size ranges from 2μm (C. immensis, K. alata and M. tabularis subsp. major) to 99μm (C. sexangularis). The abaxial epidermal cells are small, ranging from 2μm (C. distans) to 22μm (C. pulcher and C. sexangularis).

Cone-shaped silica deposits are present in the epidermal cells that abut the HSS, mostly in the abaxial epidermis (Plate 14.8-9). The genus Pycreus has more cones adaxially. Cone-shaped silica deposits are absent in C. laevigatus (Plate 14.10-11) and M. solidus. Adaxial cones are absent in C. immensis, C. rubicundus, C. sexangularis, C. sphaerospermus, K. brevifolia, K. erecta, and M. uitenhagensis. Abaxial cones are absent in M. tabularis subsp. major and P. cooperi. M. uitenhagensis has the unique characteristic that the cells beneath the abaxial HSS of the midrib and large bundles have 2-3 silica cones and not one. The cells containing these deposits are thin-walled and triangular in outline. The cells of the epidermis abutting the HSS that do not have these cones are mostly smaller than the epidermal cells adjacent the HSS.

Generally stomata are present in the abaxial epidermis, whilst the stomata in K. brevifolia are amphistomatous, with stomata also in the adaxial epidermis, close to the margins. The stomata of most of the species are flush with the epidermal surface (Plate 14.12). Slightly raised stomata are present in C. esculentus, K. brevifolia, K. elatior (Plate 15.1) and M. dawus. Both C. tennellus var. tennellus and P. mundii (Plate 15.2) have sunken stomata. Variable thickening within the guard cells occurs within the Cypereae leaves see Plates 14.12 and 15.1-3, as well as Appendix 4.
Plate 14. Shows structural details of the leaf blades of selected Cypereae in section, illustrating the distribution and arrangement of the bulliform epidermal cells; adaxial, abaxial and marginal epidermis structure; hypodermal sclerenchymatous strands and abutting cone-shaped silica deposits; hypodermis structure and arrangement; lamina cavities; mesophyll structure; stoma structure; tannin idioblast structure and arrangement of the bulliform epidermal cells; (14.1) Shows the adaxial epidermis of C. semitridifus var. semitridifus with a thickened outer periclinal wall. The cells of the adaxial hypodermis are thin-walled. The epidermal cells abutting the hypodermal sclerenchymatous strands contain cone-shaped silica deposits. (14.2) The outer periclinal wall of the adaxial epidermal cells of M. thunbergii are lignified. The walls of the adaxial hypodermis are relatively thin-walled. (14.3) The adaxial epidermal cells are larger than abaxial epidermal cells in M. dubius, where the outer periclinal wall of these cells is lignified. Cells of translucent parenchyma which resemble a partial adaxial hypodermis are present at random along the adaxial hypodermis. The midrib of this species has two adjacent abaxial hypodermal sclerenchymatous strands. (14.4) The cells of the adaxial epidermis in C. albostriatus are similar in size as the abaxial epidermal cells. An adaxial hypodermis is present in the lamina. Adaxial hypodermal sclerenchymatous strands are present at random along the epidermis. Abaxial hypodermal sclerenchymatous strands are present adjacent to the central row of vascular bundles and a few small vascular bundles. Lamina cavities are present between the central row of vascular bundles, the adaxial and abaxial row of vascular bundles. There are three rows of vascular bundles present in the lamina, adaxial, abaxial and median. (14.5) Shows the margin in M. uitenhagensis, where the adaxial epidermal cells overlap with the abaxial epidermal cells. Adaxial epidermal cells are larger than the abaxial epidermal cells, where the outer periclinal wall of the cells is lignified. There is no marginal hypodermal sclerenchymatous strands in the margin. Tannin idioblasts are present abutting the adaxial epidermal cells. Vascular bundles are in one row and two cells apart. (14.6) Enlarged bulliform cells are present in the midrib of C. fastigiatus. Beneath these cells is a small adaxial hypodermis, which is composed of translucent thin-walled cells. (14.7) The adaxial epidermal cells in C. semitridifus var. semitridifus are larger than the abaxial epidermal cells. A large adaxial hypodermis extends to the two rows of vascular bundles. This hypodermis is composed of thin-walled translucent cells. Tannin idioblasts are present scattered in the chlorenchyma. (14.8) The abaxial epidermal cells in M. dubius are lignified in the outer periclinal wall. Note that the one abaxial epidermal cell abutting the hypodermal sclerenchymatous strands has a cone-shaped silica deposit. (14.9) The abaxial epidermal cells of P. mundii are lignified in the outer periclinal wall. Note that each cell abutting the hypodermal sclerenchymatous strands have a cone-shaped silica deposit. Also, note that these cells with silica deposits are also smaller than the adjacent epidermal cells. (14.10) Shows that the outer periclinal wall of the adaxial epidermal cells in C. laevigatus are lignified. Note that the cells of the adaxial epidermis abutting the hypodermal sclerenchymatous strands have a cone-shaped silica deposit. The cells abutting the hypodermal sclerenchymatous strands are similar in size as the adjacent epidermal cells. The cells of the adaxial hypodermis are thin-walled and large in size. (14.11) The cells in the abaxial epidermis of C. laevigatus abutting the hypodermal sclerenchymatous strands also have a cone-shaped silica deposit. Note that the cells of the adaxial epidermis abutting the hypodermal sclerenchymatous strand are the same size as the adjacent epidermal cells. (14.12) The abaxial epidermal cells in C. rupestris var. rupestris have a lignified outer periclinal wall. The cells of the epidermis abutting the hypodermal sclerenchymatous strands are smaller than the adjacent epidermal cells. Stomata are flush with the epidermal surfaces. The mesophyll is composed of radiating chlorenchyma.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (Bu) bulliform epidermal cell; (C) cone shaped silica deposit; (Cs) lamina cavity; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (L) large vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (NC) no cone shaped silica deposit; (OT) outer periclinal wall (tangential); (RM) radiating chlorenchyma; (S) small vascular bundle; (St) stoma and (T) tannin idioblast. Bars = 10 μm.
Plate 14. Legend on facing page.
Plate 15. Shows structural details of the leaf blades of a few selected Cypereae in section, illustrating the distribution and arrangement of adaxial and abaxial epidermis; hypodermal sclerenchymatous strands and cone-shaped silica deposits; hypodermis arrangement and structure; lamina cavity arrangement; mesophyll structure; sclerenchymatous strand structure and arrangement; abaxial stoma structure; vascular bundle arrangement; vascular sheaths; and vascular bundle spacing, as well as vascular tissues.

(15.1) Shows the outer periclinal wall in the abaxial epidermal cells of *K. eliator*, which are thick-walled. Stoma are flush to slightly raised, with lignified guard cells and thick-walled subsidiary cells. The stoma is compact in the region not associated with the cavities. Hypodermal sclerenchymatous strands are present adjacent to the epidermis. The hypodermis extends into a multi-layered region between vascular bundles not associated with the large cavities illustrated here. Also note that the mesophyll is compact in the region not associated with the cavities. Hypodermal sclerenchymatous strands are present adjacent to the large vascular bundles. The hypodermis extends into the medulla separating the vascular bundles and the adaxial and abaxial rows of vascular bundles. Vascular bundles are present in three rows (adaxial, abaxial and median). (15.6) The adaxial epidermal cells in *C. obtusiflorus* are larger than abaxial. Hypodermal sclerenchymatous strands are present adjacent to large and intermediate vascular bundles. The hypodermis extends to the chlorenchyma abutting the vascular bundles. Vascular bundles are present in two rows (adaxial and abaxial). (15.7) Shows a large vascular bundle in *C. sphaerospermus* with abutting adaxial sclerenchymatous strands. Lamina cavities are present between vascular bundles. Tannin idioblasts mostly abut the vascular bundles. Three sheaths are present surrounding the vascular bundles, an outer sheath of translucent parenchyma, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The mestome sheath is lignified in the inner tangential wall. The sheath of border parenchyma is interrupted by the two large metaxylem vessels and the protoxylem lacuna. (15.8) Shows a large vascular bundle in *C. pulcher* with abutting adaxial sclerenchymatous strands and adjacent abaxial hypodermal sclerenchymatous strands. Lamina cavities are present between vascular bundles. There are also the same three sheaths present in the same arrangement. The only difference is that the sheath of border parenchyma is only interrupted by metaxylem vessels and lacks a protoxylem lacuna. (15.9) Shows the margin in *M. thunbergii* with two marginal hypodermal sclerenchymatous strands. Vascular bundles are in one row and one cell apart. Tannin idioblasts are scattered within the mesophyll. (15.10) The adaxial and abaxial epidermal cells in *C. difformis* are similar in size. Lamina cavities are present between each median vascular bundle. Vascular bundles are connected by parenchymatous branches adjacent to the epidermis. The vascular bundles are present in one median row. (15.11) Shows *M. thunbergii* has an adaxial and an abaxial hypodermis, where the adaxial hypodermis extends to the adaxial row of vascular bundles and the median large vascular bundles. The lamina cavities are present between median large vascular bundles, the adaxial and abaxial row of vascular bundles. Tannin idioblasts are scattered within the chlorenchymous mesophyll. Vascular bundles are present in three rows within the lamina, namely adaxial, abaxial and median. (15.12) The lamina cavities in *P. cooperi* are present between vascular bundle stacks. The adaxial hypodermis extends to the radiating chlorenchyma of the vascular bundles in both the vascular bundle stacks and the midrib vascular bundle. The lamina vascular bundles are present in multi-layered stacks.

Symbols are as follows: (1) row 1 of vascular bundles; (2) row 2 of vascular bundles; (3) row 3 of vascular bundles; (4) row 4 of vascular bundles; (Ab) abaxial epidermal cell; (Ad) adaxial epidermal cell; (BP) border parenchyma; (C) cone shaped silica deposit; (Ca) lamina cavity; (Ga) guard cell; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (Ma) marginal vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (Pb) parenchymatous bridge; (PS) parenchymatous sheath; (Pxl) protoxylem lacuna; (Ss) subsidiary cell; (Stc) sub-stomatal cavity; (SS) sclerenchymatous strands and (T) tannin idioblast. Bars = 10 μm.
Plate 15. Legend on facing page.
Stomata in K. elatior are also present in the abaxial epidermis directly below the midrib bundle. Within the sub-stomatal cavities in M. thunbergii there are concertina shaped cells that appeared to contain either lignin or suberin within their walls. The sizes of the sub-stomatal cavities are small (Tables 7 and 8A-D, Appendix 3), ranging from 0µm (C. immensis, C. textilis and M. tabularis subsp. major) to 91µm (C. albostratus).

The cells that comprise the HSS, sclerenchymatous strands (SS) and girders are small and lignified (Plates 14.1, 14.3, 14.8-11 and 15.4-9). The HSS are present adjacent to the adaxial and abaxial epidermal cells in all species (Plates 14.4 and 15.5-6), with the exception of C. laevigatus, C. rubicundus and C. sexangularis, where adaxial HSS are absent. Generally there are no HSS in the leaf margin. Both M. thunbergii and M. uitenhagensis have two terminal HSS in the margin (Plate 15.9). The outlines of the HSS are variable (see Appendix 4 for details).

The Cypereae generally have more abaxial HSS than adaxial HSS (Tables 7 and 8A-D, Appendix 3), some (C. textilis) have the same number of adaxial and abaxial HSS. M. tabularis subsp. major has more adaxial HSS than abaxial. The adaxial HSS are mostly larger, than the abaxial HSS (Plates 14.7 and 15.5, Tables 7 and 8A-D [Appendix 3]), with the exception of C. albostratus, C. denudatus, C. diffinoris, C. distans, C. fastigiatus, C. immensis, C. obtusiflorus (Plate 15.6), C. rupestris var. rupestris, C. sphaerospermus, C. tennellus var. tennellus, C. textilis, K. brevifolia, K. elatior, M. congestus, M. solidus, M. tabularis subsp. major, M. thunbergii, M. uitenhagensis, P. cooperi, P. nitidus and P. polystachyos var. polystachyos. The adaxial HSS range in size from 4µm (C. albostratus) to 50µm (C. natalensis). The abaxial HSS are small, ranging from 3µm (M. congestus and P. polystachyos var. polystachyos) to 76µm (M. tabularis subsp. major).

The distribution of HSS within the lamina and the midrib regions varies. Many HSS are present adjacent to the vascular bundles in the lamina and midrib (Plate 15.6). Only one species in the genus Mariscus has both adaxial and abaxial HSS present adjacent to all the vascular bundles, namely M. tabularis subsp. major. With the exception of the small bundles in M. thunbergii, adaxial and abaxial HSS are present adjacent to all the bundles. The only genus that lacks adaxial HSS adjacent to the bundles, is Kyllinga. The presence of abaxial and abaxial HSS adjacent to the midrib varies (Tables 7 and 8A-D, Appendix 3). Only C. rupestris var. rupestris, C. tennellus var. tennellus and C. textilis have one adaxial HSS present adjacent to the midrib. There are generally two abaxial HSS adjacent to the midrib (Plate 14.3), but a few species have none (C. laevigatus and C. rupestris var. rupestris), one (A. capensis, C. denudatus, C. natalensis, C. semitrifidus var. semitrifidus, C. tennellus var. tenellus, C. textilis, M. uitenhagensis, P. macranthus and P. nitidus) or three (M. congestus) adjacent abaxial HSS.

Adaxial HSS are present either adjacent to the large bundles (C. albostratus, C. denudatus, C. distans, C. esculentus, C. fastigiatus, C. immensis, C. natalensis, C. obtusiflorus [Plate 15.6], C. rubicundus, C. textilis, M. congestus, P. cooperi and P. nitidus), the intermediate bundles (C. albostratus, C. denudatus, C. distans, C. fastigiatus, C. immensis, C. rubicundus, C. textilis, M. solidus, P. cooperi and P. nitidus), the small bundles (C. immensis and C. textilis) and/or the marginal bundles (C. diffinoris, C. distans, C. fastigiatus, C. pulcher, C. rupestris var. rupestris, C. sphaerospermus, C. tennellus var. tennellus, C. textilis, M. solidus, P. cooperi, P. macranthus and P. polystachyos var. polystachyos). Abaxial HSS are present generally adjacent to the lamina bundles (Plates 14.4, 14.11-12, 15.5-6 and 15.8), with the exception of the marginal bundles. Only the marginal bundles in C. obtusiflorus, C. pulcher, C. semitrifidus var. semitrifidus, C. sphaerospermus, C. tennellus var. tennellus, C. textilis, M. capensis, M. congestus, M. solidus, M. sumatrensis, M. tabularis subsp. major, P. cooperi,
Ascolepis, Cyperus

The midrib and intermediate bundles, as well as between the large and intermediate bundles extending from above bundles to the adaxial hypodermis, these bundles to the adaxial hypodermis (P. macranthus and P. polystachyos var. polystachyos).

Girders are present only in A. capensis and C. denudatus. Both adaxial and abaxial girders are present abutting the vascular bundles in the laminae of A. capensis, whilst C. denudatus only has abaxial girders. Abaxial girders in A. capensis and C. denudatus abut the midrib bundle and all large bundles. Adaxial girders also abut the marginal bundles in A. capensis.

The distribution of SS within the lamina and midribs varies. SS are present abutting the xylem poles of the midrib bundle (A. capensis, C. denudatus, C. rubicundus, C. sphaerospermus, M. thunbergii, P. cooperi and P. mundii), the large bundles (A. capensis, C. denudatus, C. pulcher [Plate 15.8], C. rubicundus, C. sphaerospermus [Plate 15.7], M. thunbergii, P. cooperi and P. mundii) and/or the intermediate bundles (C. pulcher, C. sphaerospermus and P. cooperi). Phloem pole SS are present abutting the large bundles (C. semitrifidus var. semitrifidus) and the small bundles (C. denudatus). Small SS are also present in the parenchymatous bridges of C. immensis. SS are also present below the mesophyll abutting the median row of vascular bundles, which in turn abut the parenchymatous bridges in M. tabularis subsp. major.

Lamina cavities are present in the laminae of the genera Ascolepis (A. capensis), Cyperus (C. albostriatus, C. denudatus, C. diffusus [Plate 15.10], C. distans, C. esculentus, C. fastigiatus, C. immensis, C. pulcher, C. sphaerospermus, C. textilis), Mariscus (M. congestus, M. dubius, M. solidus, M. sumatrensis, M. tabularis subsp. major and M. thunbergii [Plate 15.11]) and Pycreus (P. cooperi [Plate 15.12], P. macranthus and P. mundii). The Ascolepis, Cyperus and Mariscus species that have lamina cavities are mostly from niches with wet habitats. The lamina cavities are large in size in relation to the lamina thickness (Tables 7 and 8A-D, Appendix 3), ranging from 14μm (M. congestus) to 324μm (C. immensis).

Cavities within the genus Ascolepis are present between the lamina vascular bundles. Most of the cavities in the genus Mariscus are present between the median row of vascular bundles (Plate 15.11). M. congestus and M. tabularis var. major have cavities present between the abaxial rows of vascular bundles. In the genera Cyperus and Pycreus the distribution of cavities within the lamina varies. The lamina cavities within these genera are distributed as follows: between the lamina bundles (C. denudatus, C. diffusus [Plate 15.10], C. pulcher, C. sphaerospermus, C. textilis and P. mundii); between the lamina large and intermediate bundles (C. distans); between the median row of bundles (C. albostriatus [Plates 14.4 and 15.5], C. esculentus and C. fastigiatus); between the median row of large and intermediate bundles (C. immensis); between the lamina stacks of bundles (P. cooperi [Plate 15.12]); between the midrib and intermediate bundles, as well as between the large and intermediate bundles extending from above these bundles to the adaxial hypodermis (P. macranthus).
Plate 16. Shows structural details of the leaf blades of selected Cypereae in section, including the distribution and arrangement of adaxial and abaxial epidermis; hypodermis; lamina cavities; mesophyll structure including parenchymatous bridges, stellate and translucent parenchyma; silica deposition on abaxial epidermal surface; tannin idioblast arrangement, and vascular bundle arrangement, as well as spacing.

(16.1) Shows a parenchymatous bridge in C. immensis with stellate parenchyma, which abuts the lamina cavities. The parenchymatous bridge is composed of large thin-walled, translucent parenchymatous cells. (16.2) The adaxial epidermal cells in M. capensis are larger than abaxial epidermal cells. Tannin idioblasts are present scattered within mesophyll, but are mostly present adjacent to the adaxial epidermis. The lamina mesophyll is compact in structure. The vascular bundles are present in a median row and are one to two cells apart. (16.3) The adaxial epidermal cells in C. esculentus are larger than abaxial epidermal cells. The mesophyll is composed of parenchymatous bridges and compact radiating chlorenchyma, each abutting the vascular bundles, with a few scattered cells of translucent parenchyma. An intermediate vascular bundle has an abutting abaxial parenchymatous bridge composed of translucent thin-walled parenchyma. The lamina cavities are present between the parenchymatous bridges, the adaxial row of vascular bundles, and the abaxial epidermis. Vascular bundles are present in two rows, namely adaxial and median. (16.4-5) Shows the abaxial epidermis of C. sexangularis with crescentiform silica deposits. The abaxial epidermal cells have a lignified outer periclinal wall. (16.6) The large adaxial hypodermis in C. laevigatus extends to adaxial and abaxial row of vascular bundles. The adaxial row of vascular bundles are mostly surrounded by hypodermis. Tannin idioblasts are scattered within compact mesophyll. (16.7) Shows M. thunbergii has an adaxial and abaxial hypodermis, where the adaxial hypodermis extends to the adaxial row of vascular bundles and the median large vascular bundles. The lamina cavities are present between median large vascular bundles, the adaxial and abaxial row of vascular bundles. The tannin idioblasts are scattered within the chlorenchymatous mesophyll. (16.8) C. immensis has an adaxial and an abaxial hypodermis, where the adaxial hypodermis extends to the first adaxial row of vascular bundles, to second adaxial row of large vascular bundles (to the phloem side). Present at the abaxial pole of the second row of large vascular bundles are large parenchymatous bridges composed of translucent parenchyma. These parenchymatous bridges extend to the abaxial hypodermis. The large lamina cavities are present between the parenchymatous bridges and the first adaxial row of vascular bundles, as well as extend to the abaxial hypodermis. The chlorenchymatous mesophyll is compact and composed of radiating chlorenchyma. (16.9) Shows C. denudatus has larger adaxial epidermal cells than abaxial epidermal cells. The median small vascular bundle near the margin has a few cells of translucent parenchyma abutting the xylem pole. The lamina cavities are present between the vascular bundles. (16.10) The adaxial epidermal cells of C. pulcher are larger than abaxial epidermal cells. Lamina cavities are present between the median row of vascular bundles, where the cavities abut the abaxial stomata. (16.11) M. capensis has larger adaxial epidermal cells than abaxial epidermal cells. Lamina cavities are absent. The mesophyll is compact and composed of radiating chlorenchyma. The tannin idioblasts are mostly present adjacent to the adaxial epidermis. (16.12) The adaxial epidermal cells in M. sumatrensis are larger than abaxial epidermal cells. Lamina cavities are present between the median row of vascular bundles. Vascular bundles are present in three rows, namely adaxial, abaxial and median.

Symbols are as follows: (1) row 1 of vascular bundles; (2) row 2 of vascular bundles; (3) row 3 of vascular bundles; (Ab) abaxial epidermal cell; (Ad) adaxial epidermal cell; (Ca) lamina cavity; (Hy) hypodermis; (I) intermediate vascular bundle; (L) large vascular bundle; (Pa) parenchymatous cells; (Fbr) parenchymatous bridge; (S) small vascular bundle; (Si) silica deposit; (StP) stellate parenchyma; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10μm.
Plate 16. Legend on facing page.
The outlines of the lamina cavities varies (Appendix 4). Most cavities contain thin-walled, translucent "blue", parenchyma present. The cavities in *A. capensis*, *C. textilis*, *M. tabularis* var. *major* and *M. uitenhagensis* have abutting TP. Stellate TP is present in the cavities of *C. fastigiatus*, *C. immensis* (Plate 16.1), *C. rubicundus*, *M. congestus* and *M. dubius*.

Tannin idioblasts range from many (*C. esculentus*, *C. fastigiatus*, *M. capensis*, *M. congestus*, *M. tabularis* subsp. *major*, *M. thunbergii* and *P. mundii*) to few (*C. albostriatus*, *C. distans*, *C. immensis*, *C. laevigatus*, *C. natalensis*, *C. obtusiflorus*, *C. pulcher*, *C. rubicundus*, *C. rupestris* var. *rupestris*, *C. semitrifidus* var. *semitrifidus*, *K. alata*, *K. elatior*, *K. erecta*, *K. paucijlora*, *M. macrocarpus*, *M. solidus*, *M. sumatrensis*, *M. uitenhagensis*, *P. intactus*, *P. macranthus*, *P. nitidus* and *P. polystachyos* var. *polystachyos*). Tannin idioblasts are absent in *C. denudatus*. Tannin idioblast distribution within the lamina and midrib varies (Plates 14.4, 15.5-6, 15.9 and 16.2-3). Most tannin idioblasts are scattered throughout the mesophyll tissues (*Cyperus albostriatus* [Plates 14.4 and 15.5], *C. esculentus* [Plate 16.3], *C. laevigatus*, *C. pulcher*, *C. sphaerospermus*, *C. tennellus* var. *tennellus*, most of the genus *Kyllinga*, *M. dubius*, *M. sumatrensis*, *M. tabularis* subsp. *major*, *M. thunbergii* [Plate 15.11] and most of the genus *Pycreus*). The distribution of tannin idioblasts within the leaves is as follows: abutting the adaxial epidermis (*M. albostriatus*, *M. capensis* [Plate 16.2], *M. congestus*, *M. macrocarpus*, *M. uitenhagensis* [Plates 14.5]), with the abaxial epidermis (*K. paucijlora*), mostly abutting the adaxial hypodermis (*C. fastigiatus* [Plate 14.6], *C. natalensis*, *C. obtusiflorus* [Plate 15.6] and *C. sexangularis*), in the mesophyll surrounding the outer vascular sheaths (*C. immensis*, *C. rubicundus*, *C. rupestris* var. *rupestris*, *C. semitrifidus* var. *semitrifidus*, *C. sexangularis*, *K. alata*, *M. solidus*, *P. nitidus* and *P. polystachyos* var. *polystachyos*); in the parenchymatous sheaths of bundles (*A. capensis*); with the vascular bundles (*C. diffornis*); in the lamina bridges of parenchyma (*C. fastigiatus*) and abutting the HSS (*C. textilis*).

In addition to the cone-shaped silica deposits of the adaxial and abaxial epidermal cells, there are only two species, namely *C. sexangularis* (Plate 16.4 and 16.5) and *C. textilis* that have additional deposits of silica in the leaves. These silica deposits are crescentiform in shape (semicircular) and are present on the outer periclinal walls of both the adaxial and abaxial epidermis of both species (Plate 16.4-5).

Almost half the species of the *Cypereae* in the Eastern Cape (21 species) have a hypodermis (Tables 7 and 8A-D, Appendix 3). The cells of the hypodermis are composed of thin-walled translucent cells (Plates 14.1-2, 14.4, 14.6-7, 14.10, 15.5-6, 15.12 and 16.6-8). The hypodermis is either adaxial (*C. albostriatus* [Plates 14.4 and 15.5], *C. distans*, *C. laevigatus* [Plate 16.6], *C. natalensis*, *C. obtusiflorus* [Plate 15.6], *C. rubicundus*, *C. rupestris* var. *rupestris*, *C. semitrifidus* var. *semitrifidus* [Plate 14.7], *C. sexangularis*, *C. textilis*, *K. alata*, *M. solidus*, *M. uitenhagensis*, *P. cooperi* [Plate 15.12], *P. macranthus*, *P. nitidus* and *P. polystachyos* var. *polystachyos*) or both adaxial and abaxial (*C. fastigiatus*, *C. immensis* [Plate 16.8], *C. textilis*, *M. tabularis* subsp. *major* and *M. thunbergii* [Plate 16.7]). The hypodermis may: be limited to the midrib (*C. textilis*); be present only in the lamina (*P. polystachyos* var. *polystachyos*); extend into the margins (*C. distans*); be interrupted by the HSS (*C. natalensis* and *M. tabularis* subsp. *major*); be interrupted by the adaxial row of bundles (*C. obtusiflorus* [Plate 15.6]); be interrupted by the mesophyll surrounding the large bundles (genus *Kyllinga*); be imbedded the adaxial row of bundles (*C. laevigatus*, *C. rupestris* var. *rupestris* and *C. semitrifidus* var. *semitrifidus* [Plate 14.7]); be extended to the median row of bundles (*M. solidus* and *M. thunbergii* [Plates 15.11 and 16.7]); or may abut the abaxial row of bundles (*P. nitidus*).
Within the mesophyll two main structural groups may be identified. Those with C₃ structure and those with C₄ structure. The C₃ structure is present in the genera Ascolepis (A. capensis), Cyperus (C. denudatus, C. difformis, C. pulcher, C. sphaerospermus, C. tennellus var. tennellus and C. textilis) and Pycreus (P. mundii). The C₄ structure is present in the genera Cyperus (in part), Kyllinga, Mariscus and Pycreus. The mesophyll of the C₃ species is composed of thin-walled chlorenchymatous parenchyma cells. The outline of the mesophyll of the C₃ species varies (Plates 15.7-8, 15.10 and 16.9-10). Surrounding the outer sheaths of all the vascular bundles of the C₄ species is a layer of thin-walled, chlorenchymatous parenchyma. These cells are present so that the long axis of each cell is present at right angles to the outer sheath cells (Plates 14.3, 14.11-12 and 15.11). The mesophyll cells appear to radiate (RM) from the bundle. The highest density of the chloroplasts within these cells is present closest to the outer sheath of the bundles. The RM in C. alboatriatus, C. laevigatus, C. rubicundus, C. rupestris var. rupestris and C. semitridifus var. semitridifus comprises all the mesophyll tissue present, besides the tissues of the cavities and the hypodermal cells.

In addition to the chlorenchymatous parenchyma and the hypodermis of the C₃ and C₄ species, thin-walled translucent parenchyma (TP) is also present at different locations within the Cypereae leaves. The distribution of these TP cells is as follows: in the midrib (C. rubicundus); abutting the intermediate bundles (C. denudatus [Plate 16.9] and C. textilis); abutting the small bundles (C. textilis); abutting the flange adaxial epidermis (K. elatior); scattered at random abutting the adaxial epidermis (C. esculentus [Plate 16.3], M. albomarginatus, M. dubius [Plate 14.3] and P. intactus); scattered at random abutting the abaxial epidermis (C. rupestris var. rupestris, C. semitridifus var. semitridifus and M. albomarginatus); scattered between the RM of the lamina bundles (C. natalensis and M. thunbergii); scattered at random throughout the mesophyll (M. macrocarpus, M. uitenhagensis and M. sumatrensis); present abaxially between the HSS in the midrib region (C. natalensis); abutting the abaxial sub-stomatal cavities in the midribs and margins (M. capensis) and abutting the leaf margins (M. dubius). Lobed translucent "blue" parenchyma abuts the adaxial row of the bundles in P. nitidus (present on either side of the bundle). Parenchymatous bridges (Pbr) of thin-walled translucent and chlorenchymatous parenchyma are present in C. denudatus, C. difformis, C. distans, C. esculentus (Plate 16.3), C. fastigiatuus, C. immensis (Plate 16.1 and 16.8), M. solidus and P. macranthus. The distribution of Pbr within the lamina and midribs of the Cypereae leaves is complex. Chlorenchymatous Pbr are present in C. difformis (Plate 15.10). These chlorenchymatous Pbr in C. difformis link the adaxial epidermis with the adaxial pole of all the bundles in the lamina, as well as the abaxial epidermis with the abaxial pole of the bundles (Plate 15.10), with the exception of the last two vascular bundles of the margins. Translucent Pbr are present in C. denudatus, C. distans, C. esculentus (plate 16.3), C. fastigiatuus, C. immensis (Plate 16.8), M. tabularis subsp. major and P. macranthus. The translucent Pbr in C. denudatus link the adaxial pole of a few of the large, intermediate and small bundles to the adaxial epidermis. The translucent Pbr in C. distans are present abaxially, where the Pbr abut the large and intermediate bundles linking these bundles with the abaxial epidermis. In the lamina of C. esculentus the translucent Pbr connect the abaxial epidermis with the RM of the median row of large, intermediate and small bundles (Plate 16.3). Similarly, the translucent Pbr link the abaxial epidermis with the RM of the median row of vascular bundles in C. fastigiatuus and M. solidus. The Pbr in P. macranthus link the adaxial epidermis with the RM of the midrib bundle, and the large and intermediate bundles. Pbr in C. immensis surround the HSS and SS.
The vascular bundles of the C₃ species are all present in one median row within the leaf mesophyll (Plates 15.10 and 16.10). 42 Percent of the C₃ species have two rows of vascular bundles in the lamina (Plates 14.7, 16.8 and 16.11, Tables 7 and 8A-D [Appendix 3]). 38 Percent of the C₄ vascular bundles are present in one median row within the leaf mesophyll, namely, C. rubicundus, C. sexangularis, the genus Kyllinga, P. intactus, P. macranthus and P. polystachyos var. polystachyos. 19 Percent of the C₄ species have three rows of vascular bundles (C. albostriatus [Plates 14.4 and 15.5], C. natalensis, M. macrocarpus, M. solidus, M. sumatrensis [Plate 16.12], M. thunbergii [Plates 15.11 and 16.7] and P. nitidus) and one percent four rows (P. coo peri [Plates 15.12 and 17.1]). The four rows of bundles in P. coo peri form stacks of bundles that are inter-spaced with cavities (Plates 15.12 and 17.1). This is the only species of the eastern Cape Province Cyperaceae to have these stacks of bundles in the leaf lamina.

The composition of vascular bundles in the C₄ species with three rows is generally as follows: adaxial row of intermediate and small bundles (except C. natalensis, M. macrocarpus and P. nitidus); median row of midrib, large, intermediate, small and marginal bundles (except C. albostriatus, C. natalensis, M. thunbergii and P. nitidus) and an abaxial row of small bundles (except M. thunbergii and P. nitidus). The composition of vascular bundles in P. nitidus is as follows: the adaxial row of large, some intermediate and marginal bundles; the median row of the midrib and intermediate bundles; the abaxial row of intermediate bundles and small bundles. The adaxial row in C. natalensis consists of large and small bundles. Only small bundles are present in the adaxial row of M. macrocarpus. The median row in C. albostriatus consists of a midrib, large, intermediate and small bundles. In C. natalensis the median row consists of a midrib bundle, of intermediate, small and marginal bundles. Median row of bundles in M. thunbergii consist of a midrib bundle, intermediate, small and marginal bundles, where the abaxial row has intermediate and small bundles.

Generally the C₄ species with two rows of bundles have an adaxial row of small bundles (except C. fastigiatus, C. obtusiflorus, M. albomarginatus, M. uitenhagensis and P. nitidus) and an abaxial row of midrib, large, intermediate, small and marginal bundles (except C. distans, C. fastigiatus, C. laevigatus, C. obtusiflorus, M. albomarginatus, and P. nitidus). In the species C. distans, C. fastigiatus, C. laevigatus, C. obtusiflorus, M. albomarginatus, M. uitenhagensis and P. nitidus the composition of the vascular bundles within the adaxial and abaxial rows is complex. Adaxial row bundles mostly include large (C. obtusiflorus and P. nitidus), intermediate (C. obtusiflorus, M. uitenhagensis and P. nitidus), small (C. fastigiatus, M. albomarginatus and M. uitenhagensis) and marginal bundles (C. fastigiatus and M. albomarginatus). The abaxial row of bundles may include the midrib bundle (C. distans, C. fastigiatus, C. laevigatus, C. obtusiflorus, M. albomarginatus, M. uitenhagensis and P. nitidus), large (C. distans, C. fastigiatus, C. laevigatus, C. obtusiflorus, M. albomarginatus, M. uitenhagensis and P. nitidus), intermediate (C. distans, C. fastigiatus, M. albomarginatus and P. nitidus), small (C. laevigatus, M. albomarginatus and P. nitidus) and marginal bundles (C. distans, C. laevigatus, C. obtusiflorus and P. nitidus). The adaxial row in C. rupestris var. rupestris consists of a midrib, large and intermediate bundles, with the small and marginal bundles in the abaxial row. In the adaxial row of C. semitrifidus var. semitrifidus there is a midrib bundle and large bundles, whilst the abaxial row has intermediate, small and marginal bundles.

In P. coo peri, the species with four rows of vascular bundles, the adaxial row of bundles in the lamina is composed of large bundles. The second and third row of intermediate and small bundles. The abaxial row of bundles is composed of the midrib bundle, the small and marginal bundles.
Chapter 5, Cypereae

Plate 17. Shows structural details of the leaf blades of a few selected Cypereae in section, illustrating the distribution and arrangement vascular bundles, and vascular sheaths, as well as vascular tissues.

(17.1) Shows the lamina cavities in P. cooperi, which are present between lamina stacking of vascular bundles, where the vascular bundles are present in four rows. The vascular bundles in the stacks are surrounded by radiating chlorenchyma. (17.2) The midrib in K. erecta has abaxial epidermal cells that are lignified in the outer periclinal wall. The midrib vascular bundle is present adjacent to two abaxial hypodermal sclerenchymatous strands. A small vascular bundle is present below the midrib vascular bundle. There are three sheaths present, an outer lignified mestome sheath, an inner chlorenchymatous sheath of border parenchyma on the xylem side of the vascular bundle and an inner Kranz sheath on the phloem side of the vascular bundle. The sheath of border parenchyma and Kranz sheath are separated by two large metaxylem vessels. The chloroplasts of the Kranz sheath are large, filling the cells. Vascular bundles in the midrib are one cell apart. There is a protoxylem lacuna present at the xylem pole of the midrib vascular bundle inside the sheath of border parenchyma. (17.3) The midrib vascular bundle in P. mundii has an abutting sclerenchymatous strand. The mesophyll is composed of non-radiating chlorenchyma, with numerous small chloroplasts. There are three vascular sheaths, an outer chlorenchymatous sheath of enlarged parenchyma, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The mestome sheath is thick-walled in the inner tangential wall. The sheath of border parenchyma is interrupted by two large metaxylem vessels. There is a large protoxylem lacuna present at the xylem pole of the vascular bundle inside the sheath of border parenchyma. (17.4) The large vascular bundle of P. mundii has an abutting sclerenchymatous strands. The same three sheaths are present in the same arrangement. There is a small protoxylem lacuna present at the xylem pole of the vascular bundle inside the sheath of border parenchyma. (17.5) Shows the intermediate vascular bundle of P. mundii with no sclerenchymatous strand. The mesophyll is composed of non-radiating chlorenchyma, with numerous small chloroplasts. There are three vascular sheaths, an outer chlorenchymatous sheath of enlarged parenchyma, a middle lignified mestome sheath and an inner partial sheath of non-lignified border parenchyma, present on the phloem side of the vascular bundle. The mestome sheath is thick-walled in the inner tangential wall. (17.6) The small vascular bundle in P. mundii has no abutting sclerenchymatous strand. Lamina cavities are present between the vascular bundles. Similar to the intermediate vascular bundle, there are the same three sheaths in the same arrangement. (17.7) The marginal vascular bundle in P. mundii, which has the same arrangement of sheaths as the small and intermediate vascular bundles. (17.8) Shows the midrib vascular bundle in M. dubius with two adjacent abaxial hypodermal sclerenchymatous strands. The mesophyll is composed of indistinct radiating chlorenchyma in abutting vascular bundles. Vascular bundles have two sheaths, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath is interrupted by two large metaxylem vessels. The chloroplasts of the Kranz sheath are large and fill the cell. There is a large protoxylem lacuna, which is present at the xylem pole of the vascular bundle, inside the Kranz sheath. (17.9) The large vascular bundle in M. dubius has two adjacent abaxial hypodermal sclerenchymatous strands. The mesophyll is composed of indistinct radiating chlorenchyma. The same two sheaths are present in the same arrangement. The protoxylem lacuna is present at the xylem pole of the vascular bundle inside the Kranz sheath. (17.10) Shows the intermediate vascular bundle in M. dubius with abutting radiating chlorenchyma. There are the same two sheaths present as in the midrib and large vascular bundle. The Kranz sheath is interrupted by two metaxylem vessels. The Kranz sheath chloroplasts are large, almost filling the cell. (17.11) The small vascular bundle in M. dubius has abutting radiating chlorenchyma, similar to the intermediate vascular bundle. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath is intact and encircles the vascular tissues. Kranz sheath chloroplasts are large and centrifugal. (17.12) Similar to the small vascular bundles in 17.11, the marginal vascular bundle in M. dubius has the same two sheaths in the similar structure and arrangement.

Symbols are as follows: (1) first row of vascular bundles; (2) second row of vascular bundles; (3) third row of vascular bundles; (4) fourth row of vascular bundles; (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Ca) lamina cavity; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundles; (KS) Kranz sheath; (L) large vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) large metaxylem vessel; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (SS) sclerenchymatous strands and (T) tannin idioblast. Bars = 10 μm.
Plate 17. Legend on facing page.
Within the midribs of *C. semitrifidus* var. *semitrifidus* and the genus *Kyllinga* (with the exception *K. brevifolia*) a small bundle is present directly beneath the midrib bundle (Plate 17.2). The small bundle at the margin of *P. macranthus* is present above the other vascular bundles, but does not appear to be in a second row of bundles.

All the vascular bundles of the C₃ species have a maximal cell distal count of over five cells (most cell distal counts range from 4 to 13 cells, Plates 15.10, 16.10, Table 7, Appendix 3), with the exception of *C. tennellus* var. *tennellus* (2) and *C. textilis* (3-5). Most of the C₄ species have a maximal cell distal count of two cells (Tables 8A-D, [Appendix 3], Plates 14.4-6, 14.12, 15.6, 15.9, 16.2-3, 16.11-12 and 17.1).

Within the lamina of the C₄ species there is a pattern of vascular bundle composition within the mesophyll in just over half the species (18) of the tribe (Tables 7 and 8A-D, Appendix 3), compared with the C₃ species where there are no such patterns. In these C₄ species, on average there are 2-4 small bundles (mean for tribe) present between the large and intermediate bundles. The small bundles in *K. brevifolia* are progressively smaller towards the midrib. There are no large, intermediate or small bundles in the laminae of the C₃ species, *C. tennellus* var. *tennellus* (midrib bundle and marginal bundles only).

All vascular bundles of the C₃ species are characterised by the presence of two vascular sheaths. The outermost sheath is a parenchymatous sheath (PS) and the inner sheath is a lignified mestome sheath (MS). The vascular bundles in *C. difformis, C. pulcher* (Plate 15.8), *C. sphaerospermus* (Plate 15.7), *C. tennellus* var. *tennellus* and *P. mundii* (Plate 17.3-7) are also characterised by the presence of a third partial or interrupted sheath. This sheath is present inside the MS and is composed of border parenchyma (BP). Only one species, *A. capensis*, has a partial sheath of lignified cells present inside the MS on the phloem side of the bundle.

The cells of the PS of the C₃ species are two to three times larger than the abutting mestome sheath cells (Plates 15.7-8 and 17.3-7). They are thin-walled and chlorenchymatous. Generally the walls of the MS cells are thick-walled in the radial and inner tangential walls. The MS cells in *C. tennellus* var. *tennellus* and *C. textilis* have similar lignification in all the walls. The walls of the MS in *P. mundii* are thick-walled in the inner tangential walls, especially on the phloem side of the midrib bundle, large and a few intermediate bundles (Plate 17.3-5). A few of the intermediate, small and marginal bundles are thin-walled in comparison to these bundles (Plate 17.6-7). The thickening of the walls of the MS is complex and detailed in Appendix 4. The BP of the C₃ species is bisected by the large metaxylem vessels in the midrib bundle, and the large and intermediate bundles (Plates 15.7-8 and 17.3-4). In *C. pulcher* and *C. sphaerospermus* the protoxylem lacunae may also interrupt the BP in the midrib bundle, as well as the large bundles. In a few of the intermediate and small bundles, protoxylem or metaxylem vessels may also interrupt the BP. In *P. mundii* the BP is limited to the phloem side of the small bundle (Plate 17.6) and marginal bundles (Plate 17.7). The BP cells in *C. difformis* are large. BP cells in *C. pulcher* (Plate 15.8), *C. sphaerospermus* (Plate 15.7), *C. tennellus* var. *tennellus* and *P. mundii* (Plate 17.4-5) are medium sized.

Most of the vascular bundles of the C₄ species are characterised by the presence of two vascular sheaths, and an abutting RM (Plate 17.8-12). In most species the outer sheath is a lignified mestome sheath (MS), which encircles the bundle and the inner sheath is the Kranz sheath (KS). An additional third sheath composed of non-lignified border parenchyma (BP) is present only on the xylem side of the bundle in *C. immensis, C. obtusiflorus, C. rupestris* var. *rupestris, C. semitrifidus* var. *semitrifidus*, the genus *Kyllinga* (except *K. brevifolia*), the genus *Mariscus*.
(except *M. capensis* and *M. thunbergii*) and the genus *Pyreus*. The BP replaces the KS on the xylem side of these bundles (Plate 17.2).

All of the MS cells of the C₄ species are smaller than the abutting KS cells (Plate 17.8-12). The lignification within the walls of the MS varies, see Appendix 4 for details. Generally the walls of the MS are thick-walled in the radial and inner tangential walls, especially in *C. distans*, *C. esculentus*, *C. natalensis* and *C. obtusiflorus*. The MS walls in some of the bundles within the leaves are relatively thin-walled (*C. fastigiatus*, *C. immensis*, *C. semitrigudus*, *K. brevifolia*, *K. elatior*, *K. paucijlorus*, *M. albomarginatus*, *M. capensis*, *M. congestus*, *M. dubius*) [Plate 17.8-12], *M. macrocarpus*, *M. solidus*, *M. sumatrensis*, *P. cooperi* and *P. polystachyos* var. *polystachyos*), whilst a few species have similar lignification within the walls of the MS (*C. albostriratus*, *C. laevigatus* [Plate 14.11], *C. sexangularis*, *K. paucijlorus*, *M. dubius*, *M. macrocarpus*, *M. solidus*, *M. thunbergii*, *P. macranthus* and *P. nitidus*)

The KS cells of the C₄ species are two to four times the size of the MS cells. These cells are thin-walled and have large chloroplasts, one to three per cell (Plate 17.8-12). These chloroplasts in most species are almost the same size as the cell, especially in the small and intermediate bundles (Plate 17.10-11). The chloroplasts of the KS in *C. laevigatus*, *K. alata*, *K. elatior*, *M. macrocarpus*, *M. thunbergii* and *P. intactus* are smaller than the rest of the C₄ *Cypereae*. The chloroplasts are centrifugal in position (with respect to the centre of the vascular bundle [Plate 17.11]). The chloroplasts of the KS are absent in a few of intermediate and small bundles, at the phloem pole of the bundles in the genus *Mariscus*.

A thin-walled, large celled BP is present on the xylem side of the bundles in *C. immensis*, *C. obtusiflorus*, *C. rupestris* var. *rupestris*, *C. semitrigudus* var. *semitrigudus*, the genus *Kyllinga* (except *K. brevifolia*), the genus *Mariscus* (except *M. capensis* and *M. thunbergii*) and the genus *Pyreus*. The BP is present in the midrib bundle (*C. obtusiflorus*, *C. semitrigudus* var. *semitrigudus*, *K. alata*, *K. erecta* [Plate 17.2], *M. albomarginatus*, *M. tabularis* subsp. *major*, *M. uitenhagensis*, *P. cooperi*, *P. intactus*, *P. macranthus* and *P. polystachyos* var. *polystachyos*), large bundles (*C. immensis*, *C. obtusiflorus*, *C. rupestris* var. *rupestris*, *C. semitrigudus* var. *semitrigudus*, *K. alata*, *K. elatior*, *K. erecta*, *K. paucijlorus*, *M. albomarginatus*, *M. congestus*, *M. macrocarpus*, *M. solidus*, *M. sumatrensis*, *M. tabularis* subsp. *major*, *M. uitenhagensis*, *P. cooperi*, *P. intactus*, *P. macranthus*, *P. nitidus* and *P. polystachyos* var. *polystachyos*), intermediate bundles (*C. immensis*, *C. rupestris* var. *rupestris*, *K. paucijlorus*, *M. congestus*, *M. macrocarpus*, *M. solidus*, *M. sumatrensis* and *P. nitidus*) and marginal bundles (*C. immensis*).

One of the marginal bundles in *C. obtusiflorus* has no sheaths and only has MX vessels (Plate 18.1), whilst one of the marginal bundles in *K. paucijlorus*, *M. capensis*, *M. congestus*, *M. dubius* and *P. cooperi* has the MS, KS and the vasculature mixed (Plate 18.2). A MS is absent in the marginal bundles of *M. tabularis* subsp. *major*. The MS in some of the abaxial row bundles in *P. cooperi* joins with the adjacent bundles. In the margins of *P. polystachyos* var. *polystachyos* the vascular sheaths of the marginal and adjacent small bundle touch.

The phloem and xylem outlines of both the C₃ and C₄ species varies (Appendix 4). Most of the midrib and large bundles of the C₃ and C₄ species have a protoxylem lacuna present at the xylem pole of the bundles (Plates 15.7, 17.3-4 and 17.8-9). In the C₃ species, *C. tennellus* var. *tennellus* a protoxylem lacuna is absent in the midrib. In the
Plate 18. Shows structural details of the leaf blades in *C. obtusiflorus*, *M. dubius* and *M. thunbergii* illustrating the distribution and arrangement of vascular sheaths, and vascular tissues as well as vascular bundle orientation.

(18.1) Shows the margin of *C. obtusiflorus* with an adaxial epidermis stoma. The abaxial epidermis has a thick-walled outer periclinal wall. Note the absence of the mestome and Kranz sheath in the marginal vascular bundle. The marginal vascular bundle is only one cell away from the adjacent small vascular bundle. This marginal vascular bundle appears to only have xylem vessels, with no phloem tissues. (18.2) The marginal vascular bundle in *M. dubius* also has no distinctive sheaths, and only a few xylem and phloem vessels. (18.3) In *M. thunbergii* the abaxial row of small vascular bundles has no phloem tissues only xylem vessels. An adjacent small vascular bundle is orientated so that the xylem faces the centre of the lamina cavity and not the adaxial epidermis.

Symbols are as follows: (Ab) abaxial epidermal cell; (Ad) adaxial epidermal cell; (Ca) lamina cavity; (HSS) hypodermal sclerenchymatous strands; (Ma) marginal vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (P) phloem; (S) small vascular bundle; (St) stoma and (X) xylem. Bars = 10 μm.
C₄. C. textilis and the C₄ species, M. capensis the protoxylem lacunae is only present in the midrib bundle. The midrib and large bundles of the C₃ species, C. laevigatus has intact protoxylem vessels. The abaxial small bundles of the C₄ genus Cyperus only has xylem present in the bundle and no phloem. A few small bundles in M. thunbergii also do not face the adaxial surface but the abaxial surface. In M. solidus, M. sumatrensis and M. thunbergii (Plate 18.3) a few of the abaxial small bundles only have xylem tissue and lack phloem. The xylem in the small bundle present below the midrib of the C₄ genus Kyllinga almost encircles the phloem, in an almost closed V. A few of the small bundles of the C₄ species, M. albomarginatus and M. macrocarpus have the xylem encircling the phloem tissue. The xylem in some of the small bundles of the C₃ species, M. macrocarpus, M. sumatrensis and M. thunbergii (Plate 18.3) is not orientated to face the adaxial epidermal surface but, faces parallel to the adaxial epidermal surface.

![Plate 18: See the legend on the facing page.](image)

### 5.2.4 Bract Characteristics within the Cypereae

The Cypereae are mostly homogeneous with respect to leaf and bract outline, where the bracts are V-shaped. But there are other bract shapes and they are as follows: crescentiform, with a median groove (C. marginatus); inversely W-shaped (C. immensis); triangular (C. tennellus var. tennellus); sub-triangular (P. macranthus) and scutiform (C. denudatus). The V-shaped species may be divided into four groups: true V-shaped (C. albostratus (with ribs), C. difformis, C. esculentus, C. longus var. temiflorus, C. obtusiflorus, C. rubicundus, C. sexangularis, C. sphaerospermus, K. alata, K. pauciflora, M. albomarginatus, M. capensis, M. sumatrensis, M. tabularis subsp. major, M. thunbergii, M. uitenhagensis, P. cooperi, P. intactus, P. mundii and P. polystachyos var. polystachyos); flanged V-shaped (C. distans, C. natalensis, C. pulcher, K. brevifolia, K. elatior, M. congestus, M. dubius, M. macrocarpus, M. solidus and P. nitidus); thinly V-shaped (A. capensis and C. textilis) and thickly V-shaped (C. laevigatus, C. rupestris var. rupestris, C. semitrifidas var. semitrifidas and K. erecta). In both C. distans and M. thunbergii the bract margins are orientated so that the bract tips face inwards (towards the midrib region), but, not abaxial to the leaf, adaxially (on top of the rest of the leaf tissues). There are slight flanges in the margin of the bracts in K. erecta.

Trichomes are present in the bracts of P. mundii (Plate 19.1-2). This is the only species in the Cypereae that has trichomes (Tables 9 and 10A-D. Appendix 3). These trichomes are present at the margins and on the adaxial surface of the bract. The trichomes at the margins are large (121-182μm), lanceolate and multi-cellular (Plate 19.1). These trichomes are composed of thin-walled, translucent parenchyma (TP).
Plate 19. Shows structural details of the bract blades of a few selected Cypereae in section, including the distribution and arrangement of adaxial, abaxial, marginal and midrib epidermal cells; hypodermal sclerenchymatous strands, girders and sclerenchymatous strands; hypodermis arrangement and structure; lamina cavities; mesophyll structure including parenchymatous bridges and translucent parenchyma; adaxial stoma; trichome structure; and vascular bundle arrangement, as well as spacing.

(19.1) Shows the margin in P. mundii where the adaxial epidermal cells are larger than the abaxial epidermal cells. At the margin the adaxial and abaxial epidermal cells overlap forming an elongated trichome. Abaxial hypodermal sclerenchymatous strands are present adjacent to the vascular bundles, whilst adaxial hypodermal sclerenchymatous strands are only present in the margins. Lamina cavities are present between the vascular bundles. The mesophyll is composed of non-radiating chlorenchyma. Vascular bundles are present in a median row.

(19.2) The adaxial epidermis in P. mundii has a few adaxial trichomes, composed of lanceolate lignin extensions of the outer periclinal wall of the epidermal cells. (19.3) The adaxial epidermal cells in K. erecta are thick-walled in outer periclinal wall.

(19.4) Shows details of the marginal epidermis in C. esculentus with abutting adaxial and abaxial epidermal cells, where the outer periclinal wall is thick-walled. The marginal epidermal cells are larger than the adjacent epidermal cells. (19.5) The midrib abaxial marginal epidermal cells in C. natalensis are thick-walled and larger than the adjacent cells. An epidermal cell abutting the hypodermal sclerenchymatous strands of the midrib has a cone-shaped silica deposit. (19.6) The adaxial epidermal cells in C. immensis are larger than the abaxial epidermal cells, which are thick-walled in the outer periclinal wall. Note in particular the adaxial stoma of the margin. The marginal hypodermal sclerenchymatous strand is present near the margin and does not fill the margin.

The mesophyll of the margin has a few cells of translucent parenchyma. The mesophyll is mostly composed of compact radiating chlorenchyma with a few scattered tannin idioblasts. (19.7) The adaxial epidermal cells in Ascolepis capensis are larger than the abaxial epidermal cells. The lamina large vascular bundles abut the abaxial girders. Lamina cavities are present between the vascular bundles. The mesophyll is composed of non-radiating chlorenchyma, with numerous chloroplasts. (19.8) The abaxial epidermal cells in C. rupestris var. rupestris are thick-walled in the outer periclinal wall. Hypodermal sclerenchymatous strands are present at random along the epidermis and may in some instances be present adjacent the vascular bundles. A large adaxial hypodermis, which extends to the abaxial row of vascular bundles and mostly encircles the adaxial row of vascular bundles. The mesophyll is composed of compact chlorenchymatous cells surrounding the vascular bundles. There are two rows of vascular bundles, namely adaxial and abaxial. (19.9) A few of the sclerenchymatous strands in C. denudatus are present in the aerenchymatous network of parenchymatous bridges. (19.10) These sclerenchymatous strands in C. denudatus are present at the junctions of the parenchymatous bridges, endarch to the vascular bundles. The lamina cavities are present between the bridges. The chlorenchymatous parenchyma extends from the epidermis to the vascular bundles, and to the phloem side of the large vascular bundles (encircling the smaller vascular bundles). Extending from the xylem pole of the large vascular bundles is the aerenchymatous network of parenchymatous bridges. This extends to the adaxial epidermis. The vascular bundles are in one row. (19.11) The adaxial epidermis in C. longus var. tenuiflorus is thick-walled in the outer periclinal wall. The hypodermal sclerenchymatous strands are present in the parenchymatous bridges of abaxial row of vascular bundles. The adaxial hypodermis extends to both the adaxial and abaxial row of vascular bundles. The lamina cavities are present between the adaxial and abaxial rows of vascular bundles, as well as between the translucent parenchymatous bridges and the abaxial epidermis. The mesophyll is composed of compact radiating chlorenchyma, which abuts the vascular bundles. The vascular bundles are one to three cells apart. (19.12) The adaxial epidermal cells in C. tenuiflorus var. tenuiflorus are larger than the abaxial epidermal cells. The mesophyll is composed of an outer region of chlorenchymatous parenchyma and central region of translucent parenchyma. Vascular bundles are present in the central translucent parenchyma.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (Ca) lamina cavity; (G) girder; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (L) large vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MEp) marginal epidermal cell; (Pbr) parenchymatous bridge; (OT) outer periclinal wall (tangential); (S) small vascular bundle; (St) stoma; (SS) sclerenchymatous strands; (T) tannin idioblast; (TP) translucent parenchyma and (Tr) trichome. Bars = 10 μm.
Plate 19. Legend on facing page.
The second type of trichome is composed of silica and is present in the shapes of hyphae or appears to be rod-like (Plate 19.2). These trichomes are present at random on the adaxial surface of the bract (outer periclinal walls of the adaxial epidermal cells).

The bract thickness of the different genera and species varies (Tables 9 and 10A-D, Appendix 3), ranging from 42 \( \mu \text{m} \) (K. erecta) to 687 \( \mu \text{m} \) (C. denudatus). The midrib regions are generally thicker than the lamina due to the large bulliform cells that are usually present in the midrib (Tables 9 and 10A-D, Appendix 3). Lamina are thicker than midrubs in C. longus var. tenuiflorus, C. natalensis, C. semitrijetus var. semitrijetus, K. erecta, M. macrocarpus, M. tabularis subsp. major, M. thunbergii and P. polystachyos var. polystachyos.

All species have adaxial and abaxial epidermal cell. There are no circular bracts. The shape of the adaxial and abaxial epidermal cells varies (Plates 19.1-12 and 20.1-3). The adaxial and abaxial epidermal cell walls are generally thin-walled. The outer periclinal wall of the epidermal cells in C. albostratius, C. esculentus (Plate 19.4), C. immensis (Plate 19.6), C. longus var. tenuiflorus (Plate 19.11), C. marginatus, C. pulcher, C. rupestris var. rupestris, C. semitrijetus var. semitrijetus, K. alata, K. erecta (Plate 19.3), K. pauciflora, M. capensis, M. dubius, M. macrocarpus, M. solidus, M. sumatrensis, M. tabularis subsp. major, M. thunbergii, M. uitenhagensis, P. cooperi, P. macranthus, P. nitidus and P. polystachyos var. polystachyos is thick-walled. Thin-walled, translucent bulliform cells are present in the midrib, adaxial epidermal cells in A. capensis, C. denudatus, C. laevigatus, C. longus var. tenuiflorus, C. pulcher, C. rubicundus, C. rupestris var. rupestris, C. semitrijetus var. semitrijetus, C. sexangularis, C. tennellus var. tennellus, C. textilis, K. erecta, M. capensis, M. congestus, M. dubius, M. macrocarpus, M. uitenhagensis, P. cooperi and P. macranthus. The marginal epidermal cells in C. esculentus (Plate 19.4) and M. solidus are larger than the adjacent epidermal cells. Similarly the abaxial epidermal cells in the point of the V of the midrib in C. natalensis (Plate 19.5), M. solidus and P. intactus are larger than the adjacent epidermal cells.

Generally adaxial epidermal cells are larger than the abaxial epidermal cells (the adaxial cells are almost three times the size of the abaxial [Tables 9 and 10A-D, Appendix 3]). In C. difformis, C. distans, C. esculentus, C. immensis, C. longus var. tenuiflorus, C. marginatus, C. obtusiflorus, C. rubicundus, C. rupestris var. rupestris, C. semitrijetus var. semitrijetus, C. sexangularis, C. tennellus var. tennellus, M. solidus, M. thunbergii, P. cooperi, P. maracanthus and P. nitidus, the abaxial epidermal cells are generally larger than the adaxial (Tables 9 and 10A-D, Appendix 3). The adaxial epidermal cells range from 2 \( \mu \text{m} \) (C. immensis and C. semitrijetus var. semitrijetus) to 118 \( \mu \text{m} \) (M. uitenhagensis). The abaxial epidermal cells are small (Tables 9 and 10A-D, Appendix 3), ranging from 3 \( \mu \text{m} \) (P. maracanthus) to 18 \( \mu \text{m} \) (P. mundii).

Cone-shaped silica deposits in the epidermal cells that are present abutting the HSS are generally present in the abaxial epidermal cells (91% of the species have cones in their abaxial epidermal cells [Plate 19.5]). Silica-cones are absent in the epidermal cells of C. laevigatus, M. tabularis subsp. major, P. cooperi and P. macranthus. Silica-cones are absent in the adaxial epidermis of C. esculentus, C. pulcher, C. rubicundus, C. sexangularis, C. textilis, K. brevifolia, K. elatior and P. mundii. The cells of the epidermis abutting the HSS that lacked these cones are mostly smaller than the epidermal cells adjacent the HSS.

Generally stomata are present in the abaxial hypodermis, whilst C. esculentus, C. immensis (Plate 19.6) and C. longus var. tenuiflorus are amphistomatous. The adaxial stomata are present in the adaxial epidermal cells near the...
The stomata are generally flush with the epidermal surface (Plate 19.6). Slightly raised stomata are present in \textit{C. albostriatus}, \textit{C. difformis}, \textit{K. brevifolia}, \textit{K. eliator} and \textit{K. pauciflora}. Sunken stomata are present in the bracts of \textit{C. sphaerospermus}. There are no recognisable stomata in the bracts of \textit{C. tennellus var. tennellus} and \textit{C. textilis}. Unique to \textit{A. capensis}, \textit{K. erecta} and \textit{K. pauciflora} are the stomata, which are present in the point of the midrib V. The sub-stomatal cavities are small (Tables 9 and 10A-D, Appendix 3), ranging from less than 1\textmu m (\textit{C. immensis} and \textit{C. laevigatus}) to 133\textmu m (\textit{C. pulcher}).

The cells that comprise the HSS, SS and girders are small and lignified (Plates 19.5-7, 19.9-10 and 20.1). Generally the HSS are mostly frequently found adjacent to the both the adaxial and abaxial epidermal cells. There are no adaxial HSS present in \textit{C. laevigatus}, \textit{C. rubicundus} and \textit{C. sexangularis}. Adaxial girders are present abutting all the bundles in \textit{C. marginatus}. Abaxial girders are present abutting the vascular bundles in \textit{A. capensis} (Plate 19.7). The girders in \textit{A. capensis} abut the midrib bundle, the large (Plate 19.7) and intermediate bundles. The shape of the adaxial, as well as abaxial HSS and girders are variable, see Appendix 4 for details.

Most of the \textit{Cypereae} species have more abaxial HSS than adaxial (Table 9 and 10A-D, Appendix 3). Both \textit{C. longus} var. \textit{tenuiflorus} and \textit{M. tabularis} subsp. \textit{major} have the same number of adaxial and abaxial HSS (7 and 28, respectively). Most abaxial HSS are present in the genus \textit{Mariscus} (mean: ranges from 9 to 63) and the least in the genus \textit{Kyllinga} (mean: ranges from 17 to 27). As in the leaves, the adaxial HSS are larger than the abaxial HSS, with the exception of \textit{C. albostriatus}, \textit{C. difformis}, \textit{C. distans}, \textit{C. esculentus}, \textit{C. immensis}, \textit{C. longus} var. \textit{tenuiflorus}, \textit{C. marginatus}, \textit{C. pulcher}, \textit{C. rupestris} var. \textit{rupestris}, \textit{C. sphaerospermus}, \textit{C. tennellus} var. \textit{tennellus}, \textit{K. brevifolia}, \textit{K. erecta}, \textit{M. capensis}, \textit{M. congestus}, \textit{M. tabularis} subsp. \textit{major}, \textit{M. thunbergii}, \textit{M. uitenhagensis}, \textit{P. cooperi}, \textit{P. maracanthus}, \textit{P. mundii} and \textit{P. nitidus} (Tables 9 and 10A-D, Appendix 3). The adaxial HSS size ranges from 6\textmu m (\textit{C. tennellus} var. \textit{tennellus} and \textit{M. capensis}) to 67\textmu m (\textit{C. longus} var. \textit{tenuiflorus}). The size of the abaxial HSS is smaller and ranges from 2\textmu m (\textit{P. nitidus}) to 52\textmu m (\textit{M. tabularis} subsp. \textit{major}).

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Xylem pole SS about the midrib bundle (A. capensis, C. albostriatus, C. denudatus, C. difformis, C. distans, C. esculentus, C. immensis, C. longus var. tenuiflorus, C. marginatus, C. pulcher, C. sphaerospermus, C. textilis, K. pauciflora, M. congestus, M. tabularis subsp. major, M. thunbergii, P. intactus, P. mundii and P. nitidus), the large bundles (C. denudatus, C. difformis, C. sphaerospermus, M. thunbergii and P. mundii), the intermediate bundles (C. denudatus), the small bundles (C. denudatus) and/or the marginal bundles (C. denudatus). SS are present abutting the phloem pole of large and intermediate bundles in M. tabularis subsp. major. These SS are as large as the HSS that are present adjacent to the vascular bundles. SS are also present in C. denudatus and C. marginatus. The SS in C. denudatus are present at the intersections of the parenchymatous bridges (Plate 15.9-10) and are large in size. Triangular SS are also present in the margins of C. marginatus.

Lamina cavities are present in the lamina of the genera Ascolepis (A. capensis), Cyperus, Mariscus and Pycreus (Tables 9 and 10A-D, Appendix 3). As with the leaves, the distribution of these cavities within the lamina is variable and complex. The distribution of lamina cavities is as follows: between the median row bundles (A. capensis, most Cyperus species, M. macrocarpus, M. solidus, M. sumatrensis, M. thunbergii and P. mundii); between the adaxial row of bundles (P. nitidus); between the abaxial row of bundles (M. congestus and M. tabularis subsp. major); between the vascular bundle stacks (P. cooperi); between the aerenchymatous network of the parenchymatous bridges, which link the vascular bundles with the adaxial epidermis (C. denudatus [Plate 19.10]); abutting the sub-stomatal cavities (C. natalensis and M. congestus); between the midrib, large and intermediate bundles, as well as between adaxial hypodermis, and between the bridges of parenchyma in the lamina (P. macranthus). The cavity shape varies and is detailed in Appendix 4. The size of the lamina cavities in relation to the lamina thickness is large (Table 9 and 10A-D, Appendix 3), ranging from 8µm (C. albostriatus) to 454µm (C. denudatus).

Generally translucent "blue" parenchyma is present within the lamina cavities. Thin-walled, chlorenchymatous stellate parenchyma is present in the cavities of C. difformis, C. immensis, C. pulcher, C. sphaerospermus, C. textilis
and M. congestus. Translucent parenchyma is also present in the lamina cavities of A. capensis, C. denudatus and C. textilis.

Tannin idioblasts range from very few (A. capensis, C. laevigatus, K. elatior, M. dubius, M. macrocarpus, P. cooperi, P. intactus and P. polystachyos var. polystachyos) to many (C. marginatus, C. pulcher, M. capensis, M. congestus, M. thunbergii and P. mundii). Tannin idioblasts are absent in the bracts of C. tennellus var. tennellus. Tannin idioblasts are generally scattered throughout the mesophyll. In a few species tannin idioblasts abut certain structural features. These structural features are as follows: the mesophyll surrounding vascular bundles (C. immensis, C. natalensis, C. rubicundus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus, M. capensis, M. thunbergii, P. macranthus and P. nitidus); the adaxial epidermis (C. esculentus, K. erecta, K. pauciflora, M. albomarginatus, M. congestus, M. dubius and M. uitenhagensis); the abaxial epidermis (M. congestus); the margins (M. dubius); the lamina cavities (C. albostriatus and C. pulcher); the adaxial hypodermis (C. difformis, C. sexangularis, K. alata, K. brevifolia and P. polystachyos var. polystachyos); the vascular bundles (C. longus var. tenuiflorus, C. sphaerospermus, C. textilis and K. elatior) and the outermost vascular sheath (A. capensis). As in the leaves, crescentiform deposits of silica are present on the outer periclinal walls or the surfaces of the epidermis of both the adaxial and abaxial epidermis in C. sexangularis and C. textilis.

Both adaxial and abaxial hypodermis, abut the epidermis in the bracts of the Cypereae (Plates 19.8, 19.11 and 20.1-3, Table 9 and 10A-D [Appendix 3]). An adaxial hypodermis is present in C. denudatus, C. distans, C. esculentus, C. immensis, C. longus var. tenuiflorus (Plate 19.11), C. natalensis, C. obtusiflorus, C. rubicundus, C. rupestris var. rupestris (Plate 19.8), C. semitrifidus var. semitrifidus, C. sexangularis, C. textilis, K. alata, M. congestus, M. solidus, M. tabularis subsp. major (Plate 20.1), M. thunbergii (Plate 20.3), M. uitenhagensis, P. cooperi (Plate 20.2), P. macranthus, P. nitidus and P. polystachyos var. polystachyos. An abaxial hypodermis is present in both M. tabularis subsp. major and M. thunbergii (Plate 20.3). The adaxial hypodermis in C. esculentus, M. uitenhagensis and P. mundii is present only in the midrib. The adaxial hypodermis is thickest in the genus Pycreus (mean cell thickness was between 2-4 cells) and the thinnest in the genus Kylinga (mean cell thickness 1 cell). The adaxial hypodermis in C. immensis, M. solidus and M. thunbergii (Plate 20.3) extend to the RM of the median row bundles. Similarly, the hypodermis in P. cooperi extends the adaxial row of bundles and the midrib bundle (Plate 20.2). The adaxial HSS in C. longus var. tenuiflorus (Plate 19.11) and M. tabularis subsp. major interrupt the adaxial hypodermis. Similarly, the RM of the large bundles in K. alata and P. polystachyos var. polystachyos interrupts the adaxial hypodermis in the mid-lamina regions and the margins.

There are great differences in the anatomy of the species with a RM layer (Plate 19.11) and those, where the RM is absent (Plate 19.7 and 19.12). The species with a RM are C₃ and those without the RM, C₄. The species with C₃ anatomical characteristics are A. capensis, C. albostriatus, C. denudatus, C. difformis, C. marginatus, C. pulcher, C. sphaerospermus, C. tennellus var. tennellus, C. textilis and P. mundii. The mesophyll of the C₃ species is composed of thin-walled chlorenchymatous cells that are non-radiating in appearance and variable in shape. Surrounding the outer sheaths of all the vascular bundles in the C₄ species is a layer of thin-walled, radiate mesophyll (RM), similar to the leaves. The highest density of the chloroplasts within the RM, is closest to the outer sheath of the bundles.

There is a region of thin-walled translucent parenchyma that is present between the adaxial hypodermis and the mesophyll in C. tennellus var. tennellus, which does not appear to be the same as the hypodermis (Plate 19.12).
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Plate 20. Shows structural details of the bract blades in *M. tabularis* subsp. *major*, *M. thunbergii* and *P. cooperi* in section, illustrating the distribution and arrangement of adaxial and abaxial epidermis, hypodermal sclerenchymatous strand arrangement, hypodermis, lamina cavities, mesophyll structure including parenchymatous bridges and vascular bundle arrangement.

(20.1) Shows *M. tabularis* subsp. *major* with larger adaxial epidermal cells than abaxial epidermal cells. The hypodermal sclerenchymatous strands are present adjacent to the vascular bundles. The adaxial hypodermal sclerenchymatous strands are present adjacent to the adaxial intermediate and abaxial large, as well as intermediate vascular bundles. The abaxial hypodermal sclerenchymatous strands are present adjacent to the abaxial row of vascular bundles and also are present in the parenchymatous bridges. The lamina cavities are present between the parenchymatous bridges, and the vascular bundle rows (adaxial and abaxial) and the abaxial epidermis. The mesophyll is compact and composed of radiating chlorenchyma associated with the vascular bundles. Bridges of translucent parenchyma abut the phloem side of the abaxial row of vascular bundles and the abaxial hypodermal sclerenchymatous strands. The vascular bundles are present in two rows in the lamina, namely adaxial and abaxial. 

(20.2) The adaxial and abaxial epidermal cells in *P. cooperi* are similar in size. The adaxial hypodermis extends to the adaxial row of vascular bundles and the midrib. The lamina cavities are present between the stacks of vascular bundles, the adaxial hypodermis and the third row of vascular bundles (abaxial row). The vascular bundles are present in three rows within the lamina, namely stacked in an adaxial, median row and an abaxial row. (20.3) The adaxial and abaxial epidermal cells in *M. thunbergii* are of similar size. The lamina cavities are present between the adaxial, median and abaxial row of vascular bundles. There is an adaxial and abaxial hypodermis, where the adaxial hypodermis extends to the adaxial and median row of vascular bundles. Vascular bundles are present in four rows, namely adaxial, median and two abaxial.

Symbols are as follows: (1) row 1 of vascular bundles; (2) row 2 of vascular bundles; (3) row 3 of vascular bundles; (4) row 4 of vascular bundles; (Ab) abaxial epidermis; (Ad) adaxial epidermis; (Ca) lamina cavity; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis and (Pbr) parenchymatous bridge. Bars = 10 μm.
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gives the bract a culm-like appearance. In many of the species there are cells of translucent parenchyma of different shapes, and locations present within either the lamina or midrib of the bracts. This parenchyma is only present in the C₄ species and the distribution of these cells is complex. The distribution of these TP cells is as follows: in the margins (C. immensis, C. natalensis, C. rubicundus and M. thunbergii); abutting the HSS of the margins (C. longus var. tenuiflorus and P. cooperi); abutting the abaxial HSS of the midrib (C. obtusiflorus and C. rubicundus); abutting the abaxial bundles (P. nitidus); scattered between the abaxial HSS (C. semitrifidus var. semitrifidus); abutting the adaxial epidermis (K. brevifolia and M. uitenhagensis); abutting the sub-stomatal cavities (M. capensis); abutting the abaxial epidermis of the midrib (M. dubyus); abutting the abaxial epidermis directly beneath the median row of bundles in the midrib and margins (M. solidus) and scattered within the mesophyll (M. sumatrensis).

Plate 20. Legend on facing page.

Thin-walled parenchymatous bridges (Pbr) of translucent parenchyma are present in C. denudatus, C. difformis, C. distans, C. immensis, C. longus var. tenuiflorus (Plate 19.11), C. pulcher, M. solidus, M. tabularis subsp. major (Plate 20.1), P. cooperi (Plate 20.2) and P. macranthus. The distribution of these Pbr is complex, where the Pbr extend from the following structures: the adaxial pole of the midrib bundle, and the large and intermediate bundles to the adaxial epidermis (C. denudatus [Plate 19.10]); the adaxial epidermis to the midrib bundle (C. difformis); the adaxial pole of the large, intermediate and small bundles to the adaxial epidermis (C. pulcher); the adaxial epidermis to the RM of the midrib bundle and large bundles (P. macranthus); most of the large, intermediate and small bundles to the abaxial epidermis (C. longus var. tenuiflorus [Plate 19.11]); the large and intermediate bundles to the abaxial epidermis (C. distans); the abaxial row of bundles to the abaxial epidermis (M. tabularis subsp. major [Plate 20.1]); the abaxial epidermis and hypodermis to the median row of vascular bundles (C. immensis). Generally within these Pbr are the HSS and SS, appearing almost as sheaths (one cell thick) around the HSS and SS (Plate 20.1).

All C₄ vascular bundles are present in one median row within the bract mesophyll (Plate 19.10 and 19.12). The C₄ species' vascular bundles are present in either one row (C. esculentus, C. rubicundus, C. semitrifidus var. semitrifidus, C. sexangularis, the genus Kyllinga, M. dubius, P. intactus, P. macranthus and P. polystachyos var. polystachyos), two rows (most species [Plates 19.11 and 20.1]), three rows (C. natalensis, M. macrocarpus, M. solidus, M. sumatrensis and P. cooperi [Plate 20.2]) or four rows (M. thunbergii [Plate 20.3]) within the mesophyll (Tables 10A-D, Appendix 3). As with the leaf, P. cooperi is unique in that on either side of the lamina cavities are stacks of one to three rows of vascular bundles with the abutting RM (Plate 20.2). P. cooperi is the only species of the Eastern Cape Cyperaceae that has these stacks of vascular bundles in the bracts.
The C₄ distribution of the vascular bundles within rows 2-4 rows is complex. Most of the species with two rows of bundles have an adaxial row of small bundles (except C. fastigiatus, C. laevigatus, C. obtusiflorus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus, M. congestus, M. tabularis subsp. major, M. uitenhagensis and P. nitidus) and an abaxial row of midrib, large, intermediate, small and marginal bundles (except C. distans, C. fastigiatus, C. laevigatus, C. obtusiflorus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus, and P. nitidus). The adaxial row of the remaining species consists of a midrib bundle (C. rupestris var. rupestris and C. semitrifidus var. semitrifidus), large bundles (C. laevigatus, C. obtusiflorus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus and P. nitidus), intermediate bundles (C. laevigatus, C. obtusiflorus, C. rupestris var. rupestris, M. congestus, M. tabularis subsp. major [Plate 20.1] and P. nitidus), small bundles (C. fastigiatus, M. congestus and M. tabularis subsp. major [Plate 20.1]) and/or marginal bundles (C. fastigiatus). The abaxial row of bundles of these remaining species having two rows of vascular bundles consists of the midrib bundle (C. distans, C. fastigiatus, C. laevigatus, C. obtusiflorus and P. nitidus), and either large bundles (C. distans, C. fastigiatus and C. obtusiflorus), intermediate (C. distans, C. fastigiatus and P. nitidus), and/or small bundles (C. laevigatus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus and P. nitidus) and/or marginal bundles (C. distans, C. laevigatus, C. obtusiflorus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus and P. nitidus).

The vascular bundles of the species with three rows is mostly composed of: an adaxial row of intermediate and small bundles (except C. natalensis, M. macrocarpus, M. solidus, M. sumatrensis and P. cooperi); and a median row of most either midrib, and/or large, and/or intermediate, and/or small and/or marginal bundles (except C. albostriatus, C. natalensis, M. thunbergii and P. cooperi) and an abaxial row of small bundles (except M. solidus and P. cooperi). The adaxial row for C. natalensis consists of large and small bundles, whilst that of M. macrocarpus, M. solidus and M. sumatrensis only of small bundles. The adaxial row of bundles in P. cooperi consists of large, intermediate and marginal bundles. The median row in C. albostriatus consists of a midrib, large, intermediate and small bundles. In C. natalensis and M. thunbergii the median row of bundles consists of a midrib bundle, intermediate, small and marginal bundles. Intermediate and small bundles are present in the median row of P. cooperi, as well as the abaxial row in M. solidus. The abaxial row in P. cooperi consists of the midrib bundle, a few intermediate and small bundles.

M. thunbergii is the only Cypereae species with four rows of bundles in the bracts. The adaxial or first row consists of intermediate and small bundles. The midrib bundle, large, marginal and a few intermediate bundles are present in the second row. The third and fourth (abaxial row) row consists of intermediate and small bundles.

As with the leaves, a small bundle is present directly below the midrib bundle in C. semitrifidus var. semitrifidus and the genus Kyllinga (except in K. brevifolia). In the margins of the C. longus var. tenuiflorus, the adaxial and abaxial row small bundles join with each other. In C. tennellus var. tennellus the vascular bundles face towards the region of translucent parenchyma (Plate 19.12).

Generally the maximal cell distal count between vascular bundles for the C₄ species is over five cells (ranging from 3 to 12 cells on average), ranging from 2-4 cells (C. tennellus var. tennellus) to 13-21 cells (C. albostriatus, [Table 9, Appendix 3]). All the vascular bundles in the C₄ species have a maximal cell distal count of less than three cells.
(mean 2 cells). The smallest number of cells between bundles is present in the genus *Pycreus* and the largest in the genus *Cyperus* (Tables 10A-D, Appendix 3).

There is generally a recognisable pattern with respect to vascular bundle number and distribution within the lamina mesophyll of the C₄ species in just over half the species (18) of the tribe (Tables 10A-D, Appendix 3). In these species, 2-4 small bundles (on average) are present between the large and intermediate bundles. Generally there are more small bundles than intermediate and large bundles in the C₄ species. This is in contrast to the C₃ species, where there is no recognisable pattern with respect to vascular bundle number and distribution in the following species: *C. distans*, *C. esculentus*, *C. laevigatus*, *C. obtusiflorus*, *C. rupestris* var. *rupestris*, *C. semitrifidus* var. *semitrifidus*, *K. alata*, *K. brevifolia*, *K. elatior*, *M. albomarginatus*, *M. capensis*, *M. dubius*, *M. sumatrensis*, *M. thunbergii*, *M. uitenhagensis*, *P. cooperi*, *P. macranthus* and *P. nitidus*. Large, intermediate and small bundles are absent in the bracts of *C. tennellus* var. *tennellus*, where only the midrib and marginal bundles are present. Large bundles are absent in *C. rupestris* var. *rupestris*.

Most of the C₃ vascular bundles are characterised by the presence of three vascular sheaths. The outer sheath is the parenchymatous sheath (PS), the central sheath is the lignified mestome sheath (MS) and the third inner sheath is a non-lignified sheath of border parenchyma (BP). In *C. tennellus* var. *tennellus* there is no PS. In both *A. capensis* and *C. textilis* only the PS and MS are present surrounding the bundles. The PS is absent in the small bundles of *C. albostriatus*. The PS is also absent at the xylem pole of the midrib bundle in *C. albostriatus*.

The PS cells of the C₃ species are small, but are two to three times larger than the abutting MS cells and mostly chlorenchymatous. The PS cells in *C. albostriatus* and *C. denudatus* are chlorenchymatous. The MS cells in *C. tennellus* var. *tennellus* are large in size. The walls of the MS are generally thick-walled in the radial and inner tangential walls. In *C. textilis* the thickening is the same in all the walls of the MS cells. The cell walls of the MS in *C. tennellus* var. *tennellus* and *C. textilis* are comparatively thin-walled. The lignification within the MS walls is detailed in Appendix 4. The BP cells are bisected by the large metaxylem vessels in the midrib bundle, large, intermediate and marginal bundles of the C₃ species. The protoxylem or metaxylem vessels may also interrupt the BP in the small bundles. The BP cells are mostly medium sized. BP cells in *C. pulcher* and *C. sphaerospermus* are large in size.

Most of the vascular bundles in the C₄ species are characterised by the presence of two vascular sheaths and an abutting RM. The outer sheath is a lignified MS, which encircles the entire bundle. The inner sheath is a unlignified Kranz sheath (KS), which in the midrib bundle, large, intermediate and a few marginal bundles, where the KS is bisected by the large metaxylem vessels. An additional third sheath is present only on the xylem side of the midrib bundle and large bundles of *C. distans*, *C. esculentus*, *C. immensis*, *C. semitrifidus* var. *semitrifidus*, the genus *Kyllinga* (except *K. erecta*), *M. albomarginatus*, *M. congestus*, *M. dubius*, *M. macrocarpus* and the genus *Pycreus* (except *P. macranthus*), which is composed of unlignified border parenchyma (BP). One of the marginal bundles in *C. obtusiflorus* has no sheaths and only MX vessels. The MS is also incomplete in the one of the marginal bundles of *K. elatior*. In *K. elatior* the MS of the marginal bundle mix with the vascular tissues and the vascular sheaths. Additionally the vascular sheaths of *K. elatior* are absent at the phloem pole of the intermediate bundles. The KS of the small bundles in *M. thunbergii* is absent in some bundles. In *K. erecta*, *K. pauciflora*, *M. congestus*, *M. dubius*,
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*M. tabularis* subsp. *major* and *P. macranthus* the KS of one of the two marginal bundles may be mixed with the vascular tissues. In these bundles, the MS is also jumbled with the KS and the vascular tissues.

All of the MS cells of the *C.* species are smaller than the abutting KS cells. Generally the MS cells are thick-walled in the radial and inner tangential walls. The MS cells in *C. immensis*, *C. longus* var. *tenuiflorus* and *P. intactus* are mostly thin-walled. Thin-walled MS cells are present in *C. laeavigatus*, *C. rubicundus*, *C. sexangularis*, *K. elatior*, *M. albomarginatus* (thickest in the midrib), *M. capensis*, *M. dubius*, *M. uitenhagensis* (thickest in the midrib), *P. cooperi*, *P. nitidus* and *P. polystachyos* var. *polystachyos*. The lignification within the walls of the MS is variable and is detailed in Appendix 4.

The KS cells are generally two to four times the size of the MS cells, thin-walled and contain large centrifugal chloroplasts (one to three per cell). Most of the chloroplasts are almost the same size as the cell, whilst *C. longus* var. *tenuiflorus* has small KS chloroplasts. The KS chloroplasts of the intermediate and small bundles in *C. rubicundus* and *C. sexangularis* are centripetal in position. Two cells similar to the KS cells are also present inside the KS at the phloem pole of the adaxial row, midrib bundle and large bundles of *P. nitidus*. These cells form lacunae in the older tissues. The KS of one of the marginal bundles in *M. tabularis* subsp. *major* abuts the MS of the closest intermediate bundle, the phloem of this bundle is absent.

Thin-walled BP is present on the xylem side of the midrib bundle and large bundles in the genus Cyperus (except *C. immensis* and *C. sexangularis* var. *semitrifidus*), genus Kylinga (except *K. erecta* and *K. pauciflora*), *M. albomarginatus*, *M. congestus*, *M. dubius*, *M. macrocarpus* and the genus Pycreus (except *P. macranthus*). Only the marginal bundles of *C. immensis* and the large bundles in *C. distans* and *K. pauciflora* have a BP on the xylem side of the vascular bundles.

Phloem and xylem outlines vary (variability is detailed in Appendix 4). Generally the midrib bundle and large bundles of most of the species have protoxylem lacunae present at the xylem poles of the bundles. Only *C. rupestris* var. *rupestris*, *C. sexangularis* var. *semitrifidus*, *C. sexangularis* and *M. capensis* lacked protoxylem lacunae in the bracts. There are no protoxylem lacunae in the large bundles of *C. immensis*. In the lamina of *M. congestus* near the midrib, some of the intermediate bundles fuse in such a way that the vascular sheaths and vascular tissues mix. Some of the small bundles in *M. capensis*, *M. macrocarpus* and *M. thunbergii*, as well as the abaxial row of small bundles in *M. solidus* lack phloem tissue. One of the marginal vascular bundles in *M. solidus* only has xylem tissue in the bundle. In some of the small bundles in the lamina near the midrib in *M. tabularis* subsp. *Major*, tannin idioblasts are present, in the position of the xylem vessels. The xylem tissue of some of the small bundles in the abaxial row of bundles is not orientated at right angles to the adaxial surface, where the xylem in these species may face parallel to the leaf surfaces or even towards the abaxial surface. As with the leaves, a few of the small bundles in *M. albomarginatus* have the xylem encircling the phloem tissue.

### 5.2.5 Culm characteristics within the tribe Cypereae

The culm shape within the *Cypereae* is generally triangular. The genera *Cyperus* and *Mariscus* are mostly obtusely triangular. There are also culms that are oval with wavy outlines (*C. laeavigatus* and *C. tennellus* var. *tennellus*), circular with wavy outlines (*C. marginatus* and *C. sexangularis* var. *semitrifidus*), heptagonal (*C. rubicundus* and *C.
sexangularis), acutely heptagonal (K. brevifolia), acutely triangular (C. difformis and M. congestus), triangular with concave sides (C. pulcher, K. elatior and K. pauciflora) and triangular with a wavy outline (K. erecta). Culms are large in size (Tables 11 and 12A-D, Appendix 3), ranging from 140μm (C. tenellus var. tenellus) to 5334μm (C. immensis).

Epidermal cells are variable in shape. The outer periclinal walls of the epidermal cells are thick-walled (Plate 21.1-7), whilst the epidermal cells in C. tenellus var. tenellus are thin-walled. Epidermal cell size is small when compared to the culm size (Tables 11 and 12A-D, Appendix 3), ranging from 3μm (C. esculentus and C. tenellus var. tenellus) to 21μm (P. cooperi).

Conical silica deposits that occur in the epidermal cells that abut the HSS are absent only in C. albostriatus, C. immensis, C. laevigatus, C. rupestris var. rupestris, C. sexangularis, K. pauciflora, M. congestus, M. macrocarpus, M. solidus, M. sumatrensis, M. tabularis subsp. major, P. cooperi, P. macranthus, P. mundii and P. polystachyos var. polystachyos. The cells of the epidennis abutting the HSS that lack these cones, are mostly smaller than the epidermal cells adjacent the HSS (Plate 21.6-7).

Distinctive stomata are not present in the culms of M. macrocarpus. Generally the stomata of the Cypereae are flush with the epidermis (Plate 21.2 and 21.5). Raised stomata are present in C. difformis, C. tenellus var. tenellus, M. solidus, M. uitenhagensis and P. cooperi. C. pulcher and P. mundii have sunken stomata. The stomata in P. intactus are present between the HSS. The cells surrounding the sub-stomatal cavities in M. thunbergii are lignified and concertina shaped (Plate 21.5). There is variable thickening on the adaxial and abaxial poles of the guard cells (Plate 21.2-5, Appendix 4). The sub-stomatal cavity size is small (Tables 11 and 12A-D, Appendix 3), ranging from no cavities (C. denudatus, C. longus var. tenuijlorus, C. marginatus, C. textilis and K. brevifolia) to 35μm (P. nitidus).

The cells of the SS are small and thick-walled (Plate 21.6-7). The SS and girder shape vary, see Appendix 4 for details. There is generally no SS present adjacent the vascular bundles. The SS in C. distans are present adjacent to the outer row of intermediate vascular bundles. The SS in C. immensis are present adjacent to the outer row of intermediate and small bundles. SS abut the MS of the outer row of large bundles in C. obtusiflorus. Both C. difformis and K. erecta have two SS present adjacent to the large bundles, which are present adjacent to the corners of the triangular culms, resembling the SS within the leaf midribs. An additional small bundle is present below these large bundles in K. erecta, which is almost identical to the vascular bundle organisation within the leaf midribs. Girders are present in C. distans, where these girders abut the outer row of large bundles and a few of the small bundles.

Many SS are present in the culms of the Cypereae, whilst C. tenellus var. tenellus has few (Tables 11 and 12A-D, Appendix 3), ranging from 9 (C. tenellus var. tenellus) to 390 (C. marginatus). The SS size is small in comparison to the culm size (Tables 11 and 12A-D, Appendix 3), ranging from 6μm (K. erecta) to 75μm (C. obtusiflorus).

The distribution of SS within the culms of the Cypereae is complex (Plates 21.8-12 and 22.1-2). Generally SS are present abutting the xylem pole of the inner row of large bundles (Plate 21.8-9 and 21.12).
Plate 21. Shows structural details of the culms of selected Cypereae in section, illustrating the distribution and arrangement of the cavities; epidermis, ground tissues including chlorenchymatous parenchyma and translucent parenchyma; hypodermal sclerenchymatous strand and sclerenchymatous strand arrangement; stomata structure, with associated tissues; vascular bundle arrangement; vascular bundle spacing; and vascular sheaths, as well as associated vascular tissues.

(21.1) Shows the culm of *M. tabularis* subsp. *major*, where the epidermis is thick-walled in the outer periclinal wall. The epidermal cells abutting the hypodermal sclerenchymatous strands are not smaller than the adjacent epidermal cells. (21.2) The epidermis in *K. alata* has a thick-walled outer periclinal wall. The stoma is flush with the epidermis, where subsidiary cells and guard cells are lignified. The stoma has a small sub-stomatal cavity. (21.3) The epidermis in *M. tabularis* subsp. *major* has flush stoma, where the subsidiaries are un-lignified. The guard cells and adjacent epidermal cells are lignified. The stoma has a small sub-stomatal cavity. (21.4) Shows the thick-walled (outer periclinal wall) of the epidermis of *P. introflexus* with flush stoma. The small subsidiary cells of this stoma are un-lignified, whilst the guard cells are lignified. The sub-stomatal cavity is small. (21.5) Shows a flush stoma in *M. thunbergii* that is surrounded by lignified mesophyll, guard and epidermal cells. The subsidiary cells are relatively thin-walled. The sub-stomatal cavity is relatively small. Note the lignified concertina shaped cells bordering the sub-stomatal cavity. (21.6) The epidermis in *P. nitidus* is thick-walled in the outer periclinal wall. The epidermal cells abutting the hypodermal sclerenchymatous strands are smaller than the adjacent epidermal cells. Note that the hypodermal sclerenchymatous strands are associated with translucent parenchymatous cells. Outer cavities are present between a few of the outer row vascular bundles. Ground tissues are composed of compact radiating chlorenchymatous cells that abut the vascular bundles. (21.7) Shows the epidermal cells in *M. uitenhagensis* with thick-walled outer periclinal wall. The cells of the epidermis abutting the hypodermal sclerenchymatous strands are smaller than the adjacent to epidermal cells. A few cells of translucent parenchyma abut the hypodermal sclerenchymatous strands. The hypodermal sclerenchymatous strands are present adjacent to the small vascular bundles. Ground tissues are composed of radiating chlorenchyma surrounding an outer row of vascular bundles and translucent parenchyma endarch to the chlorenchymatous layer. (21.8) An inner large vascular bundle in *C. marginatus* is surrounded by translucent parenchyma. The vascular bundle has sclerenchymatous strands at the xylem pole. There is only one distinct vascular sheath, the mestome sheath. (21.9) Shows details of an inner large vascular bundle in *C. laevigatus* surrounded by translucent parenchyma, with abutting sclerenchymatous strands. The outer cavity is exarch to this vascular bundle. Note that rounded parenchymatous cells surround the vascular bundle similar to a parenchymatous sheath and appear radial in nature. These cells are chlorenchymatous. There are two sheaths in addition to this apparent sheath of parenchyma, an outer mestome sheath and an inner sheath of border parenchyma. The sheath of chlorenchymatous border parenchyma is interrupted by a large protoxylem lacuna in the xylem pole of the vascular bundle and by two large metaxytem vessels. (21.10) Outer vascular bundles in *C. marginatus* with abutting sclerenchymatous strands. The ground tissues are composed non-radiating chlorenchyma, which abut the outer row of vascular bundles (extending to the phloem side of the intermediate vascular bundles and the sclerenchymatous strands of the small vascular bundles) and translucent parenchyma is present endarch to this. (21.11) The outer small vascular bundles in *M. tabularis* subsp. *major* are present adjacent to a hypodermal sclerenchymatous strand. A few of the small vascular bundles also abut a sclerenchymatous strand. The chlorenchymatous ground tissues abut the outer row of vascular bundles, resembling radiating chlorenchyma. (21.12) An inner large vascular bundle in *C. immensus* is surrounded by an aerenchymatous network of translucent parenchyma. This vascular bundle is also abutting by both adaxial and abaxial sclerenchymatous strands. There are two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath cells on the phloem side of the vascular bundle are filled with lignin. The sheath of border parenchyma is interrupted by two large metaxytem vessels. A large protoxylem lacuna is present at the xylem pole of the vascular bundle inside the sheath of border parenchyma.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundles; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxytem vessel; (OT) outer periclinal wall (tangential); (Pe) parenchymatous cells; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (SS) sclerenchymatous strands; (St) stoma; (Stc) stomatal cavity; (Su) subsidiary cell and (TP) translucent parenchyma. Bars = 10 μm.
Plate 21. Legend on facing page.
The distribution of SS within the Cypereae culms is as follows: abutting the xylem poles of the outer large bundles (A. capensis, C. albostratius, C. denudatus, C. distans, C. esculentus, C. laevigatus, C. marginatus, C. obtusiflorus, C. pulcher, C. rubicundus, C. rupestris var. rupestris, C. semitridus var. semitridus, C. textilis, K. brevifolia, K. elatior, K. erecta, K. pauciflora, M. capensis, M. congestus, M. dubius, M. macrocarpus, M. sumatrensis, M. uitenhagensis, P. intactus, P. macranthus, P. mundii, P. nitidus and P. polystachyos var. polystachyos); abutting the xylem pole of the outer intermediate bundles (A. capensis, C. albostratius, C. denudatus, C. distans, C. esculentus, C. marginatus [Plate 21.10], C. obtusiflorus, C. pulcher, C. textilis, M. dubius, M. macrocarpus, M. sumatrensis, M. uitenhagensis, P. macranthus and P. mundii); abutting the xylem poles of the outer row small bundles (C. immensis, C. denudatus, C. longus var. tenuiflorus, C. marginatus, C. natalensis, C. obtusiflorus, C. pulcher, C. sexangularis, C. textilis, M. albomarginatus M. solidus, M. tabularis subsp. major [Plate 21.11], M. thunbergii and P. cooperi); abutting the phloem pole of a few of the outer large bundles (C. difformis); abutting the phloem pole of a few inner large bundles (A. capensis, C. immensis [Plate 21.12], C. marginatus, C. natalensis, C. obtusiflorus, M. sumatrensis and M. uitenhagensis [Plate 22.1]); abutting the phloem pole of the outer intermediate bundles (C. difformis); abutting the phloem pole of the inner row intermediate bundles (M. albomarginatus), abutting the xylem pole of the solenostele 1 (S 1, M. solidus) and present in the parenchymatous bridges of the aerenchymatous network present in the centre of the culm (C. denudatus [Plate 22.2]). The SS in C. denudatus are present where the bridges join and are surrounded by thin-walled translucent parenchyma cells. The SS of C. denudatus are large in size (61-89 μm). In A. capensis the SS of the second and third row large bundles join. The phloem pole SS of the inner row large bundles in C. difformis join with the xylem pole SS of the outer row large bundles.

Within the culms of the Cypereae, cavities are generally present near the margin (outer) or near the centre of the culm (inner), see Plates 22.3-9. The outer cavities are present between the vascular bundles that are closest to the epidermis (C. difformis, C. pulcher [Plate 22.4] and P. nitidus). The central cavities are present near the centre culm (A. capensis, C. denudatus [Plate 22.5], C. esculentus, C. immensis [Plate 22.7 and 22.9], C. marginatus [Plate 22.6], C. pulcher, C. textilis [Plate 22.8], K. brevifolia, K. elatior, K. erecta, K. pauciflora [Plate 22.3], M. sumatrensis, M. tabularis subsp. major, M. thunbergii, P. cooperi, P. intactus, P. macranthus, P. mundii, P. nitidus and P. polystachyos var. polystachyos). Only two species, C. pulcher and P. nitidus have both outer and inner cavities. The cavities in C. denudatus (Plate 22.5), C. immensis (Plates 22.7 and 22.9), C. marginatus (Plate 22.6) and C. textilis (Plate 22.8) are present in an aerenchymatous network of parenchymatous bridges, which occur in the central regions of the culm. A few cavities in M. thunbergii are present between some of the large and intermediate bundles of the fourth row of inner bundles. Cavities in P. cooperi are present between the second row of vascular bundles. Cavity shapes are variable, see Appendix 4 for details.

Present within the central culm cavities is translucent "blue" and stellate parenchyma. The stellate parenchyma is also present within the outer cavities (Plate 22.4). C. immensis has unique bulbous shaped cells attached at random along the walls of the parenchymatous cells that make up the aerenchymatous central cavity network (Plate 22.7 and 22.9). The outer cavities are smaller than the inner cavities (Tables 11 and 12A-D, Appendix 3). Outer cavity sizes range from 29 μm (C. difformis and P. nitidus) to 149 μm (C. pulcher), whilst the inner cavity sizes range from 30 μm (C. immensis) to 681 μm (C. pulcher).
Plate 22. Shows structural details of the culms of selected Cypereae in section, including the distribution and arrangement of cavities; ground tissues (including chlorenchymatous parenchyma, parenchymatous bridges, translucent parenchyma, stellate parenchyma and the bulbous cells of the aerenchymatous network; hypodermal sclerenchymatous strands, girders and sclerenchymatous strands; tannin idioblast arrangement; vascular sheath arrangement; and vascular bundle arrangement, as well as vascular tissues.

(22.1) Shows an inner large vascular bundle in M. uttenhagensis surrounded by translucent parenchyma, with abutting sclerenchymatous strands. There are two vascular sheaths, an outer mestome sheath and an inner sheath of border parenchyma. The sheath of border parenchyma is interrupted by two large protoxylem vessels. A large protoxylem lacuna is present inside the sheath of border parenchyma at the xylem pole of the vascular bundle. (22.2) Shows the sclerenchymatous strands present in the parenchymatous bridges enclosing the central cavities in C. denudatus. (22.3) The triangular culm in K. pauciflora with a large central cavity. Vascular bundles are present close to the epidermis and the central cavity is endarch to the vascular bundles. (22.4) The hypodermal sclerenchymatous strands of C. pulcher are associated with the outer row of large vascular bundles. Non-radiating chlorenchyma extends from the epidermis to the phloem side of the outer row of vascular bundles. Abutting the xylem pole of these vascular bundles is thin-walled translucent parenchyma. The second row of vascular bundles is present in the translucent parenchyma. Outer cavities are present between the outer row of large vascular bundles, the chlorenchyma and the translucent parenchyma. Present in the outer cavities is stellate parenchyma. (22.5) The sclerenchymatous strands in C. denudatus are present in the central aerenchymatous network of parenchymatous bridges. The ground tissues are composed of an outer chlorenchymatous layer abutting the outer row of vascular bundles and a central aerenchymatous network of parenchymatous bridges. The cavities are present between chlorenchyma and aerenchymatous network of translucent parenchyma bridges. The vascular bundles are present in three rows, one in the chlorenchyma and two in the aerenchyma. The outer row is composed of large, intermediate and small vascular bundles, whilst the inner rows are composed of large vascular bundles. (22.6) The cavities in C. marginatus are present in the aerenchymatous network of translucent parenchyma and the translucent parenchymatous bridges. The ground tissues are composed of an outer region of chlorenchyma associated with the first two rows of vascular bundles, and the aerenchymatous network of parenchymatous bridges and translucent parenchyma. Tannin idioblasts are scattered within the ground tissues of the culm. Two rows of vascular bundles are present in the chlorenchyma and four rows in the inner aerenchyma. (22.7) The ground tissues in C. immensis are composed of an outer chlorenchymatous region of radiating chlorenchyma abutting the first two rows of vascular bundles and a region of aerenchyma, which is composed of a network of translucent parenchymatous cells. Cavities are present between the cells of the aerenchymatous network. Bulbous cells are present at random within the aerenchyma and project into the cavities between the cells. The tannin idioblasts are scattered in the ground tissue but are mostly present at the boundary between the chlorenchyma and aerenchyma. The first row of vascular bundles is present in the chlorenchyma and the second row of vascular bundles has chlorenchyma on the phloem side of the vascular bundle. Aerenchyma is present on the xylem side of the second row of vascular bundles, whilst the inner two rows of vascular bundles are all present in the aerenchyma. (22.8) The cavities in C. textilis are present between the parenchymatous bridges of the aerenchyma. The ground tissues are composed of chlorenchyma, translucent parenchyma and aerenchyma. The chlorenchyma abuts the epidermis extending to the xylem pole of the first row of vascular bundles. Abutting the chlorenchyma is a layer of translucent parenchyma, where the second row of vascular bundles is present. Endarch to the translucent parenchyma is an aerenchymatous network of translucent parenchymatous bridges. The inner rows of vascular bundles are present in the aerenchyma. (22.9) Shows details of the aerenchyma in C. immensis, which is composed of a network of translucent parenchyma cells. Bulbous cells extend into the cavities formed between the network of inner parenchymatous cells. (22.10) The outer row large vascular bundles in C. albostriatus have girders on the phloem side of the vascular bundle. Hypodermal sclerenchymatous strands are present between the vascular bundles with girders. The ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma abuts the phloem side of the outer row of vascular bundles. Endarch to the chlorenchyma is translucent parenchyma. There are two rows of vascular bundles, the first is present in the chlorenchyma and the second is in the central region of translucent parenchyma. (22.11) In the corners of the triangular culm in C. pulcher, the hypodermal sclerenchymatous strands are present on either side of the large vascular bundle closest to the corner. The chlorenchyma extends from the epidermis to the phloem side of the outer row of vascular bundles. Abutting the xylem pole of these vascular bundles is translucent parenchyma. This translucent parenchyma extends to the central cavities. The cavities are present between the outer row of vascular bundles, the chlorenchyma and translucent parenchyma. Cavities are also present in the central parts of the culm. Vascular bundles are present in three rows, the first row is present in the chlorenchyma, whilst rows two and three are present in the translucent parenchyma. Tannin idioblasts are present within the chlorenchyma. (22.12) The ground tissues in M. tabularis subsp. major are composed of a region of chlorenchyma and translucent parenchyma. The chlorenchyma is composed of compact radiating chlorenchyma abutting the outer row of vascular bundles and extending to the phloem side of the second row of vascular bundles. Translucent parenchyma is endarch to the chlorenchyma. There are four rows of vascular bundles, the first two are present in the chlorenchyma, whilst the third and fourth rows are present in the translucent parenchyma.

(legend continues on the next facing page)
Plate 22. Legend on facing page.
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Symbols are as follows: (1) row 1 of vascular bundles; (2) row 2 of vascular bundles; (3) row 3 of vascular bundles; (4) row 4 of vascular bundles; (5) row 5 of vascular bundles; (A) aerenchyma; (BPC) bulbous parenchymatous cell; (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (G) girder; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (L) large vascular bundle; (MX) metaxylem vessel; (Pbr) parenchymatous bridge; (PxL) protoxylem lacuna; (RM) radiating chlorenchyma; (SS) sclerenchymatous strands; (StP) stellate parenchyma; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10 μm.
Plate 23. Shows structural details of the culms of selected Cypereae in section, illustrating the distribution and arrangement of ground tissues, and vascular sheaths, as well as vascular tissues.

(23.1) Shows the epidermis in C. immensus with thick-walled outer periclinal wall. Translucent parenchyma abuts the epidermis and is present between hypodermal sclerenchymatous strands. The epidermal cells that abut the hypodermal sclerenchymatous strands are smaller than the adjacent epidermal cells. The outer row of vascular bundles have compact radiating chlorenchyma present abutting the vascular bundles. (23.2) An inner large vascular bundle in C. denudatus with abutting parenchymatous bridges and sclerenchymatous strands. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The border parenchyma is interrupted by two large metaxyem vessels. A large protoxylem lacuna is present inside the sheath of border parenchyma at the xylem pole of the vascular bundle. (23.3) An outer large vascular bundle in C. denudatus with an abutting outer cavity and sclerenchymatous strands. There are three sheaths, similar to the inner large vascular bundle present in the same arrangement as the large vascular bundle. The large protoxylem lacuna is present inside the border parenchyma and does not interrupt the sheath. (23.4) An outer intermediate vascular bundle in C. denudatus with an abutting outer cavity and sclerenchymatous strand. The chlorenchyma is non-radiating, with numerous chloroplasts. Three sheaths are present, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner partial non-lignified sheath of border parenchyma. The sheath of border parenchyma is only present on the phloem side of the vascular bundle. (23.5) An outer small vascular bundle in C. denudatus with abutting outer cavity and chlorenchyma. The chlorenchyma is non-radiating, with numerous chloroplasts. There are two vascular sheaths, an outer translucent parenchymatous sheath and an inner lignified mestome sheath. (23.6) An inner large vascular bundle in M. dubius with sclerenchymatous strands on the xylem pole. Radiating mesophyll is present on the phloem side of the vascular bundle, whilst translucent parenchyma surrounds most of the vascular bundle. There are three vascular sheaths, an outer lignified mestome sheath, an inner partial Kranz sheath on the phloem side of the vascular bundle and an inner sheath of border parenchyma present on the xylem side of the vascular bundle. The Kranz sheath and the sheath of border parenchyma are separated by two large metaxyem vessels. A large protoxylem lacuna is present inside the sheath of border parenchyma on the xylem pole of the vascular bundle. (23.7) An outer large vascular bundle in M. dubius with three vascular sheaths, similar to the inner large vascular bundle. The sheaths are in the same arrangement as the inner large vascular bundle. The Kranz sheath has large chloroplasts, which are centrifugal in location, whilst the sheath of border parenchyma has smaller chloroplasts. There is no protoxylem lacuna. (23.8) An outer intermediate vascular bundle in M. dubius with radiating chlorenchyma. There are two vascular sheaths present, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath not interrupted by metaxyem vessels. The Kranz sheath chloroplasts are large and are centrifugal in location. (23.9) An outer small vascular bundle in M. dubius with radiating chlorenchyma. Similar to the intermediate vascular bundle, there are the same two sheaths present in the same arrangement. The Kranz sheath has large chloroplasts that almost fill the cells. (23.10) Shows a solenostele type one vascular bundle (S 1) vascular bundle in M. thunbergii with abutting sclerenchymatous strands and translucent parenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner sheath of border parenchyma. The sheath of border parenchyma is composed of non-lignified tissue endarch to the mestome sheath. The phloem tissue is endarch to xylem, which completely encircles it. (23.11) An S 1 vascular bundle in M. uitenhagensis with abutting sclerenchymatous strands and translucent parenchyma. There is one vascular sheath consisting of a lignified mestome sheath, where the cells are thick-walled in the inner tangential and radial walls. Vascular tissues consist of a large protoxylem lacuna and xylem encircling the inner phloem tissues. (23.12) Shows a solenostele type two vascular bundle (S 2) in M. solidus with abutting sclerenchymatous strands and translucent parenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner sheath of border parenchyma. The sheath of border parenchyma is composed of non-lignified cells encircling the vascular tissues. Vascular tissues consist of xylem vessels not encircling the phloem.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (HSS) hypodermal sclerenchymatous strands; (KS) Kranz sheath; (MS) mestome sheath; (MX) metaxyem vessel; (Px) phloem; (PBr) parenchymatous bridge; (PS) parenchymatous sheath; (PXL) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (SS) sclerenchymatous strands; (TP) translucent parenchyma and (X) xylem. Bars = 10 μm.
Chapter 5, Cypereae

The number of tannin idioblasts within the culms of the Cypereae varies. No tannin idioblasts are present in the culms of C. laevigatus, M. albomarginatus, M. uitenhagensis, P. cooperi and P. intactus. The tanniniferous cells within the Cypereae culms range from very few (C. distans, C. esculentus, C. semir trifidus var. semir trifidus, C. sexangularis, C. tenellus var. tenellus, K. brevifolia, K. elatior, M. dubius, M. solidus, M. sumatrensis, P. nitidus and P. polystachyos var. polystachyos) to many (C. denudatus, M. macrocarpus, M. thunbergii, P. macranthus and P. mundii) The tannin idioblasts are generally scattered within particular ground tissues or present at the boundary between ground tissues (Plate 22.7). The distribution of tannin idioblasts within the Cypereae culms is as follows: within vascular bundles (A. capensis); abutting the bundles (C. diffinis and K. elatior); present in the translucent parenchyma (C. marginatus and C. obtusiflorus); in the chlorenchymatous tissues close to the epidermis (C. albostriatus, C. denudatus, C. distans, C. pulcher [Plate 22.11], C. sphaerospermus and P. mundii); specifically present in the chlorenchymatous cells that abut the outer row of vascular bundles (C. rubicundus, C. semitrifidus var. semitrifidus, C. sexangularis, K. alata, K. brevifolia, K. erecta, K. pauciflora, M. capensis, M. congestus, M. dubius, M. sumatrensis, P. macranthus and P. nitidus); specifically present at the boundary between the outer chlorenchymatous layer and the central translucent parenchymatous regions (C. esculentus, C. longus var. tenuiflorus, C. natalensis, C. rupestris var. rupestris, C. textilis, K. alata, M. solidus, M. tabularis subsp. major and P. polystachyos var. polystachyos) and present in concertina-shaped cells that are present in the sub-stomatal cavities (M. thunbergii [Plate 21.5]). As with the leaves and bracts, additional silica deposits other than the conical silica deposits of the epidermis are present in C. sexangularis and C. textilis, where numerous crescentiform shaped, silica deposits are present on the outer periclinal walls of the epidermal cells.

The species may be divided into two distinct groups based on the structure of the outer most chlorenchyma and the vascular sheath structure, namely the C₃ and C₄ species (to be discussed separately). There are a further two distinct tissue types that are present in all the culms of the Cypereae. The first is chlorenchyma that is present in an outer layer that surrounds the outer row of vascular bundles and abuts the epidermis, which may extend to either the SS of the outer row of large bundles or to the phloem pole of the second row of large bundles (Plates 22.4-8 and 24.10-12). The distribution of the chlorenchyma is species specific. The second tissue is composed of translucent parenchyma (TP) and is present abutting the chlorenchyma extending to either the central cavities or to a central aerenchymatous tissue (Plate 22.4-8 and 22.10-12). The location of TP is also species specific.

The Cypereae with C₃ anatomy are A. capensis, C. albostriatus, C. diffinis, C. denudatus, C. marginatus, C. pulcher, C. tenellus var. tenellus, C. textilis and P. mundii. In these species the chlorenchyma is not specifically present with the long axis of the chlorenchyma cells at right angles to the vascular bundles (Plates 21.10 and 22.4). The chlorenchyma in these species is generally present up to the SS abutting the xylem pole of the outer row large bundles, with the exception of A. capensis, C. denudatus, C. marginatus, C. tenellus var. tenellus and C. textilis. The chlorenchyma in A. capensis and C. marginatus (Plate 22.6) extends to the phloem side of the second row of large bundles. The chlorenchyma in both C. denudatus (Plate 22.5) and C. textilis (Plate 22.8) extends only to the phloem side of the outer row large and intermediate bundles. The chlorenchyma in C. tenellus var. tenellus is only one to three cells thick abutting the epidermis. The chlorenchyma cells are variable in shape. A layer of oval shaped, TP (1 cell thick) is present between the HSS and the chlorenchyma in A. capensis that resembles the hypodermis of the leaves and bracts.
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The chlorenchymatous layer of the C₄ species abuts the epidermis and the vascular bundles. This chlorenchyma abuts the outer vascular sheath at right angles to the centre of the bundle and resembles a sheath of parenchyma ensheathing the vascular bundles (Plates 21.3, 21.6-7, 21.11 and 23.1). This ensheathing chlorenchyma resembles the RM of the leaves and bracts. On the xylem pole of the large and a few of the intermediate bundles, the RM is absent, and SS are present. The RM in *C. rupestris* var. *rupestris* is also present on the phloem side of the second and third row large bundles, even though these bundles are present in the TP region. Similarly, the RM of the second and third row large bundles in *M. macrocarpus* have RM on the phloem side, even though they too are surrounded by TP. The intermediate bundles of *M. macrocarpus* have RM absent at the xylem pole. The second row bundle RM in *M. dubius* is interrupted only by the SS, whilst the inner row large bundles also have RM abutting the phloem side of the bundle. The RM in *C. esculentus* is present only on the phloem side of the outer row large bundles. The chlorenchyma in *C. semitrifidus* var. *semitrifidus*, *M. dubius* (Plate 23.6) and *P. cooperi* extends to the RM of the second row of large bundles. In most species, adjacent to the RM and the epidermis, are a few oval cells of TP. These TP cells are present in the C₄ culms of *C. esculentus*, *C. immensis* (Plate 23.1), *M. albomarginatus*, *M. dubius*, *M. sumatrensis*, *M. tabularis* subsp. *major*, *M. thunbergii* and *P. nitidus*. A layer of oval TP (1 cell thick) is present between the HSS in *C. esculentus*, *C. immensis* (Plate 23.1) and *M. albomarginatus*, resembling the hypodermis of the leaves, similar to the C₃ species *A. capensis*. TP is also present in *M. dubius*, *M. sumatrensis*, *M. tabularis* subsp. *major*, *M. thunbergii* and *P. nitidus*, abutting the HSS, but is not in contact with the epidermis.

The *Cypereae* culms may be separated into three groups based on the location of the TP. In the first TP is present abutting the chlorenchyma and extending to the centre of the culm. The structure of the first group is present in the C₃ species, *A. capensis*, *C. alohostriatus* (Plate 22.10), *C. difformis* and *C. sphaerospermus*, as well as most of the C₄ species (Plate 22.12). *C. rubicundus*, *K. alata*, *M. capensis* and *M. congestus* have large intercellular cavities between the TP cells. The inner rows of vascular bundles are present in the TP.

The second group is present only in the C₃ species, *C. pulcher*, *P. mundii*, as well as the C₄ species of *K. brevifolia*, *K. elatior*, *K. erecta*, *K. pauciflora* and *P. macranthus*. This group has TP abutting the chlorenchyma or xylem pole of the outer row bundles and extending for one to four cells towards the central cavity. The location of the TP in *C. pulcher* is complex. The chlorenchyma extends to the phloem side of the outer row of vascular bundles (1-4 cells), between the outer row of bundles are the outer cavities. The TP in *C. pulcher* (Plate 22.11) abuts the SS of the large and intermediate bundles, where the TP is present from the SS of the outer row bundles to the SS of the phloem pole of the second row of bundles (1-4 cells) and the xylem poles of the second rows bundles. Abutting the TP is the central cavity. The outer cavities are present endarch to the small bundles. The TP layers also form a rectangular buttress of tissue (1-3 cells thick) in the corners of the triangular stem.

The third group has TP forming an aerenchymatous network of multicellular bridges and is present in the C₃ species, *C. denudatus*, *C. marginatus* and *C. textilis*, as well as the C₄ species, *C. immensis*, *C. sexangularis*, *M. congestus* and *M. tabularis* subsp. *major*. The inner vascular bundles are present in these bridges and the cavities are present between the bridges. The outer chlorenchyma in *C. denudatus* is three to five cells thick and extends to the phloem side of the outer row of vascular bundles (Plate 22.5). Abutting this chlorenchyma and extending to the centre is an aerenchymatous network of multicellular parenchymatous bridges (1-3 cells wide). These bridges abut the PS at the xylem poles of the outer row of large bundles, forming a netlike structure of cavities and parenchyma bridges. Within these thread-like bridges are the SS and the inner vascular bundles. The SS are present between the outer row.
bundles and the next row of bundles. These SS are also present between the bundles within the rows and between the rows of bundles. As with *C. denudatus*, the chlorenchyma in *C. marginatus* (Plate 22.6) and *C. textilis* (Plate 22.8) abuts the central region of TP bridges, where the inner rows of vascular bundles are present. Pbr in *C. marginatus* extend from the xylem side of some second row and the xylem poles of some third row large bundles. Most of the outer row of intermediate and small bundles are surrounded by the chlorenchyma. The bridges in *C. textilis* extend from SS of the outer row of large and intermediate bundles (Plate 22.8). These multicellular bridges are inter-spaced with the small cavities that abut translucent "blue" parenchyma. These Pbr are thin (1 cell thick), where they bridge the cavities but, are thick and form dense mats consisting of TP, where the vascular bundles are present (3-8 cells thick). The distribution of ground tissues within the C₄ culms of *C. sexangularis*, *M. congestus* and *M. tabularis* subsp. *major* is almost identical to that of *C. textilis*. The chlorenchyma of this group is composed of RM. Endarch to the RM is a layer of TP (one to four cells). Abutting the TP, extending to the centre of the culm is aerenchyma. In *C. immensis* however, the aerenchyma is unique in its structure (Plate 22.7 and 22.9). The aerenchymatous tissue consists of unicellular, triangular TP. All the inner vascular bundles are present in the region of aerenchyma. The central large bundles are surrounded by a sheath of TP that resembles a PS (Plate 22.7).

Most of the vascular bundles of the *Cypereae* are present in one to 11 rows (Table 11 and 12A-D, Appendix 3). In *C. immensis* (Plate 22.7), *C. laevigatus*, *C. natalensis*, *C. textilis* (Plate 22.8) and *K. brevifolia* there is one outer row of bundles and endarch to this a spiral or row structure of vascular bundles is absent (vascular bundles are scattered in appearance). One row of bundles is present in the culms of *A. capensis* and *C. tenellus* var. *tenellus*, whilst the largest number of rows is present in *M. thunbergii* (11 rows). The mean number of rows for each genus is as follows: *Ascolepis*, one row; *Cyperus*, one to six rows; *Kyllinga*, two to three rows; *Mariscus*, three to 11 rows; *Pycreus*, two to five rows.

The distribution of vascular bundles within rows is complex. Generally the outer row of bundles consists of large, intermediate and small bundles. The inner rows of the C₃ species are composed of large bundles, with the exception of *C. textilis*. The first row of bundles in *C. textilis* is composed of small and intermediate bundles. The second row of bundles is composed of intermediate and large bundles. The inner rows are all composed of large bundles. For the C₄ species the outer row is composed of small and intermediate bundles. The second row is mostly composed of intermediate and large bundles. The inner rows are mostly composed of large bundles. Large and intermediate bundles are present in all the inner rows in *C. laevigatus*. Small bundles are present in the second row of bundles for *C. rupestris* var. *rupestris*.

For *M. solidus*, *M. thunbergii* and *M. uitenhagensis*, unusual vascular bundle structures are present between the inner rows of bundles. These bundles are unique to these species and are referred to as solenostele 1 and 2 bundles (S 1 and S 2, respectively). The S 1 bundles in *M. solidus* are present in the second and inner rows, while S 2 bundles are present near the outer row, as well as between the third and fourth rows. Similarly S 1 bundles are also present between the third and fourth row in *M. uitenhagensis*, as well as a few within the third row. S 1 Bundles are also present between the fourth and fifth row bundles in *M. thunbergii*.

A few small bundles in *C. longus* var. *tenuiflorus* abut near the outer row of large bundles. These bundles are surrounded by lobed TP, resembling bulbous parenchyma. Similarly a few small bundles in *M. dubius* and *M. thunbergii* abut the outer sheath of each bundle. A few of the small bundles in *M. solidus* and *M. thunbergii* are
orientated with the long axis of the vascular bundle parallel to the epidermis. In a few of the other small bundles the xylem is closest to the epidermis and not the phloem. Similarly, the xylem is closest to the epidermis and not the phloem in a few small bundles of \( P. \) polystachyos var. polystachyos. One of the inner large bundles in \( M. \) uitenhagensis has a small bundle abutting the phloem pole.

Generally all vascular bundles of the \( C_3 \) species are characterised by the presence of two vascular sheaths (Plate 23.2-5). The outer sheath is a parenchymatous sheath (PS) and the inner sheath is a lignified mestome sheath (MS). A third partial or interrupted sheath is present inside the mestome sheath, composed of non-lignified border parenchyma (BP), in \( C. \) denudatus, \( C. \) difformis, \( C. \) marginatus, \( C. \) pulcher, \( C. \) tenellus var. tenellus and \( P. \) mundii. The PS is absent on the xylem side of the small bundles in \( A. \) capensis. Only the PS surrounds the vascular bundles in \( C. \) tenellus var. tenellus. Within the TP the outer vascular sheath is mostly absent (Plates 21.8, 21.12 and 22.1). In the second row bundles in \( C. \) pulcher the PS is present on the phloem side of the bundles, that abut the outer cavities (Plate 22.4).

The cells of the PS in the \( C_3 \) species are thin-walled, two to three times larger than the abutting MS cells (Plates 21.10, 22.1 and 23.2-5) and contain a few small chloroplasts. The PS in both \( C. \) denudatus and \( C. \) pulcher mostly lack chloroplasts (Plate 23.2-5). The walls of the MS are generally thick-walled in the radial and inner tangential walls (Appendix 4). The walls of the MS cells in \( A. \) capensis and \( C. \) tenellus var. tenellus are relatively thin-walled. The walls of the cells of the MS of the Cypereae are especially thick-walled in the cells on the phloem side of the bundle and abutting the large metaxylem vessels in the large and intermediate bundles (Plate 21.10). For the small bundles especially thick-walled MS cells are present on the phloem side of the bundle. The BP in the large bundles of \( A. \) capensis, \( C. \) marginatus and \( C. \) denudatus is bisected by large metaxylem vessels. In \( C. \) denudatus the BP is limited to the phloem side of the intermediate and small bundles (Plate 23.4-5). The BP of \( C. \) difformis, \( C. \) pulcher, \( C. \) tenellus var. tenellus and \( P. \) mundii is bisected in the large and intermediate bundles by the large metaxylem vessels. In the small bundles of \( C. \) pulcher the BP is present only on the phloem side of the bundle. The BP cells are mostly medium sized. BP cells in \( C. \) marginatus are small and large in \( P. \) mundii.

Generally there are two vascular sheaths present in the \( C_4 \) culms (Plates 21.9, 21.12, 22.1, 22.12, 23.1 and 23.6-9). The outer sheath is a lignified mestome sheath (MS) and the inner sheath is a non-lignified Kranz sheath (KS). In the S 1 and S 2 bundles a BP is present inside the MS (Plates 23.10-12 and 24.1), where the MS may have multiple layers. A BP is present in most of the inner bundles of the \( C_4 \) Cypereae where the BP replaces the KS either on the xylem side or both sides of the vascular bundles. (Plate 24.2-5). A BP is also present on the xylem side of the outer large vascular bundles in \( C. \) esculentus, \( K. \) alata, \( C. \) rupestris var. rupestris, \( K. \) brevifolia, \( K. \) eliator, \( K. \) erecta, \( K. \) pauciflora, \( M. \) albomarginatus, \( M. \) capensis, \( M. \) congestus, \( M. \) dubius (Plate 23.7), \( M. \) macrocarpus, \( M. \) solidus, \( M. \) sumatrensis, \( M. \) tabularis subsp. major, \( M. \) uitenhagensis, \( P. \) intactus, \( P. \) nitidus and \( P. \) polystachyos var. polystachyos.

The cells of the MS are small, thick-walled and lignified (Plates 23.6-10 and 24.2-6). The radial and inner tangential walls of the MS are thick-walled, with the exception of \( C. \) immensus, \( C. \) longus var. tenuiflorus, \( K. \) eliator, \( K. \) pauciflora, \( M. \) solidus, \( M. \) thunbergii, \( P. \) nitidus and \( P. \) polystachyos var. polystachyos. The S 1 and S 2 bundles are surrounded by MS sheaths (one to three cells thick, Plates 23.10-12 and 24.1), the outermost MS cells are twice as big as the inner MS sheath cells.
Plate 23. Shows structural details of the culms of selected Cyperaceae in section, illustrating the distribution and arrangement of ground tissues, and vascular sheaths, as well as vascular tissues.

(23.1) Shows the epidermis in C. immensis with thick-walled outer periclinal wall. Translucent parenchyma abuts the epidermis and is present between hypodermal sclerenchymatous strands. The epidermal cells that abut the hypodermal sclerenchymatous strands are smaller than the adjacent epidermal cells. The outer row of vascular bundles have compact radiating chlorenchyma present abutting the vascular bundles. (23.2) An inner large vascular bundle in C. denudatus with abutting parenchymatous bridges and sclerenchymatous strands. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The border parenchyma is interrupted by two large metaxylem vessels. A large protoxylem lacuna is present inside the sheath of border parenchyma at the xylem pole of the vascular bundle. (23.3) An outer large vascular bundle in C. denudatus with an abutting outer cavity and sclerenchymatous strands. There are three sheaths, similar to the inner large vascular bundle present in the same arrangement as the large vascular bundle. The large protoxylem lacuna is present inside the border parenchyma and does not interrupt the sheath. (23.4) An outer intermediate vascular bundle in C. denudatus with an abutting outer cavity and sclerenchymatous strand. The chlorenchyma is non-radiating, with numerous chloroplasts. Three sheaths are present, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner partial non-lignified sheath of border parenchyma. The sheath of border parenchyma is only present on the phloem side of the vascular bundle. (23.5) An outer small vascular bundle in C. denudatus with abutting outer cavity and chlorenchyma. The chlorenchyma is non-radiating, with numerous chloroplasts. There are two vascular sheaths, an outer translucent parenchymatous sheath and an inner lignified mestome sheath. (23.6) An inner large vascular bundle in M. dubius with sclerenchymatous strands on the xylem pole. Radiating mesophyll is present on the phloem side of the vascular bundle, whilst translucent parenchyma surrounds most of the vascular bundle. There are three vascular sheaths, an outer lignified mestome sheath, an inner partial Kranz sheath on the phloem side of the vascular bundle and an inner sheath of border parenchyma present on the xylem side of the vascular bundle. The Kranz sheath and the sheath of border parenchyma are separated by two large metaxylem vessels. A large protoxylem lacuna is present inside the sheath of border parenchyma on the xylem pole of the vascular bundle. (23.7) An outer large vascular bundle in M. dubius with three vascular sheaths, similar to the inner large vascular bundle. The sheaths are in the same arrangement as the inner large vascular bundle. The Kranz sheath has large chloroplasts, which are centrifugal in location, whilst the sheath of border parenchyma has smaller chloroplasts. There is no protoxylem lacuna. (23.8) An outer intermediate vascular bundle in M. dubius with radiating chlorenchyma. There are two vascular sheaths present, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath not interrupted by metaxylem vessels. The Kranz sheath chloroplasts are large and are centrifugal in location. (23.9) An outer small vascular bundle in M. dubius with radiating chlorenchyma. Similar to the intermediate vascular bundle, there are the same two sheaths present in the same arrangement. The Kranz sheath has large chloroplasts that almost fill the cells. (23.10) Shows a solenostele type one vascular bundle (S 1) vascular bundle in M. thunbergii with abutting sclerenchymatous strands and translucent parenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner sheath of border parenchyma. The sheath of border parenchyma is composed of non-lignified tissue endarch to the mestome sheath. The phloem tissue is endarch to xylem, which completely encircles it. (23.11) An S 1 vascular bundle in M. uitlenhagensis with abutting sclerenchymatous strands and translucent parenchyma. There is one vascular sheath consisting of a lignified mestome sheath, where the cells are thick-walled in the inner tangential and radial walls. Vascular tissues consist of a large protoxylem lacuna and xylem encircling the inner phloem tissues. (23.12) Shows a solenostele type two vascular bundle (S 2) in M. solidus with abutting sclerenchymatous strands and translucent parenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner sheath of border parenchyma. The sheath of border parenchyma is composed of non-lignified cells encircling the vascular tissues. Vascular tissues consist of xylem vessels not encircling the phloem.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (HSS) hypodermal sclerenchymatous strands; (KS) Kranz sheath; (MS) mestome sheath; (MX) metaxylem vessel; (P) phloem; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (SS) sclerenchymatous strands; (TP) translucent parenchyma and (X) xylem. Bars = 10 μm.
Plate 23. Legend on facing page.
Plate 24. Shows structural details of the culms of selected Cypereae in section, illustrating the distribution and arrangement of ground tissue structure, sclerenchymatous strands, and vascular sheaths, as well as vascular tissues.

(24.1) Shows an inner S 2 vascular bundle in *M. solidus* with abutting sclerenchymatous strands and translucent parenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner sheath of lignified border parenchyma. Vascular tissues consist of xylem vessels where the xylem does not encircle the phloem vessels. (24.2) An inner large vascular bundle in *M. tabularis* subsp. *major* with abutting sclerenchymatous strands and translucent parenchyma. There are three vascular sheaths, an outer lignified mestome sheath, an inner partial Kranz sheath present on the phloem side of the vascular bundle and an inner sheath of border parenchyma present on the xylem side of the vascular bundle. On the phloem side of the vascular bundle and adjacent to the large metaxylem vessels the mestome sheath is thick-walled in the inner tangential and radial walls. The large metaxylem vessels separate the Kranz sheath and sheath of border parenchyma. A large protoxylem lacuna interrupts the border parenchymatous sheath at the xylem pole of the vascular bundle. (24.3) An inner large vascular bundle in *M. thunbergii* with abutting sclerenchymatous strands and translucent parenchyma. There are two sheaths present, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled. The sheath of border parenchyma is interrupted by two large metaxylem vessels. Note the enlarged cells of the border parenchyma at the phloem pole of the vascular bundle. A large protoxylem lacuna is present inside the sheath of border parenchyma at the xylem pole of the vascular bundle. (24.4) An inner large vascular bundle in *P. nitidus* with abutting sclerenchymatous strands, radiating chlorenchyma on phloem side of the vascular bundle and translucent parenchyma, surrounding most of the vascular bundle. There are two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential wall. The sheath of border parenchyma is interrupted by two large metaxylem vessels. Note the three enlarged cells of the border parenchyma at the phloem pole of the vascular bundle. A large protoxylem lacuna is present inside the sheath of border parenchyma at the xylem pole of the vascular bundle, similar to *M. thunbergii*. (24.5) An inner large vascular bundle in *C. rupestris* var. *rupestris* with abutting sclerenchymatous strand, radiating mesophyll and translucent parenchyma. There are three vascular sheaths, an outer lignified mestome sheath, an inner partial Kranz sheath on the phloem side of the vascular bundle and an inner sheath of border parenchyma on the xylem side of the vascular bundle. The mestome sheath is thick-walled in the inner tangential and radial walls. The Kranz sheath and sheath of border parenchyma are separated by two metaxylem vessels. A small protoxylem lacuna is present inside the sheath of border parenchyma on the xylem pole of the vascular bundle. (24.6) A few of the outer small vascular bundles in *M. thunbergii* only have xylem present in the vascular bundle. A few of the small vascular bundles are orientated so that the xylem faces the adjacent epidermis of the triangular culm and not the centre of the culm similar to most species.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (HSS) hypodermal sclerenchymatous strands; (KS) Kranz sheath; (MS) mestome sheath; (MX) metaxylem vessel; (P) phloem; (PxL) protoxylem lacuna; (TP) translucent parenchyma; (RM) radiating chlorenchyma; (SS) sclerenchymatous strands and (X) xylem. Bars = 10 μm.
In some of the inner large bundles in *M. thunbergii* and *M. uitenhagensis*, two additional MS cells are present inside the MS on the phloem pole of the bundle. Lignification within the walls of the MS is detailed in Appendix 4.

Plate 24. Legend on facing page.

The chloroplasts of the KS are generally large (chloroplasts appear to be the same size as the cell) and are centrifugal in position (Plate 22.7-8). The chloroplasts in the KS of both *K. brevifolia* and *M. sumatrensis* are small. The KS chloroplasts in *M. sumatrensis* are centripetal in position in a few of the outer small bundles. The KS is interrupted and absent at various sites abutting the vascular tissues (Plates 23.6-8, 24.2 and 24.5). In the small bundles the KS mostly surrounds the vascular tissues (Plate 23.7). A few of the small bundles in *P. cooperi* have a partial KS. A KS is present only on the phloem side, where a BP is present on the xylem side of the bundle, in the outer large bundles (*C. esculentus, C. immensis, C. semitrifidus* var. *semitrifidus, C. sexangularis, K. alata, K. erecta, K. pauciflora, M. albomarginatus, M. capensis, M. dubius [Plate 23.7], M. solidus, M. tabularis subsp. *major, M. thunbergii, M. uitenhagensis, P. intactus and P. nittidus*), the inner large bundles (*C. rupestris* var. *rupestris* [Plate 24.5], *M. dubius* and *P. nittidus* [Plate 24.4]), outer intermediate bundles (*C. immensis, M. capensis, M. sumatrensis and M. thunbergii*) and the inner intermediate bundles (*M. tabularis subsp. major*). In a few species, the KS is bisected by the large metaxylem vessels in the outer large bundles (*C. distans, C. laevigatus, C. longus var. *tenuiflorus, C. rubicundus, C. rupestris* var. *rupestris, K. brevifolia, K. elatior, M. congestus, M. macrocarpus, *P. cooperi, P. macranthus* and *P. polystachyos* var. *polystachyos*), outer intermediate bundles (*C. distans, C. laevigatus, C. longus var. *tenuiflorus, C. rubicundus, C. rupestris* var. *rupestris, K. brevifolia, K. elatior, M. congestus, M. macrocarpus, *P. cooperi, P. macranthus* and *P. polystachyos* var. *polystachyos*) and inner intermediate bundles (*C. semitrifidus* var. *semitrifidus*). The intermediate bundles in *C. natalensis* and *M. dubius* are
not bisected by the metaxylem vessels so that the KS is entire (Plate 23.8). A KS is absent in many of the inner bundles. In these bundles a BP is bisected by the large metaxylem vessels (Plates 21.9, 21.12, 22.1 and 24.3-4). A BP is also present inside the MS of the S 1 (Plate 23.10-11) and S 2 bundles (Plates 23.12 and 24.1) in _M. solidus_, _M. thunbergii_ and _M. uitenhagensis_. The BP in some of these species is interrupted by a xylem element at various places along the BP. The cells of the BP are generally medium sized. BP cells in _C. rupestris_ var. _rupestris_, _K. brevifolia_ and _K. elatior_ are large.

Phloem and xylem outlines vary (see Appendix 4 for detail). Protoxylem lacunae (PxL) are present in all large bundles of the _Cypereae_ culms (Plates 21.9, 21.12, 22.1, 23.2-3, 23.6 and 24.2-5). PxL are also present in the S1 bundles of _M. uitenhagensis_ (Plate 23.11). A few of the small bundles in _M. solidus_ either lack phloem or xylem tissues. Few of the small bundles in _M. thunbergii_ have no vascular tissues, whilst a few others have no xylem (Plate 24.6). Similarly, a few of the outer small bundles in _P. cooperi_ have only xylem present, in these bundles the KS may also be partially absent.
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6.1. Introduction to the Hypolytreæ


The tribe Hypolytreæ senso lato has approximately 147 species that are distributed in shady open habitats. The distribution of most of the genera is limited to a specific region or continent. Capitularina and Chorizandra are endemic to Malaysia and Fiji. Chrysithrix is present in the Cape and Australia. Exocarya and Scirpodendron are endemic to Australia. Hellmuthia is endemic to Africa. Principina is endemic to the African rainforests of the Principe Island (Bruhl 1993). Thoracostachyum is endemic to Malaysia, Polynesia and the Seychelles (Metcalfe 1971). Lepironia, Mapaniopsis and Paramapania have a more cosmopolitan distribution. Lepironia occurs in Africa, Australia and New Guinea. Mapaniopsis is occurs in South and Central America, New Guinea, as well as the West Indies. Paramapania is present in Africa and New Guinea (Bruhl 1993).

Only two genera and four species of tribe Hypolytreæ senso lato are present in South Africa. Chrysithrix (C. capensis, C. dodii and C. junciformis) and Hellmuthia (H. membranacea) have been cited as present in South Africa (Arnold and de Wet 1993).

6.2 Results

6.2.1 Hypolytreæ species collected in the Eastern Cape

Only one species of the tribe Hypolytreæ, Chrysithrix capensis is present in the Eastern Cape (refer to Appendix 1 for specimens collected). To date, only two other investigators have collected C. capensis in the Eastern Cape (Esterhuysen, 6767 PRE and Horn, 2469 PRE).

The three C. capensis specimens collected in the Eastern Cape, all from the Humansdorp area (3424AA and BB). C. dodii C.B.Clarke, which had been previously collected in the area by Fourcade (2416 GRA and 3018 PRE), was not present when the author re-collected in the area in 1997.

6.2.2 Distribution and habitat of Hypolytreæ

The distribution of C. capensis is limited to the eastern border of the Eastern Cape. C. capensis is present in the coastal Pine forests of Witelsbos and Humansdorp. This species is only present on dry and stony soils.
Plate 25. Shows structural details of the leaves of *Chrysithrix capensis* in section, including the epidermis; stomata; girder and sclerenchymatous strand structure and arrangement; lamina cavities; mesophyll structure; vascular bundle arrangement; vascular bundle spacing; and vascular sheaths, as well as associated vascular tissues.

(25.1) Shows the lamina with lignified outer periclinal wall of the epidermis. Ground tissues are composed of chlorenchymatous and translucent parenchyma. Chlorenchyma abuts the epidermis, extending to the phloem side of the large and intermediate vascular bundles. Endarch to the chlorenchyma is a region of translucent parenchyma that extends to the central cavity. A large cavity is present in the centre of the leaf. Tannin idioblasts are present scattered within the ground tissues, where many are present at the border of the chlorenchymatous and translucent parenchyma regions. (25.2) The epidermal cells are lignified in the outer periclinal wall. The stomata are sunken and have lignified guard cells. The subsidiary cells are relatively thin-walled. The sub-stomatal cavities are small. (25.3) The large vascular bundles have an abutting abaxial girder and adaxial sclerenchymatous strands. On the xylem side of the vascular bundle is the region of translucent parenchyma. There are two vascular sheaths, the outer sheath is a lignified mestome sheath and the inner sheath is composed of non-lignified border parenchyma. On the phloem side of the vascular bundle the cells of the mestome sheath are almost filled with lignin. On the xylem side of the vascular bundle the mestome sheath is relatively thin-walled. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the protoxylem lacuna. (25.4) Shows an intermediate vascular bundle with an abutting abaxial girder and adaxial sclerenchymatous strands. On the phloem side of the vascular bundle is non-radiating chlorenchyma. On the xylem side of the vascular bundle is the region of translucent parenchyma. There are three vascular sheaths, an outer partial parenchymatous sheath, a middle mestome sheath and an inner partial non-lignified sheath of border parenchyma. The parenchymatous sheath is composed of thin-walled translucent parenchyma and is present as two cells on both sides of the vascular bundle. The cells of the mestome sheath on the phloem side are so lignified that the cells are almost filled with lignin. The cells of the mestome sheath on the xylem side of the vascular bundle are relatively thin-walled. The sheath of border parenchyma is present only on the phloem side of the vascular bundle. (25.5) An outer small vascular bundle with an abutting abaxial girder. The cells of the chlorenchyma are non-radiating, containing numerous chloroplasts and abut the phloem side of the vascular bundle. The vascular bundle has three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner partial sheath of non-lignified border parenchyma. The parenchymatous sheath similar to the intermediate vascular bundle is composed of thin-walled translucent parenchyma. The mestome sheath cells on the phloem side of the vascular bundle are almost filled with lignin, whilst on the xylem side of the vascular bundle the cells are thick-walled in the inner tangential and radial walls. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. Note that there are only two xylem vessels present in the vascular bundle. (25.6) A more magnified view of an outer small vascular bundle with abutting girder. Note that in this vascular bundle there is only one protoxylem vessel present.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermis; (G) girder; (MS) mestome sheath; (MX) metaxylem vessel; (OT) outer periclinal wall of epidermal cells; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (SS) sclerenchymatous strands; (St) stoma; (Sto) sub-stomatal cavity; (Su) subsidiary cells; (T) tannin idioblasts; (TP) translucent parenchyma and (X) xylem. Bars = 10 μm.
6.2.3 Leaf Characteristics in the tribe Hypolytreæ

Chrysothrix capensis has oval leaves, with no midrib or marginal bundles. C. capensis has thick leaves (692-1077μm), with no trichomes (Plate 25.1).

Plate 25. Legend on facing page.

There is one layer of small, epidermal cells (Plate 25.1), where the shape of these cells is square to rectangular (Plate 25.2). No bulliform cells are present in the epidermal cells of the leaves (Plate 25.1). The outer periclinal walls of the epidermis are lignified, whilst the inner periclinal and anticlinal walls are relatively thin-walled (Plate 25.2).

No cone-shaped silica deposits are present in the epidermal cells that abut the girders. The cells of the epidermis that abut the girders are the same size as those epidermal cells adjacent to the girders.

The stomata in C. capensis are sunken below the epidermal surface (Plate 25.2). The guard cells are thick-walled at the adaxial and abaxial poles. The sub-stomatal cavities are small (ranging from less than 1 to 4μm).

The girders are small and lignified (Plate 25.3-6). All vascular bundles have one abutting girdler in the leaves of C. capensis (Plate 25.3-6). Girders are small in size, when compared with leaf thickness, ranging from 36μm to 51μm. Small, lignified sclerenchymatous strands (SS) are present abutting the xylem poles of the large and intermediate bundles (Plate 25.3-4).
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A lamina cavity is present in the centre of the leaf (Plate 25.1). The lamina cavity is large in size, when compared to the leaf thickness, ranging from 293μm to 610μm.

There are a few, scattered tannin idioblasts present within the leaves of *C. capensis*. Most of the tannin idioblasts are present in the region of translucent parenchyma (Plate 25.1). No silica deposits are present in tissues or on epidermal surfaces of the leaves of *C. capensis*.

The mesophyll is composed of thin-walled chlorenchymatous parenchyma and translucent parenchyma (TP). The chlorenchyma abuts the epidermis, extending to the SS of the large and intermediate bundles. The chlorenchyma also extends to the xylem pole of the small bundles (Plate 25.1 and 25.4-6). The TP abuts the chlorenchyma and extends to the central leaf cavity (Plate 25.1).

All vascular bundles are present in one row. This row is present in the chlorenchyma near the epidermis (Plate 25.1) and consists of large, intermediate, as well as small bundles (Plate 25.1 and 25.4-6). The bundles have a maximal cell distal count of between 5 and 9 cells. One small bundle is usually present between the large and intermediate bundles.

Most vascular bundles are surrounded by three vascular sheaths (Plate 25.4-6). The outer sheath is a parenchymatous sheath (PS), the middle sheath is a lignified mestome sheath (MS) and the inner sheath is composed of non-lignified border parenchyma (BP, Plate 25.3-5). The PS is absent in the large bundles (Plate 25.3). In the intermediate bundles the PS is only present on the sides of the vascular bundles (Plate 25.4). In the small bundles the PS is absent at the xylem pole abutting the TP (Plate 25.5). The cells of the PS are large (two to three times larger than the MS), thin-walled and are achlorenchymatous (Plate 25.4-6). The walls of the MS are lignified in the radial and inner tangential walls especially on the phloem side of the bundle (Plate 25.4-6). The BP of the large bundles is bisected by large metaxylem vessels (Plate 25.3-4). The intermediate and small bundles the BP is limited to the phloem sides of the bundles (Plate 25.4-5). The cells of the BP are thin-walled and range from small to medium in size.

Generally small bundles are characterised by one to two protoxylem vessels (Plate 25.5-6). Protoxylem lacunae are present only in the outer large bundles (Plate 25.4). The phloem and xylem outlines vary (see Appendix 4 for detail).

### 6.2.4 Bract Characteristics in the tribe *Hypolytreae*

As in the leaves, *C. capensis* has oval bracts (Plate 26.1), with no midrib or marginal bundles. The bracts in *C. capensis* are thick, ranging from 721μm to 782μm. No trichomes are present in the bracts of *C. capensis*.

The epidermal cells are generally thin-walled in the inner periclinal and anticlinal walls. The outer periclinal walls are thick-walled (Plate 26.1-2). Most of the outer periclinal walls of the epidermal cells have small, lanceolate, lignified projections present in the middle of the cell (Plate 26.2).
Plate 26. Shows structural details of the bracts of Chrysithrix capensis in section, including epidermal and stomata structure; girder and sclerenchymatous strands arrangement and structure; lamina cavity, mesophyll structure; and vascular sheaths, as well as associated vascular tissues.

(26.1) Shows the lamina with epidermal cells that have a lignified outer periclinal wall. Ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem side of the vascular bundles. Present endarch to the chlorenchyma is a layer of one to three cells of thin-walled translucent parenchyma, which extends to the central cavity. (26.2) The epidermis with lignified outer periclinal wall. Note particularly the lignified extension of the outer periclinal wall in the middle of the epidermal cell. (26.3) The epidermis has sunken stomata, with small sub-stomatal cavities. Both the guard cells and the subsidiary cells are lignified. (26.4) A large vascular bundle with abutting abaxial girder and adaxial sclerenchymatous strands. The chlorenchyma on the phloem side of the vascular bundle is non-radiating and has numerous small chloroplasts. On the xylem side of the vascular bundle is thick-walled translucent parenchyma. There are three sheaths present, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath is composed of thick-walled translucent parenchyma that is present on the sides of the vascular bundle. The mestome sheath cells on the phloem side of the vascular bundle are almost filled with lignin, those on the xylem side of the vascular bundle are relatively thin-walled. The sheath of border parenchyma is interrupted by metaxylem and protoxylem vessels that abut the mestome sheath. (26.5) An intermediate vascular bundle with abutting sclerenchymatous strands. This vascular bundle has three sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of border parenchyma. The cells of the parenchymatous sheath are composed of thick-walled translucent parenchyma. The mestome sheath cells on the phloem side of the vascular bundle are almost filled with lignin, whilst the cells on the xylem side are relatively thin-walled. The sheath of indistinct border parenchyma is limited to the phloem side of the vascular bundle. (26.6) A small vascular bundle with abutting abaxial girder. The chlorenchyma on the phloem side of the vascular bundle is composed of elongated rectangular cells that are non-radiating, with numerous small chloroplasts. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is limited to the xylem pole of the vascular bundle and is composed of thick-walled translucent parenchyma. The cells of the mestome sheath abutting the girder are almost filled with lignin, whilst the cells in the rest of the sheath are thick-walled in the inner tangential and radial walls. As with 25.6, there is only one protoxylem vessel present within the vascular bundle.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermis; (G) girder; (MS) mestome sheath; (MX) metaxylem vessel; (Ot) outer periclinal wall of epidermal cells; (PS) parenchymatous sheath; (SS) sclerenchymatous strands; (Stc) sub-stomatal cavity; (Su) subsidiary cells; (T) tannin idioblasts; (TP) translucent parenchyma and (X) xylem. Bars = 10 µm.
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As with the leaves, no cone-shaped silica deposits are present in the epidermal cells that abut the girders. The cells of the epidermis that abut the girders are the same size as the epidermal cells adjacent the girders, similar to the leaves.

The stomata in *C. capensis* are sunken (Plate 26.3). The size of the sub-stomatal cavities is small (ranging from less than 1μm to 6μm). The outer periclinal and anticlinal walls of the subsidiary cells, as well as the guard cells are additionally lignified (Plate 26.3).

![Diagram](Plate 26.3)

**Plate 26. Legend on facing page.**

As with the leaves, the cells that comprise the girders are small and lignified. All vascular bundles have an abutting girder (Plate 26.1 and 26.4). Girders are small in comparison to bract size, ranging from 51μm to 55μm. Small, thick-walled SS are present abutting the xylem poles of the large and intermediate bundles (Plate 26.4-5).

As in the leaves, a lamina cavity is present at the centre of the bract. This cavity is large in relation to bract thickness (Plate 26.1), ranging from 360μm to 542μm.

There are few, scattered tannin idioblasts present in the bracts in *C. capensis*. Most of these tannin idioblasts are present in the layer of translucent parenchyma (Plate 26.1).

As with the leaves, the mesophyll is composed of thin-walled, chlorenchymatous parenchyma and translucent parenchyma (Plate 26.1). The chlorenchyma abuts the epidermis, extending to the sclerenchymatous strands of the
large and intermediate bundles, as well as the xylem poles of the small vascular bundles. The translucent parenchyma abuts the chlorenchyma and extends for 1-4 cells to central bract cavity.

All vascular bundles are present in one row, within the bract chlorenchyma. The vascular bundles have a maximal cell distal count ranging from 7 to 11 cells.

Vascular bundles are characterised by the presence of two vascular sheaths (Plate 26.4-6). The outer sheath is a PS and the inner sheath is a lignified MS. An additional third sheath of non-lignified BP is present in the large and intermediate bundles (Plate 26.4-5). The PS is only present on the sides of the vascular bundles and is absent at the xylem, as well as phloem poles of the bundles (Plate 26.4-6).

The cells of the PS are large (two to three times larger than the abutting MS), thin-walled and achlorenchymatous (Plate 26.4-6). The walls of the MS are thick-walled in the radial and inner tangential walls, especially on the phloem side of the bundle (Plate 26.4-6). The BP of the large bundles is bisected by the large metaxylem vessels (Plate 26.4). In the intermediate bundles the BP is limited to the phloem side of the bundle (Plate 26.5). The cells of the BP are small or NK-S to medium sized or NK-M.

As with the leaves, one to two protoxylem vessels are present in the small bundles (Plate 26.6). No Protoxylem lacunae are present in the bracts in *C. capensis*. The phloem and xylem outlines vary (Appendix 4).

### 6.2.5 Culm Characteristics in the tribe Hypolytreae

As with the leaves and bracts, the shape of the culm is oval. The culms in *C. capensis* are large, ranging from 709µm to 1315µm (Plate 27.1). There are no trichomes present in the culms of *C. capensis*.

The epidermal cells are small, ranging from 4µm to 12µm (Plate 27.2). The walls of the epidermis cells are thin-walled in the inner periclinal and anticlinal walls (Plate 27.1-2). The outer periclinal walls are relatively thick-walled.

As with the leaves and bracts, cone-shaped silica deposits are absent in the epidermal cells abutting the girders. The cells of the epidermis that abut the girders are the same size as those epidermal cells adjacent the girders, similar to the bracts.

The stomata in *C. capensis* are sunken (Plate 27.2), similar to the leaves and bracts. The outer periclinal walls of the guard cells and the subsidiary cells are lignified (Plate 27.2). The size of the sub-stomatal cavities is small (ranging from less than 1 to 3µm).

The girders are small (61-70µm), thick-walled and abut all outer row bundles (Plates 27.1 and 27.3-6) Hypodermal sclerenchymatous strands are present at random along the epidermis. Small thick-walled SS are present on the xylem poles of the large and intermediate bundles (Plate 27.3-4). The SS are also present at the phloem poles of the inner large bundles (Plate 27.3).
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Plate 27. Shows structural details of the culms of Chrysithrix capensis in section, which includes epidermal and stomatal complex structure; girders; sclerenchymatous strands arrangement and structure; cavity; tannin arrangement and structure; ground tissue structure; vascular bundle arrangement; and vascular sheaths, as well as vascular tissues.

(27.1) Shows the epidermis with lignified outer periclinal wall. Ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem side of the vascular bundles. Endarch to the chlorenchyma is thick-walled translucent parenchyma, which extends to the central cavity. There are two rows of vascular bundles. An outer row that is present in both the chlorenchyma and the translucent parenchyma, as well as a second row of vascular bundles present in the translucent parenchyma. Tannin idioblasts are scattered within the ground tissues, with most present at the intersection of the chlorenchyma and translucent parenchyma. (27.2) The epidermis with lignified outer periclinal wall. Stomata are sunken and have small substomatal cavities. Both the guard cells and the subsidiary cells are lignified, the guard cells more so than the subsidiary cells. (27.3) An inner large vascular bundle with abutting sclerenchymatous strands at both the xylem and phloem poles of the vascular bundle. Surrounding the vascular bundle is translucent parenchyma. There are two sheaths present, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath cells on the phloem pole of the vascular bundle are almost filled with lignin, whilst most of the cells of the mestome sheath are relatively thin-walled. The indistinct sheath of border parenchyma is interrupted by two metaxylem vessels. (27.4) An outer large vascular bundle with an abutting abaxial girder and adaxial sclerenchymatous strands. There are two sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath cells abutting the girder are thick-walled in the inner tangential and radial walls, whilst most of the mestome sheath cells are relatively thin-walled. The indistinct sheath of border parenchyma is interrupted by large metaxylem vessels and the protoxylem lacuna. (27.5) An outer intermediate vascular bundle with abutting abaxial girder and adaxial sclerenchymatous strands. The chlorenchyma on the phloem side of the vascular bundle is non-radiating and contains numerous small chloroplasts. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified partial sheath of border parenchyma. The parenchymatous sheath is composed of thick-walled translucent parenchyma. The mestome sheath cells abutting the girder are filled with lignin. Most of the mestome sheath cells are thick-walled in the inner tangential and radial walls. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (27.6) An outer small vascular bundle with abutting girder. The chlorenchyma is composed of elongated rectangular cells, with numerous chloroplasts. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The cells of the parenchymatous sheath are thin-walled and translucent. The mestome sheath cells abutting the girder are filled with lignin, similar to those of the intermediate vascular bundle. Most of the mestome sheath cells are thick-walled in the inner tangential and radial walls similar to those of the intermediate vascular bundle. As with both 25.6 and 26.6, the small vascular bundle has only one protoxylem vessel inside.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermis; (G) girder; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (OT) outer periclinal wall of epidermal cells; (PS) parenchymatous sheath; (SS) sclerenchymatous strands; (St) stoma; (Stc) sub-stomatal cavity; (Su) subsidiary cells; (T) tannin idioblasts; (TP) translucent parenchyma and (X) xylem. Bars = 10 μm.
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A single cavity is present at the centre of the culm, similar to the leaves and bracts. This cavity is large in size, ranging from 230\(\mu m\) to 967\(\mu m\) (Plate 27.1).

The ground tissues are composed of an outer region of thin-walled chlorenchymatous parenchyma and an inner translucent parenchymatous (TP) region, similar to the leaves and bracts. The chlorenchyma abuts the epidermis and extends to the phloem side of the outer large and intermediate bundles (Plate 27.1 and 27.4-5), as well as the xylem pole of the outer small bundles (Plate 27.6). The TP is present inside the chlorenchymatous layer and extends to the edge of the cavity (Plate 27.1).

Plate 27. Legend on facing page.

There are many, scattered tannin idioblasts present in the culms of *C. capensis*. Most of these idioblasts are present in the TP and on the boundary of the TP/chlorenchyma (Plate 27.1). The tannin idioblasts at the TP/chlorenchymatous boundary are rectangular and smaller than the rounded tannin idioblasts of the TP (Plate 27.1). There were no silica-containing cells present in the culm or on any of the surfaces of the culms.

The vascular bundles are present in two rows. The first row is present within the chlorenchymatous tissue abutting the TP and consists of large, intermediate, as well as small bundles. The second row is present in the TP and consists of large bundles.

Generally the vascular bundles have two vascular sheaths (Plate 27.3-6). The outer sheath is the PS and the inner sheath is a lignified MS (Plate 27.5-6). In the inner and outer large bundles the PS is absent (Plate 27.3-4). In the intermediate and small bundles the PS is limited to the sides of the vascular bundles. The PS in these bundles is absent at the xylem and phloem poles of the bundles (Plate 27.5-6). In the large and intermediate bundles an
additional sheath of non-lignified BP is present (Plate 27.3-5). In the outer and inner row large bundles the BP is bisected by large metaxylem vessels (Plate 27.3-4). In the intermediate bundles the BP is limited to the phloem side of the bundle (Plate 27.5).

The cells of the PS are large, thin-walled and achlorenchymatous (Plate 27.5-6). PS cells are larger than the abutting MS cells. The MS cells are small and thick-walled in the radial, as well as inner tangential walls (Plate 27.3-6). Most of the MS cells on the phloem side of the bundle are completely filled with the lignin. The cells of the BP are thin-walled and small to medium sized (Plate 27.3-5).

As with the leaves and bracts, small bundles are characterised by one to two protoxylem elements (Plate 27.6). Protoxylem lacunae are present only in the large bundles (Plate 27.3). The phloem and xylem outlines vary (Appendix 4).
7.1 Introduction to the Rhynchosporae

The tribe Rhynchosporae is part of the sub-family Caricoideae and contains four genera: Micropapyrus Suessenguth; Pleurostachys Brongniart; Rhynchospora Vahl and Syntrinema Pfeiffer (Bruhl 1995). The classification by Bruhl (1990 & 1995) closely follows Goetghebeur's (1985) classification of the Rhynchosporae, which differs radically from Metcalfe's (1971) classification. Metcalfe (1971) included 41 genera within the Rhynchosporae, placing genera from the Schoeneae into the Rhynchosporae. Metcalfe (1971) also stated that the Rhynchosporae are a heterogeneous tribe that have many similarities with the Hypolytreae. Metcalfe (1971) followed Govindarajalu (1969) by stating that the shape and presence or absence silica deposits are the only distinguishing characteristics of the tribe. This was further supported by investigations of the systematic anatomy of the south Indian Cyperaceae by Govindarajalu in 1975. Both Bruhl (1995) and Goetghebeur (1985 and 1989) removed most of the genera that Metcalfe (1971) had included within the tribe and placed them in the Schoeneae.

Bruhl's (1995) findings agreed closely with those of Ueno and Koyama (1987). Bruhl (1995), as well as Ueno and Koyama (1987) stated that the Rhynchosporae tribe, like most of the Cyperaceae might divided into C₃ and C₄ species, based on bundle sheath structure. The C₄ group was further sub-divided into two groups, based on vascular sheath structure, into the chlorocyperoid and rhynchosporoid C₄ anatomical groups (Ueno and Koyama 1987; Bruhl 1995). The C₄ chlorocyperoid anatomical group is present in the C₄ chlorocyperoid genus Rhynchospora. The rhynchosporoid C₄ anatomical group is present in the C₄ genera Rhynchospora and Syntrinema (Bruhl 1995).

The C₃ plants are characterised as non-Kranz. However, the vascular bundles are reported here and elsewhere to be surrounded by two vascular sheaths, namely an outer parenchymatous sheath and an inner mestome sheath (Brown 1975; Gilliland and Gordon-Gray 1978; Takeda et al. 1980; Ueno and Koyama 1987; Bruhl 1995; Bruhl and Perry 1995). C₃ species are present in the genera Micropapyrus, Pleurostachys and Rhynchospora.

Rhynchosporae are a cosmopolitan family with a wide distribution range and number of habitats. These species are more dominant in shade habitats that are helophytic to mesophytic in microclimate. Only the C₃ and the C₄ rhynchosporoid, genus Rhynchospora is present within habitats all over the world. Micropapyrus and Syntrinema are monotypic and present in the West Indies as well as South and Central America. Pleurostachys has 50 species, which are also distributed, within habitats in the West Indies, South and Central American habitats. Similarly the C₃ chlorocyperoid genus Rhynchospora is present in habitats within the West Indies, South and Central America (Bruhl 1993). The C₃ species are more dominant in tropical to temperate conditions, and are absent in arid conditions. The C₄ species are present in humid tropics and subtropical savannahs, where the wet seasons alternate with dry (Ueno and Koyama 1987).

Only the C₃ and the C₄ rhynchosporoid, genus Rhynchospora is said to be present within Africa and within the boundaries of South Africa. Only R. africana is not present within the boundaries of southern Africa (Arnold and de Wet 1993). Bruhl (1993) looked at only two Rhynchospora species from southern Africa (R. cephalantha var. pleiocephala and R. cyperoides). Metcalfe (1971) described four species from Zambia (R. africana, R. candida, R. rugosa [= R. brownii] and R. subquadrate [= R. gracillima subsp. subquadrate]) and one from Nigeria (R. corymbosa). Clearly very few of the southern African Rhynchospora species have been described.
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7.2 Results

7.2.1 Rhynchosporae species collected in the Eastern Cape

Two species of the Rhynchosporae were collected and both from the genus Rhynchospora Vahl, namely R. barrosiana Guaglianone (refer to Appendix 1 for specimens collected), as well as R. brownii Roem and Schult. (Appendix 1). The collection of R. barrosiana in the Cape Morgan Nature Reserve near Kei Mouth, is the first collection of this species in the Eastern Cape, whilst R. brownii is common within the region.

7.2.2 Distribution and habitat of Rhynchosporae

The distribution of R. barrosiana is coastal (Fig. 15). R. brownii has been more commonly collected from habitats further inland (Fig. 15). The habitat and conditions within the habitat differs between the two species. R. barrosiana is habitat specific, and was collected from coastal thickets (Fig. 16), on dry (Fig. 17) and sandy soils (Fig. 18). R. brownii is not habitat specific and occurs in a wide range of habitats, ranging from fynbos, to grasslands, to marsh and river bank habitats (Fig. 16). Specimens of R. brownii are more commonly collected from habitats with wet soils (Fig. 17), generally on stony substratum (Fig. 18).

Figure 15: Shows the distribution of habitats of the Rhynchosporae in the Eastern Cape. Symbols are as follows: (Rha-C4) R. barrosiana, C4 species and (Rbr-C3) R. brownii, C3 species.
Figure 16: Shows the habitats of the *Rhynchosoraeae* in the Eastern Cape. Symbols are as follows: (Ba) banks of rivers or streams; (Fo) forests; (Fy) fynbos; (Gr) grassland; (Ma) marshes; (O) open areas with no vegetation; (Rba-C4) *R. barostana*, C₄ species; (Rbr-C3) *R. brownii*, C₃ species and (Th) thickets.

Figure 17: Shows the soil hydration of the soils within the habitats of the *Rhynchosoraeae* of the Eastern Cape. Symbols are as follows: (Rba-C4) *R. barostana*, C₄ species and (Rbr-C3) *R. brownii*, C₃ species.
7.2.3 Leaf Characteristics of the tribe Rhynchosporeae

Leaves of both species are V-shaped. Leaves are thin (Table 13, Appendix 3) and lack trichomes. The midrib is generally thicker than the lamina (Table 13, Appendix 3). Bulliform cells are present in the adaxial epidermal cells of the midribs of both species (Plate 28.1-2). The inner periclinal and anticlinal walls of the epidermal cells are thin-walled. The outer periclinal walls are thick-walled (Plate 28.2-10). The adaxial epidermal cells are generally larger than the abaxial epidermal cells (Plate 28.3, Table 13, Appendix 3) and range from 18µm (R. brownii) to 68µm (R. barrosiana, [Table 13, Appendix 3]). The abaxial epidermal cell size ranges from 6µm (R. brownii) to 16µm (R. barrosiana, [Table 13, Appendix 3]).

Cone-shaped silica deposits are present in both species. Cone-shaped silica deposits are present only in the abaxial epidermal cells in R. barrosiana, which abut the hypodermal sclerenchymatous strands (HSS). Cone-shaped silica deposits are present in both the adaxial and abaxial epidermal cells that abut the HSS and girders in R. brownii (Plate 28.2, 28.7-8 and 28.10). The epidermal cells that are present adjacent to the cells with the cones, abutting the HSS or girders, are generally smaller than the cells of the epidermis that are between the HSS or girders.

The stomata of both species are present in the abaxial epidermis and are flush with the epidermal surfaces (Plate 28.4-5). There are small horn shaped lignin deposits on the adaxial pole of the guard cells in R. brownii. The substomatal cavities are small in relation to the leaf thickness (Table 13, Appendix 3), ranging from 6µm (R. brownii) to 18µm (R. barrosiana, [Table 13, Appendix 3]).
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Plate 28. Shows structural details of the leaves of Rhynchospora barrosiana and R. brownii in section, including adaxial and abaxial epidermis structure; bulliform epidermal cell arrangement and structure; stomatal complex structure; hypodermal sclerenchymatous strands, girders, sclerenchymatous strands arrangement and structure; lamina cavities; hypodermis; tannin idioblast structure and arrangement; mesophyll structure; vascular bundle arrangement and spacing; and vascular sheaths, as well as vascular tissues.

(28.1) Shows the adaxial epidermis in R. barrosiana with elongated bulliform cells present in the midrib. The midrib vascular bundle has an abutting adaxial girder and a protoxylem lacuna on the xylem pole of the vascular bundle. (28.2) Bulliform cells are also present in the midrib of R. brownii. The abaxial epidermal cells are lignified in the outer periclinal wall. The midrib vascular bundle has an abutting abaxial girder and adaxial sclerenchymatous strands. Present between vascular bundles are the lamina cavities. The abaxial epidermal cells abutting the girder have a cone-shaped silica deposit. (28.3) The adaxial epidermal cells in R. barrosiana are larger than the abaxial epidermal cells. The outer periclinal walls of these epidermal cells are thick-walled. The mesophyll is composed of compact chlorenchymatous cells with large chloroplasts. Vascular bundles are present in a median row and are one to three cells apart. Tannin idioblasts are present scattered in the mesophyll. (28.4) The abaxial epidermis in R. barrosiana has flush stomata, with small sub-stomatal cavities. Both the guard cells and the subsidiary cells are thick-walled. (28.5) The abaxial epidermis in R. brownii also has flush stomata with small sub-stomatal cavities. The guard cells are lignified, with the subsidiary cells relatively thin-walled. The abaxial epidermal cells are lignified in the outer periclinal wall. (28.6) The abaxial hypodermal sclerenchymatous strands in R. barrosiana are present adjacent to the intermediate vascular bundles. The mesophyll is composed of compact radiating chlorenchyma, with large chloroplasts. Tannin idioblasts are scattered within the mesophyll. The adaxial hypodermis is composed of thin-walled translucent cells. Vascular bundles are present in a median row. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath is interrupted by two metaxylem vessels. The chlorenchyma of the Kranz sheath are so large that they appear to fill the whole cell. (28.7) The midrib vascular bundle in R. brownii with abutting adaxial and abaxial girder. The abaxial epidermal cells abutting the girder are smaller than the adjacent epidermal cells and have a cone-shaped silica deposit. The mesophyll is composed of non-radiating chlorenchyma, with numerous small chloroplasts. There are three vascular sheaths, an outer chlorenchymatous sheath of parenchyma, a middle lignified mestome sheath and an inner partial sheath of border parenchyma. The parenchymatous sheath is thin-walled. The mestome sheath is thick-walled in the inner tangential and radial walls, especially abutting the girder. The sheath of border parenchyma is limited to the xylem side of the vascular bundle, where a protoxylem vessel interrupts the sheath. (28.8) A large vascular bundle in R. brownii with abutting adaxial girder and adaxial sclerenchymatous strands. The abaxial epidermal cells abutting the girder are smaller than the adjacent epidermal cells and contain a cone-shaped silica deposit. The chlorenchyma and vascular sheaths are in the same arrangement as the midrib. The only difference is that a large protoxylem lacuna is present at the xylem pole of the vascular bundle where it interrupts the sheath of border parenchyma. (28.9) Shows an intermediate vascular bundle in the lamina of R. brownii with abutting abaxial girder. The mesophyll is composed of non-radiating chlorenchyma with numerous chloroplasts. Lamina cavities are present between the vascular bundles. Tannin idioblasts mostly abut the outer sheaths of the vascular bundles. Vascular bundles have three vascular sheaths, an outer chlorenchymatous sheath of parenchyma, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is thin-walled. The cells of the mestome sheath are thick-walled in the inner tangential and radial walls, especially abutting the girder. An indistinct sheath of border parenchyma is interrupted by two protoxylem and metaxylem vessels. (28.10) One of the two marginal vascular bundles in R. brownii with an abutting abaxial girder. The abaxial epidermal cells abutting the girder have a cone-shaped silica deposit. The mesophyll, tannin idioblast and vascular sheath arrangement is the same as the intermediate vascular bundle of 28.9. (28.11) The other marginal vascular bundle in R. brownii with abutting adaxial girder, which extends to the adjacent large vascular bundle. The mesophyll is composed of non-radiating chlorenchyma with numerous chloroplasts. A few tannin idioblasts abut the girder, marginal and adjacent large vascular bundle. This marginal vascular bundle has two vascular sheaths, the outer sheath is a chlorenchymatous sheath of parenchyma and the inner sheath is a lignified mestome sheath. The parenchymatous sheath is thin-walled. (28.12) Shows a large vascular bundle in the lamina of R. barrosiana with two adjacent abaxial hypodermal sclerenchymatous strands. The chlorenchyma is composed of compact radiating chlorenchyma, with few chloroplasts. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath is interrupted by two large metaxylem vessels. The chloroplasts of the Kranz sheath are so large that they appear to fill the cells. A large protoxylem lacuna is present at the xylem pole of the vascular bundle inside the Kranz sheath.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (Bu) bulliform epidermal cell; (BP) border parenchyma; (Ca) cavity; (G) girder; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (I) intermediate vascular bundle; (K5) Kranz sheath; (MP) midrib vascular bundle; (Mx) mestome sheath; (MX) metaxylem vessel; (OT) outer periclinal wall (tangential); (P5f) parenchymatous sheath; (PL) protoxylem lacuna; (RM) radiating mesophyll/chlorenchyma; (S) small vascular bundle; (St) stoma; (Stc) sub-stomatal cavity; (SS) sclerenchymatous strands; (Su) subsidiary cell and (T) tannin idioblast. Bars = 10 μm.
Plate 28. Legend on facing page.
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The cells of the HSS and girders in the Rhynchosporeae are small and lignified (Plate 28.2 and 28.6-12). HSS are present in the leaves of *R. barrosiana* (Plate 28.6 and 28.12), whilst girders and HSS are present in the leaves of *R. brownii*. The HSS in *R. barrosiana* are present at random, as well as present adjacent to the large and intermediate bundles (Plate 28.6 and 28.12). The vascular bundles in *R. brownii* have adaxial and abaxial girders. The midrib bundle (Plate 28.7), large bundles (Plate 28.8), intermediate bundles (Plate 28.9) and marginal bundles (Plate 28.10) in *R. brownii* have an abutting abaxial girder. One of the marginal bundles in *R. brownii* also has an adaxial triangular girder (Plate 28.11). The large bundles adjacent the marginal bundle also have an adaxial girdle but, no abaxial girdle (Plate 28.11). Two abaxial HSS are present adjacent the midrib of *R. barrosiana* (Plate 28.12). A single abaxial girdle abuts the midrib bundle in *R. brownii* (Plate 28.7). Girders abut the xylem pole of the midrib bundles in both species (Plate 28.1-2 and 28.7). There are fewer adaxial HSS/girders than abaxial HSS/girders (Table 13, Appendix 3). The adaxial HSS in *R. barrosiana* are larger than the abaxial HSS (Table 13, Appendix 3). Adaxial girders/HSS in *R. brownii* are also larger than the abaxial girders/HSS (Table 13, Appendix 3).

Small, thick-walled SS are also present abutting the adaxial poles of the large bundles (Plate 28.8), and a few of the intermediate and small bundles in *R. brownii*. A few of the small bundles in *R. brownii* also have SS abutting the phloem poles of the bundle.

Large lamina cavities are present only in *R. brownii* (Table 13, Appendix 3). These cavities are present between the vascular bundles in the lamina. Translucent "blue" parenchyma is usually present within these cavities.

An adaxial thin-walled, translucent hypodermis is present only in *R. barrosiana* (Table 13 [Appendix 3], Plate 28.6). This hypodermis is only present in the lamina and is absent in the midrib (Plate 28.1).

The mesophyll cells are thin-walled, with many small chloroplasts. The mesophyll structure differs for both species. The mesophyll in *R. barrosiana* is rectangular in shape, the long axis of the cells are present at right angles to the first vascular sheath, forming a sheath of mesophyll around the vascular sheath (Plates 28.3, 28.6, 28.12 and 29.1-2), similar to the RM in the Abildgaardieae and C₄ Cypereae species. The mesophyll in *R. brownii* is not present in this radiate manner (Plates 28.2, 28.7-11 and 29.3), there is no apparent pattern of mesophyll arrangement, similar to the C₃ species in the Cypereae, Hypolytreae, Schoeneae and the Scirpeae.

The tannin idioblast distribution differs for both species. There are very few, scattered tannin idioblasts present in the leaves of *R. barrosiana* (Plate 28.3 and 28.6). Similarly there are few tannin idioblasts present in the leaves of *R. brownii*, where the idioblasts are generally present abutting the vascular bundles (Plates 28.9-11 and 29.3).

All vascular bundles are solitary and present in one median row (Plate 28.3 and 28.6). The maximal cell distal count, between vascular bundles differs for the two species. *R. barrosiana* has a cell count of zero to two cells (Plates 28.3, 28.6, 28.12 and 29.1-2) and *R. brownii* of 3-11 cells. There does not appear to be a pattern in the position and number of the vascular bundles in the leaves of the Rhynchosporeae (Table 13, Appendix 3).

The vascular sheath composition differs for the two species and these will be discussed separately. The vascular bundles in *R. barrosiana* have two vascular sheaths (Plates 28.3, 28.6, 28.12 and 29.1-2), an outer fibrous or mestome sheath (MS) and the inner sheath Kranz sheath (KS). The MS is composed of small, thick-walled cells,
Plate 29. Shows structural details of the vascular sheaths and vascular tissues prepared from sections of the leaves of *R. barrosiana* and *R. brownii*.

(29.1) Shows a small vascular bundle in lamina of *R. barrosiana*, with abutting compact radiating chlorenchyma. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath is entire and surrounds all the vascular tissues. The chloroplasts of the Kranz sheath are large and appear to fill the cell.

(29.2) The margin in *R. barrosiana*, with adaxial and abaxial epidermal cells that are lignified outer periclinal wall. The margin vascular bundle has compact radiating chlorenchyma abutting the vascular bundle. This vascular bundle has two sheaths similar to the small vascular bundle, an outer mestome sheath and an inner Kranz sheath. The structure of these sheaths is the same as it was for the small vascular bundle. (29.3) A small lamina vascular bundle in *R. brownii* with non-radiating chlorenchyma present around the vascular bundle. The lamina cavities are present on either side. Tannin idioblasts abut the outer vascular sheath. There are two distinct vascular sheaths, an outer chlorenchymatous sheath of parenchyma and an inner lignified mestome sheath. The parenchymatous sheath is thin-walled.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Ca) cavity; (KS) Kranz sheath; (MS) mestome sheath; (PS) parenchymatous sheath; (RM) radiating chlorenchyma and (S) small vascular bundle. Bars = 10 μm.
that are lignified in the radial and inner tangential walls, especially on the phloem side of the bundles, as well as adjacent the large metaxylem vessels in the midrib bundle (Plate 28.12), large and intermediate bundles (Plate 28.6). The thin-walled KS cells are mostly larger than the thick-walled MS cells (Plates 28.6, 28.12 and 29.1-2). The chloroplasts within the KS are centrifugal in position. The KS is bisected by the large metaxylem vessels in the midrib bundle (Plate 28.12), the large and the intermediate bundles (Plate 28.6). The KS is entire and surrounds all the vascular tissues in the small (Plates 28.2 and 29.1) and marginal bundles (Plate 29.2).

Plate 29. Legend on facing page.

The vascular bundles in *R. brownii* have three vascular sheaths (Plates 28.7-10 and 29.3), the outer sheath is the PS, the middle sheath is a lignified MS and the inner sheath is composed of non-lignified border parenchyma (BP). The cells of the PS are thin-walled large and chlorenchymatous. The PS cells are larger than the abutting MS cells (Plates 28.7-10 and 29.3). All the walls of the MS are lignified, especially on the phloem side of the bundles (Plate 28.7-10). The BP is bisected by the large metaxylem vessels in all bundles, except the small bundles and one marginal bundle (Plate 28.7-10). The BP is only present on the phloem side of the small bundles and one marginal bundle (Plate 29.3). The BP is also interrupted by the protoxylem lacunae (PxL) in the midrib and large bundles (Plate 28.8). In one of the marginal bundles the BP is also interrupted by a protoxylem vessel (Plate 28.10). The cells of the BP are thin-walled and small to medium sized.

Phloem and xylem outlines are varied, see Appendix 4 for detail. PxL are present in the midrib bundle (Plate 28.7 and 28.12) and large bundles (Plate 28.8) of both species.

7.2.4 Bract Characteristics of the tribe *Rhynchosporae*

Both species have different bract outlines. In *R. barrosiana* the bracts are flanged V-shaped, whilst the bracts of *R. brownii* are V-shaped with a median groove. The *Rhynchosporae* bracts have no trichomes. Bract laminae are thin, ranging from 78μm (*R. barrosiana*) to 175μm (*R. brownii*, Table 14 [Appendix 3]). Laminae of *R. barrosiana* are thinner than the midribs, whilst in *R. brownii* the lamina are thicker than the midribs (Table 14, Appendix 3).

Bulliform cells are present only in the adaxial epidermal cells of the midribs in both *R. barrosiana* (Plate 30.1) and *R. brownii* (Plate 30.2). The abaxial median epidermal cells in *R. barrosiana* are mostly larger than the abutting
epidermal cells. Adaxial and abaxial epidermal cells are thick-walled in the outer periclinal wall (Plate 30.1-3), similar to the leaves. Similarly, the adaxial epidermal cells of both species are larger than abaxial epidermal cells (Table 14, Appendix 1). Adaxial epidermal cells range from 8μm (R. barrosiana) to 39μm (R. brownii). Abaxial epidermal cells range from 7μm (both species) to 12μm (both species).

Cone-shaped silica deposits are present in both the adaxial and abaxial epidermal cells in *R. barrosiana*. In *R. brownii* these silica deposits are only present in the abaxial epidermis.

Stomata occur in the abaxial epidermis and are flush with the epidermal surfaces of both species. The lignification in the guard cells differs for both species (Appendix 4). The sub-stomatal cavities are small in comparison to lamina thickness, ranging from 5μm (*R. brownii*) to 21μm (*R. barrosiana*).

The HSS and girders are composed of small, lignified cells, similar to those of the leaves in both species (Plate 30.1-7). The adaxial HSS in *R. barrosiana* are present in the margins of the bract (Plate 30.2), as well as at random along the adaxial and abaxial epidermis. The large bundles in *R. barrosiana* have an adjacent adaxial and abaxial HSS. Only the midrib bundle (Plate 30.3) and the intermediate bundles have an adjacent abaxial HSS (Plate 30.4). There are two abaxial HSS that are present adjacent the midrib bundle in *R. barrosiana* (Plate 30.3). Only one abaxial HSS is present adjacent the intermediate bundles. The adaxial girders in *R. brownii* are present abutting the marginal bundles. Abaxial girders abut the midrib bundle (Plate 30.1), large and intermediate bundles. As with the leaves, the adaxial HSS/girders are larger than the abaxial (Table 14, Appendix 3). The outlines of the HSS and girders is detailed in Appendix 4.

SS cells are small in diameter and lignified (Plate 30.3). The SS in *R. barrosiana* and *R. brownii* are present abutting the xylem pole of the midrib bundle (Plate 30.1 and 30.3). Additional SS are present abutting the xylem pole of the large bundles in *R. brownii*.

Lamina cavities are present only in *R. brownii*, which are present between the bundles. Translucent "blue" parenchyma is present within the cavities. As with the leaf, the bract cavities are large when related to the bract thickness (Table 14, Appendix 3).

An adaxial hypodermis is present in the bracts of *R. barrosiana* (Plate 30.5, Table 14 [Appendix 3]), resembling that of the leaf, and occurred only in the lamina. Mesophyll cells are thin-walled and chlorenchymatous for both species. The mesophyll structure differs for both species. The mesophyll cells radiate around the first vascular sheath in *R. barrosiana* (Plate 30.4-7). In *R. brownii* the mesophyll is not present in this radiate manner (Plate 30.8-9). There are a few circular, thin-walled translucent parenchyma cells scattered at random throughout the mesophyll in *R. barrosiana*, similar to the TP in the C₄ species of the Cypereae.

Very few tannin idioblasts are present scattered within the radiate mesophyll (RM) of the bracts in *R. barrosiana*. A few tannin idioblasts in *R. brownii* are present abutting the vascular bundles (Plate 30.8-9).
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Plate 30. Shows structural details of the bracts of R. barrosiana and R. brownii in section, including adaxial and abaxial epidermis structure; the arrangement and structure of hypodermal sclerenchymatous strands, girders, sclerenchymatous strands; lamina cavities; hypodermis; tannin idioblast arrangement; mesophyll structure; vascular bundle arrangement and spacing; and vascular sheaths, as well as associated vascular tissues.

(30.1) Shows the midrib of R. brownii with adaxial bulliform cells and abaxial epidermal cells with a lignified outer periclinal wall. The epidermal cells abutting the girders of the midrib vascular bundle are smaller than the adjacent epidermal cells. The midrib vascular bundle has an abutting abaxial girdle and adaxial sclerenchymatous strands. Lamina cavities are present between the vascular bundles. The mesophyll is composed of non-radiating chlorenchyma, with numerous chloroplasts. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is lignified in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by the large metaxylem vessels. (30.2) The margin in R. barrosiana with adaxial and abaxial epidermal cells that are lignified in the outer periclinal wall. Both the abaxial and aerial hypodermal sclerenchymatous strands of the margin do not appear to be adjacent the vascular bundles. The vascular bundles are present in one median row and are one to two cells apart. (30.3) The midrib vascular bundle in R. barrosiana with two adjacent abaxial hypodermal sclerenchymatous strands. The abaxial epidermis abutting these strands are smaller than the adjacent epidermal cells and are thick-walled in the outer periclinal wall. The midrib vascular bundle has an adaxial sclerenchymatous strand and a large protoxylem lacuna at the xylem pole of the vascular bundle. The mesophyll is compact and composed of radiating chlorenchyma, with few chloroplasts. Vascular bundles are one to three cells apart in the midrib. (30.4) A lamina intermediate vascular bundle in R. barrosiana with adjacent abaxial hypodermal sclerenchymatous strands. The mesophyll is compact and composed of radiating chlorenchyma, with few chloroplasts. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath is interrupted by one metaxylem vessel. The chloroplasts of the Kranz sheath are large and centrifugally positioned. (30.5) A lamina large vascular bundle in R. barrosiana with two adjacent abaxial hypodermal sclerenchymatous strands. The epidermal cells abutting these strands are smaller than the adjacent epidermal cells. The adaxial hypodermal cells are thin-walled. The mesophyll is compact and composed of radiating chlorenchyma, with few chloroplasts. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath is interrupted by two large metaxytem vessels. The chloroplasts of the Kranz sheath are large and appear to fill the cells. There is a large protoxylem lacuna at the xylem pole of the vascular bundle inside the Kranz sheath. (30.6) Shows a small marginal vascular bundle present near the margin in R. barrosiana with adjacent adaxial and abaxial hypodermal sclerenchymatous strands of the margin. Radiating chlorenchyma surrounds this vascular bundle. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The chloroplasts of the Kranz sheath are large and are centrifugally positioned. (30.7) One of the marginal vascular bundles in R. barrosiana with adjacent adaxial hypodermal sclerenchymatous strands. The adaxial and abaxial epidermal cells of the margin have a lignified outer periclinal wall. Radiating chlorenchyma with few chloroplasts surround the marginal vascular bundle. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The chloroplasts of the Kranz sheath are large and are centrifugally in position. (30.8) Shows an intermediate vascular bundle in the lamina of R. brownii. Lamina cavities are present between vascular bundles. The mesophyll is composed non-radiating chlorenchyma with numerous chloroplasts. Tannin idioblasts mostly abut the outer vascular sheath. There are three vascular sheaths, an outer chlorenchymatous sheath of parenchyma, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is thin-walled. The cells of the mestome sheath are almost filled with lignin on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by metaxylem vessels. (30.9) A small vascular bundle in the lamina of R. brownii. The mesophyll, tannin idioblasts and lamina cavities are in the same arrangement and structure as for the intermediate vascular bundle. There are two vascular sheaths, an outer thin-walled chlorenchymatous sheath of parenchyma and an inner lignified mestome sheath. The cells of the mestome sheath are almost filled with lignin on the phloem side of the vascular bundle.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Bu) bulliform epidermal cell; (Ca) cavity; (G) girdle; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (KS) Kranz sheath; (Me) marginal vascular bundle; (MS) mestome sheath; (OT) outer periclinal wall (tangential); (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (SS) sclerenchymatous strands and (T) tannin idioblast. Bars = 10 μm.
As with the leaves, the vascular bundles are present in one median row within the lamina. The cell count between vascular bundles for *R. barrosiana* is zero to two cells, as with the leaves (Plate 30.2-3). The vascular bundles in *R. brownii* are 4-8 cells apart. There is no recognisable pattern with respect to vascular bundle number and position within the lamina in the *Rhynchosporae* bracts (Table 14, Appendix 3).

The vascular sheath composition differs for both species, but is effectively similar to that of their respective leaves. As with the leaf lamina, the vascular bundles in *R. barrosiana* have two sheaths (Plate 30.4-7), an outer lignified MS and an inner non-lignified KS. The MS is composed of small thick-walled cells, that are lignified in the inner tangential and radial walls of the MS (Plate 30.4-7). The KS chloroplasts are centrifugal in position, similar to the leaves (Plate 30.2-4 and 30.6-7).
Bract bundles in *R. brownii* have three sheaths (Plate 30.1 and 30.8-9), an outer parenchymatous sheath (PS), a middle fibrous MS and an inner sheath of BP. The structure for the BP and the PS is the same as in the leaves (Plate 30.1 and 30.8-9). The MS cells are lignified and similarly shaped to the leaves (Plate 30.1 and 30.8-9).

Phloem and xylem tissue outlines/shapes are detailed in Appendix 4. Protoxylem lacunae are present in the midrib bundle and large bundles of both species (Plate 30.1, 30.3 and 30.5).

### 7.2.5 Culm Characteristics of the tribe *Rhynchosporeae*

In *R. barrosiana* the culms are obtusely triangular, whilst in *R. brownii* they are irregularly scutiform, with no trichomes. The culms size in *R. barrosiana* is larger (999-1345 μm) than *R. brownii* (462-512 μm, Table 15 [Appendix 3]).

Epidermal cells are small in size, ranging from 3 μm (*R. barrosiana*) to 11 μm (both species, Table 15 [Appendix 3]). The outer periclinal walls of the epidermal cells are thick-walled (Plate 31.1-4). No cone-shaped silica deposits are present in the epidermal cells of both species (Plate 31.2-4). The cells of the epidermis in *R. barrosiana* that abut the HSS are smaller than the epidermal cells that are present between the HSS (Plate 31.2). The epidermal cells in *R. brownii* are similar in size (Plate 31.3).

The stomata of the *Rhynchosporeae* are flush with epidermal surfaces (Plate 31.1). The guard cells of both species are thick-walled at the adaxial and abaxial poles of the cell (Plate 31.1). The sub-stomatal cavities are small, ranging from 4 μm (*R. barrosiana*) to 16 μm (*R. barrosiana*, Table 15 [Appendix 3]).

HSS are present only in *R. barrosiana* (Plate 31.2), where there are 49 HSS present abutting the epidermis. The HSS are small in comparison to the size of the culm (23-57 μm). There does not appear to be a pattern with respect to the distribution of HSS along the epidermis. The girders of the culms in *R. brownii* support three rows of vascular bundles (Plate 31.3-5). Extending from the girders to the phloem side of the third row of vascular bundles is a sclerenchymatous layer, that abuts the first row of bundles, on the xylem side of the bundles (Plate 31.3-4).

SS are present in *R. barrosiana*, abutting the xylem side of the large bundles, but not adjacent the large metaxylem vessels (Plate 31.6-8). A few (1-2) of the inner large bundles in *R. barrosiana* also have SS on the phloem side of the bundle. SS are present abutting the phloem poles of the first row small bundles of *R. brownii* (Plate 31.5).

Central cavities are present near the centre of the culms in *R. barrosiana* (Plate 31.9). These cavities are small in size when compared to the culm size (49-195 μm).

No tannin idioblasts are present in the culms of *R. barrosiana*. Many tannin idioblasts are present in the chlorenchymatous parenchyma and translucent parenchyma of *R. brownii* (Plate 31.3-5).
Plate 31. Shows structural details of the culms of *R. barrosiana* and *R. brownii* in section, including epidermal and stomatal complex structure; cavities; tannin idioblasts; ground tissue arrangement and structure, vascular bundle arrangement; and vascular sheaths, as well as associated vascular tissues.

(31.1) Shows the epidermal cells of *R. barrosiana* with lignified outer periclinal wall. There is a flush stoma with a small sub-stomatal cavity. Both the guard cells and the subsidiary cells are lignified. (31.2) The epidermal cells in *R. barrosiana* abutting the hypodermal sclerenchymatous strands are smaller than the adjacent epidermal cells. (31.3) The epidermal cells in *R. brownii* are thick-walled in the outer periclinal wall. The guard cells of the outer row of large vascular bundles extend to form a sclerenchymatous ring that joins with the sclerenchymatous strands of the second row of large vascular bundles. Present within the sclerenchymatous layer of tissue are small vascular bundles. Chlorenchyma extends from the epidermis and guard cells to the sclerenchymatous layer. The outer row of large vascular bundles have two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. Within these large vascular bundles are huge protoxylem lacunae. (31.4) The epidermis in *R. brownii* has a lignified outer periclinal wall. The cells of the chlorenchyma are thin-walled and contain few chloroplasts. Tannin idioblasts are present scattered within the layer of chlorenchyma. The small vascular bundles are present within the sclerenchymatous layer. Both the first row and second row of large vascular bundles have numerous large metaxylem vessels. (31.5) Shows a small vascular bundle in *R. brownii* that is present in the sclerenchymatous layer. These small vascular bundles have sclerenchymatous strands, which are present at the phloem pole of the vascular bundle. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is translucent and thick-walled. (31.6-7) The inner row of large vascular bundles in *R. barrosiana* is surrounded by translucent parenchyma. On the xylem side of the vascular bundles sclerenchymatous strands are found, whilst on the phloem side of the vascular bundle are cells resembling radiating chlorenchyma. The cells of the radiating chlorenchyma contain a few small chloroplasts. There are three vascular sheaths, an outer lignified mestome sheath, an inner partial non-lignified Kranz sheath (on the phloem side of the vascular bundle) and an inner partial sheath of border parenchyma (on the xylem side of the vascular bundle). Separating the Kranz sheath and the sheath of border parenchyma are two large metaxylem vessels. The chloroplasts of the Kranz sheath are large and almost fill the cell. There is a large protoxylem lacuna present at the xylem pole of the vascular bundle, which is present inside the sheath of border parenchyma. (31.8) Shows an outer row large vascular bundle in *R. barrosiana* with abutting sclerenchymatous strands. On the phloem side of the vascular bundle is radiating chlorenchyma. There are three sheaths and a large protoxylem lacuna similar to inner large vascular bundles. The arrangement and structure of these tissues is the same as in the large vascular bundles. (31.9) The ground tissues in *R. barrosiana* are composed of radiating chlorenchyma and translucent parenchyma. The radiating chlorenchyma extends from the epidermis to the phloem side of the second row of vascular bundles. Endarch to the chlorenchyma is translucent parenchyma, which extends to the central cavity. The inner rows of vascular bundles are present in the translucent parenchyma. (31.10) One second row intermediate vascular bundle in *R. barrosiana*. Radiating chlorenchyma, with few chloroplasts surrounds this vascular bundle. Translucent parenchyma is present endarch to the vascular bundle. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath is interrupted by metaxylem vessels. The chloroplasts of the Kranz sheath are large and fill the cell. (31.11) One outer row intermediate vascular bundle in *R. barrosiana* with adjacent hypodermal sclerenchymatous strands. The ground tissue surrounding the vascular bundle is compact and mostly composed of radiating chlorenchyma. There are two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The Kranz sheath is interrupted by two metaxylem vessels. The chloroplasts of the Kranz sheath are large and fill the cells. (31.12) An outer row small vascular bundle in *R. barrosiana*, with adjacent hypodermal sclerenchymatous strands. Ground tissues are composed of radiating chlorenchyma surrounding the outer row of vascular bundles and endarch to this is translucent parenchyma. There are also two vascular sheaths, an outer mestome sheath and an inner Kranz sheath. The chloroplasts of the Kranz sheath are large and centrifugal.

Symbols are as follows: (Ca) cavity; (Ch) chlorenchyma; (BP) border parenchyma; (Ep) epidermal cell; (G) girder; (HSS) hypodermal sclerenchymatous strands; (KS) Kranz sheath; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (OT) outer periclinal wall (tangential); (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (RM) radiating chlorenchyma; (S) small vascular bundle; (Sc) sclerenchyma; (St) stoma; (Stc) sub-stomatal cavity; (SS) sclerenchymatous strands; (Su) subsidiary cell; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10 μm.
Plate 31. Legend on facing page.
In both species the ground tissues are comprised of an outer chlorenchymatous region and an inner region of translucent parenchyma (TP). The location of the chlorenchyma and TP differs considerably. The ground tissues of each species will be discussed separately.

The ground tissues in *R. barrosiana* are composed of two tissue types (Plate 31.9-12). The outer most tissue is composed of radiate chlorenchyma (RM). The chlorenchyma abuts the outer row of bundles in a radiate manner and extends to the epidermis. The RM surrounds the outer row of intermediate and small bundles extending to the outer row of large bundles. The RM of the outer row large bundles is present only abutting the phloem side of the bundles. The inner rows of large bundles also have a single layer of RM abutting the phloem side of the bundle. The RM cells have a few (1-4) chloroplasts present within the cells. The peripheral ring of thin-walled chlorenchyma is mostly composed of rectangular RM, with a few thin-walled chlorenchymatous cells that are also present between the RM, the HSS and the epidermis. Inside the chlorenchymatous layer, extending to the central cavities is thin-walled translucent parenchyma (TP, Plate 31.9). Scattered within the TP are a few polygonal cells of translucent "blue" parenchyma. The inner rows of bundles are present in the TP (Plate 31.9).

The thin-walled, chlorenchymatous parenchyma in *R. brownii* is present in layer (1-4 cells) of tissue abutting the epidermis and is interrupted by the girders that support three rows of vascular bundles (Plate 31.3-4). In the centre of the culm and extending to the xylem pole of the outer sheaths of third row of bundles is lignified TP. The appearance of the lignified TP is similar to that of a multi-pointed star. Extending from the sclerenchymatous layer to the lignified TP, between the third row of bundles, is a layer (one cell thick) of thin-walled, non-lignified translucent parenchyma.

The vascular bundles in *R. barrosiana* are present in six rows that spiral inwards, whilst the bundles in *R. brownii* are present in four concentric rows (Table 15, Appendix 3). Intermediate and small bundles are present in the first row of bundles in the culms of *R. barrosiana* (Plate 31.11-12). The second row is composed only of intermediate bundles (Plate 31.10). The inner rows in *R. barrosiana* are composed of large bundles only. The first row of vascular bundles in *R. brownii* is composed of only small bundles (Plate 31.5). Large, intermediate and small bundles are present in the second row (Plate 31.3). The third and fourth rows of bundles are composed of large bundles.

There generally are two partial or entire sheaths present surrounding the bundles in *R. barrosiana* (Plate 31.10-12). The outer sheath is a lignified MS and the inner sheath a non-lignified KS, which is interrupted by the large metaxylem vessels in the intermediate bundles (Plate 31.10-11). The MS in *R. barrosiana* is composed of small, translucent, lignified cells (Plate 31.6-8 and 31.10-12). The walls of the MS have similar levels of lignification in all the walls of the cells. The cells of the MS of the large bundles are larger than that of the intermediate and small bundles. The MS of these large bundles is thick-walled appearance in comparison with the other bundles, which is accentuated by the large size of the large bundles. In the large bundles, the KS is absent on the xylem side of the bundle, where a layer of BP is present (Plate 31.6-8). The cells of the KS are thin-walled and larger than the MS, with the exception of the large bundles (Plate 31.6-8 and 31.10-12). The KS and MS cells of the large bundles are similar in size (Plate 31.6-8). The cells of the KS are characterised by the presence of large centrifugal chloroplasts (1-3). The cells of the BP in *R. barrosiana* are small and thin-walled (similar size to the MS). The BP and KS is not interrupted by the protoxylem lacunae (Plate 31.6-8).
There are two partial or entire sheaths surrounding the bundles in *R. brownii*. All the small bundles have an outer parenchymatous sheath (PS) and an inner MS (Plate 31.5). The PS cells in *R. brownii* are translucent, thin-walled and mostly larger than the MS cells. In the large and intermediate bundles, the outer sheath is the MS. This sheath surrounded the whole bundle. The MS cells in *R. brownii* in all bundles are similar to the cells that comprise the sclerenchymatous layer (Plate 31.5). The parts of the large and intermediate bundles that are not in contact with the sclerenchymatous layer bear little resemblance to the MS of the leaves and bracts. The MS cells that are in contact with the lignified TP are similar in size and appearance to the cells of the sclerenchymatous layer. The MS cells of the inner large bundles are larger than the MS cells abutting the sclerenchymatous and TP layer, and lignification is present in a few of these cells in the outer tangential and radial walls. The lignified layer within these cells has a sieve-like appearance, similar to the casparian strip of the root endodermis. The inner sheath is composed of BP, which is interrupted by the larger metaxylem vessels. The BP cells in *R. brownii* of the large bundles are in a degenerated and damaged state in the older culms. The non-damaged BP of these bundles is interrupted by the large protoxylem lacunae. The BP of the large bundles is large in size. In the intermediate bundles the BP is also large in size and interrupted by a few of the metaxylem vessels.

Phloem and xylem outline varies (Appendix 4). The area of the xylem tissues in *R. brownii* in the large bundles is large, possibly because of the extremely large metaxylem vessels and protoxylem lacunae (Plate 31.3-4). The xylem vessels of the inner large bundles of this species encircle the phloem tissue. Protoxylem lacunae in *R. barrosiana* are present in the large bundles (Plate 31.6-8). The protoxylem lacunae in *R. brownii* are present only in the inner outer ring of large bundles and form large cavities that are two to four times the size of the intact xylem tissue (Plate 31.3).
8.1 Introduction to the Schoeneae


The classification of the Schoeneae by Bruhl (1995) made a radical change from previous classifications of these genera by Goetghhebeur (1985) and Metcalfe (1971). Bruhl (1995) stated that the Schoeneae are a highly distinctive cluster that included part of the Arthostylideae and the Rhynchosporeae. It is not hard then to understand why both Metcalfe (1971) and Goetghhebeur (1985) cited the genera of the Schoeneae as part of the Rhynchosporeae. Six of Bruhl's 1995 genera of the Schoeneae were not listed as present within the Rhynchosporeae by Metcalfe in 1971, namely Baumea, Cyathocoma, Morelotia, Ptilothrix, Rhynchocladium and Schoenoides. Metcalfe (1971) did not list or describe these six genera.

Bruhl (1995) stated that all genera were C3. Metcalfe (1971) admitted that his classification of the Rhynchosporeae was heterogeneous from an anatomical point of view. That only the genera Cladium, Epischoenus, Gymnoschoenus, Mesomelaena, Oreobolus and Reedia stood out. Cladium and Mesomelaena were listed to have pseudo-dorsiventral leaves (Metcalfe 1971). Fisher (1971) also described pseudo-dorsiventral leaves in Cladium, and also described the vascular bundles as being inverted. Epischoenus was said to have distinctive rod-like silica deposits in the leaves (Metcalfe 1971). Metcalfe (1971) also stated that Oreobolus stood out on its own, with a pseudo-petiole in the leaves and with domed to conical silica deposits. The presence of the pseudo-petiole was confirmed Seberg (1988), who found the presence of the pseudo-petiole to be distinctive in Oreobolus and Schoenoides. Seberg (1988) also described the distinctiveness of the domed, conical and pyriform silica deposits present in the anticinal walls of the epidermis. Bruhl (1995) stated that a species revision of Costularia, Tetraria and Tricostularia was needed.

According to Bruhl (1993) there are 327 species present in the Schoeneae tribe. The species of the Schoeneae are present in habitats that range from hydrophytic through helophytic to mesophytic, with the exception of Caustis. Caustis is more common in dryer habitats that are mesophytic to xerophytic in condition (Bruhl 1993).

Caustis, Cyathochaeta, Evandra, Gahnia, Gymnoschoenus, Mesomelaena, Ptilothrix and Schoenoides are present in the Pacific, Australasia and New Guinea. Costularia is present in Africa and the Pacific. Capeobolus (= Costularia brevicaulis), Cyathocoma, Epischoenus, Neesenbeckia, Tetraria and Trianoptiles are endemic within Africa. Lophoschoenus and Morelotia are endemic to the Pacific. Rhynchocladium is present in the West Indies, South and Central America. Reedia is endemic to Australia and New Guinea (Bruhl 1993). Tetrariopsis is endemic to Australia. Tricostularia is in present East Asia, Australia, and Malaysia (Metcalfe 1971). Baumea, Carpha, Cladium, Lepidosperma, Machaerina, Oreobolus, Schoenus have a cosmopolitan distribution. With the exception of Carpha, Cladium, Lepidosperma, Machaerina, Oreobolus and Schoenus these species are present in habitats within
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Eastern Asia, Africa, the Pacific, Australasia and New Guinea. Carpha is present in South and Central America, Australia, New Guinea, New Zealand as well as South Africa, but not in Asia. Cladium is also present in the Mediterranean, the Americas and the West Indies. Machaerina and Oreobolus are present in the West Indies, as well as South and Central America. Schoenus is also present in Western Eurasia, Russia, the Mediterranean, South America, Central America and the West Indies.

Only eleven of the 28 genera of the Schoeneae are present within Africa (Bruhl 1993). These genera are as follows: Baumea, Capeobolus, Carpha, Cladium, Costularia, Cyathocoma, Episcoenus, Neesenbeckia, Schoenus, Tetraria and Trianoptiles (Bruhl 1993). Capeobolus (Browning and Gordon-Gray 1999B), Cyathocoma, Episcoenus, Neesenbeckia, Tetraria and Trianoptiles are listed as mostly endemic to the Cape flora. Metcalfe (1969 & 1971) only cited that he described nine species from South Africa, namely Costularia brevicaulis (Knysna, = Capeobolus brevicaulis (C.B.Clarke) J. Browning), Episcoenus quadrangularis, E. villosus (both from the Palmiet River), Neesenbeckia punctata (Palmist River and Pringle Bay), Schoenus nigricans (Pringle Bay), Tetraria flexosa, T. thermalis (both from the Hottentots Holland), T. involucrata (no area cited) and Trianoptiles capensis (Rondebosch Common). Similarly Bruhl (1993) investigated five species from the South African Schoeneae, namely Cyathocoma hexandra, Episcoenus complanatus, E. gracilis, Neesenbeckia punctata. Browning and Gordon-Gray (1999B) investigated nine specimens of Capeobolus brevicaulis (C.B.Clarke) J. Browning from the Southern Cape and one from the Eastern Cape (Humansdorp). None of the species investigated by either Metcalfe (1969 & 1971) or Bruhl (1993) had been collected from within the boundaries of the Eastern Cape Province of South Africa.

8.2 Results

8.2.1 Schoeneae species collected in the Eastern Cape

Only five of the eleven genera from the tribe Schoeneae listed to occur within Africa were collected in the Eastern Cape by the author, namely Carpha Banks and Solander ex R.Brown, Cladium P.Browne, Cyathocoma Nees, Schoenus Linnaeus and Tetraria P.Beauvois. A total of seven species from these five genera were collected, namely Carpha bracteosa C.B.Clarke (refer to Appendix 1 for specimens collected), C. glomerata (Thunb.) Nees (Appendix 1), C. schlechteri C.B.Clarke (Appendix 1), Cladium mariscus (Linnaeus) Pohl. subsp. jamaicense (Crantz) Kükenthal (Appendix 1), Cyathocoma hexandra (Nees) J.Browning (Appendix 1), Schoenus nigricans Linnaeus (Appendix 1) and Tetraria cuspidata (Rotth.) C.B.Clarke (Appendix 1).

Eleven of the Schoeneae previously collected in the Province were not re-collected by the author. The species that were not re-collected are as follows: Carpha capitellata (Nees) Boeck., as well as ten water-loving Tetraria species. However, Cyathocoma hexandra was collected for the first time in the Eastern Cape by the author.

8.2.2 Distribution and habitats of the Schoeneae

Generally the Schoeneae species of the Eastern Cape have been collected from coastal habitats (Fig. 19). Both Carpha and Tetraria species were collected mostly from inland habitats. The genera Cladium and Cyathocoma are absent inland (Fig. 19).
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Figure 19: Shows coastal and inland distribution of the habitats of the genera within the *Schoeneae* collected in the Eastern Cape. Symbols are as follows: (Ca) *Carpha*; (Cl) *Cladium*; (Cy) *Cyathocoma*; (S) *Schoenus* and (T) *Tetraria*.

Though the *Schoeneae* did not appear to be habitat specific (Fig. 20), where species were collected from a wide range of habitats within the region. Generally the *Schoeneae* species were collected from fynbos habitats. *Cladium mariscus* subsp. *jamaicense* is habitat specific and was mostly collected from fynbos, thicket and marshes. *Cyathocoma hexandra* was more frequently collected in forests and from rivers. *Schoenus nigricans* was more commonly collected from riverbanks in fynbos. *Tetraria cuspidata* is also more commonly present in fynbos and grassland habitats. Generally the substratum type within habitats is stone (Fig. 21), with the exception *Schoenus nigricans*. *Schoenus nigricans* is present equally on sand and stone substratum. Generally species were more commonly collected from habitats with wet soils (Fig. 22). The genus *Carpha*, *Cyathocoma hexandra* and *Tetraria cuspidata* were not collected from habitats with dry soils. *Cladium mariscus* subsp. *jamaicense* was more frequently collected from habitats with dry soils (Fig. 22).
Figure 20: Shows the habitats of the genera within the Schoeneae in the Eastern Cape. Symbols are as follows: (Ba) banks of rivers or streams; (Ca) Carpha; (Cl) Cladium; (Cy) Cyathocoma; (Fe) exotic forests; (Fm) forest margin; (Fn) natural or indigenous forests; (Fo) forests (not designated as natural or exotic); (Fy) fynbos; (Gr) grassland; (Ma) marshes; (O) open areas with no vegetation; (Ri) in rivers or streams; (S) Schoenus; (T) Tetraria and (Th) thicket.
Figure 21: Shows the soil types of the habitats of the genera within the Schoeneae collected in the Eastern Cape. Genus symbols are as follows: (Ca) Carpha; (Cl) Cladium; (Cy) Cyathocoma; (S) Schoenus and (T) Tetraria.

Figure 22: Shows the hydration status of the soils within the habitats that the genera of the Schoeneae were collected from in the Eastern Cape. Genus symbols are as follows: (Ca) Carpha; (Cl) Cladium; Cyathocoma; (S) Schoenus and (T) Tetraria.
8.2.3 Leaf Characteristics of the tribe Schoeneae

Generally leaves are V-shaped, with no trichomes. There are three basic leaf outlines for the Schoeneae, V-shaped (genus Carpha and Cladium mariscus subsp. jamaicense), crescentiform (Cyathocoma hexandra) and scutiform (S. nigricans and T. cuspidata). The V-shaped leaves range from thin-V (Carpha bracteosa), to flanged-V (C. glomerata and C. schlechteri) to pseudo-dorsiventral V-shaped (Cladium mariscus subsp. jamaicense). The crescentiform species range from true crescentiform (C. hexandra) to irregularly crescentiform (T. cuspidata). The scutiform species range from true scutiform (S. nigricans) to irregularly scutiform (T. cuspidata). The scutiform and crescentiform leafed species lacked midribs.

Leaf thickness is variable (Table 16, Appendix 3), ranging from 170μm (Carpha schlechteri) to 739μm (Cladium mariscus subsp. jamaicense). Generally the midribs are thicker than the lamina (Table 16, Appendix 3). The lamina in only Cladium mariscus subsp. jamaicense is thicker than the midrib.

Bulliform epidermal cells are only present in the adaxial epidermis of the midribs in Carpha schlechteri (Plate 32.1). The adaxial and abaxial epidermal shape is variable. The outer periclinal walls of the adaxial and abaxial epidermal cells are generally thick-walled and lignified (Plates 32.2-12 and 33.1-8).

The adaxial epidermal cells in Carpha bracteosa, C. glomerata, Cyathocoma hexandra and T. cuspidata are larger than the abaxial epidermal cells (Table 16, Appendix 3). Carpha schlechteri, Cladium mariscus subsp. jamaicense and S. nigricans generally have smaller adaxial epidermal cells than abaxial (Table 16, Appendix 3). The adaxial epidermal cell size is small (Table 16, Appendix 3), ranging from 7μm (Cladium mariscus subsp. jamaicense) to 42μm (Cyathocoma hexandra). The abaxial epidermal cells range from 6μm (Carpha schlechteri) to 21μm (Cyathocoma hexandra). The marginal epidermal cells in Carpha schlechteri (Plate 32.6), Cladium mariscus subsp. jamaicense and Cyathocoma hexandra are larger than the abutting adaxial and abaxial epidermal cells. These marginal epidermal cells are two to four times the size of the adaxial epidermal cells and lignified.

Cone-shaped silica deposits are present in the epidermal cells that abut the hypodermal sclerenchymatous strands (HSS) and girders in the Schoeneae leaves (Plate 33.3), with the exception of Cyathocoma hexandra (Plate 32.5). Only the genus Carpha has cones abutting the HSS/girders in both the adaxial and abaxial epidermis. Adaxial cones are present in the genera Carpha and Cladium. Abaxial cones are present in the genera Carpha, Schoenus and Tetraria. Generally the cells of the epidermis abutting the HSS/girders that lacked these cones, are mostly smaller than the epidermal cells adjacent the HSS/girders, with the exception of Carpha glomerata, C. schlechteri and Cyathocoma hexandra. The epidermal cells abutting the HSS/girders in Carpha glomerata and C. schlechteri are similar in size as the epidermal cells adjacent the HSS/girders. Epidermal cells abutting the HSS/girders in Cyathocoma hexandra are larger than the epidermal cells adjacent the HSS/girders (Plates 32.5 and 33.8).

Generally stomata are present in the abaxial epidermis (Plate 32.8-10). The stomata in Cladium mariscus subsp. jamaicense and Cyathocoma hexandra are amphistomatous (Plate 32.7). The stomata in the Schoeneae are generally flush with the epidermal surfaces (Plate 32.8). Cladium mariscus subsp. jamaicense has sunken stomata (Plate 32.9).
Plate 32. Shows structural details of the leaves of the Schoeneae in section, including adaxial, abaxial, bulliform and marginal epidermal structure; stomatal complex structure and arrangement; arrangement and structure of hypodermal sclerenchymatous strands, girders and sclerenchymatous strands; lamina cavities; hypodermis arrangement and structure; tannin idioblast arrangement; mesophyll structure; vascular bundle arrangement and spacing; and vascular tissue structure.

(32.1) Shows the midrib in *Carpha schlechteri* with bulliform cells. Adaxial hypodermal sclerenchymatous strands abut the lamina vascular bundles closest to the midrib. A thin-walled adaxial hypodermis is present in the midrib. Lamina cavities are present between the vascular bundles. The midrib arrangement and structure vascular bundle has two intermediate arrangement and structure vascular bundles present in close proximity. The lamina vascular bundles are many cells apart. (32.2) The adaxial epidermal cells in *Carpha schlechteri* are larger than the abaxial epidermal cells. The outer periclinal wall of the epidermal cells is thick-walled. Adaxial and abaxial hypodermal sclerenchymatous strands are present at random along the epidermis. Lamina cavities are present between the vascular bundles. The mesophyll is composed of thin-walled non-radiating chlorenchyma, with many chloroplasts. Tannin idioblasts are scattered throughout the mesophyll. (32.3) The adaxial epidermis of *Tetrania cuspidata* is thick-walled in the outer periclinal wall. Tannin idioblasts are thin-walled. (32.4) The abaxial epidermis in *T. cuspidata* is also thick-walled in the outer periclinal wall. The cells of the epidermis abutting the hypodermal sclerenchymatous strands are smaller than the adjacent epidermal cells. (32.5) Shows that the abaxial epidermal cells in *Cyathocoma hexandra* that abut the girders have no cone-shaped silica deposits and are larger than the adjacent epidermal cells. A few abaxial stoma are raised. All stomata are lignified. (32.6) The marginal epidermal cell in *Carpha schlechteri* is larger than the adjacent adaxial and abaxial epidermal cells. The outer periclinal wall of the marginal, adaxial and abaxial epidermal cells is thick-walled. There are many hypodermal sclerenchymatous strands present in the margins. (32.7) Shows that the stomata present in the margins of *Cyathocoma hexandra* are amphistomatous, with flush adaxial and abaxial stomata. Both the adaxial and abaxial epidermal cells are thick-walled in the outer periclinal wall. Adaxial hypodermal sclerenchymatous strands and abaxial girder abut the marginal vascular bundle. The chlorenchyma is thin-walled, non-radiating and contains many small chloroplasts. (32.8) The abaxial epidermis in *Carpha schlechteri* is thick-walled in the outer periclinal wall. The stomata are flush with the epidermal surface and have small sub-stomatal cavities. The guard cells are thick-walled in the periclinal walls. The subsidiary cells are relatively thin-walled. (32.9) Shows that the abaxial epidermis in *Cladium mariscus* subsp. jamaicense with a sunken stoma and small sub-stomatal cavity. The guard cells are thick-walled in the periclinal walls. The subsidiary cells are thick-walled in the outer periclinal wall. (32.10) An abaxial stoma in *Schoenus nigricans* with subsidiary cells and adjacent epidermal cells, that have a lignified outer periclinal wall. The guard cells have lignified periclinal walls, especially the outer periclinal wall. The sub-stomatal cavity is small. (32.11) Shows the midrib in *Carpha schlechteri* with many adjacent abaxial hypodermal sclerenchymatous strands. The adaxial epidermis is thick-walled in the outer periclinal wall. The abutting adaxial sclerenchymatous strands abuts the midrib vascular bundle and extends to the xylem pole of the opposite intermediate vascular bundles. The midrib vascular bundle also has abutting abaxial sclerenchymatous strands. There is a large protoxylem lacuna present at the xylem pole of the midrib vascular bundle. (32.12) The pseudo-dorsiventral lamina in *Cladium mariscus* subsp. jamaicense has two rows of vascular bundles, which are separated by the lamina cavity. Large trans-lamina girders and abutting parenchymatous bridges connect the adaxial and abaxial row of large vascular bundles.

Symbols are as follows: (1) row 1 of adaxial vascular bundles; (2) row 2 of abaxial vascular bundles; (Ab) abaxial epidermis; (Ad) adaxial epidermis; (Bu) bulliform epidermal cells; (Ca) lamina cavity; (G) girder; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (I) intermediate vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MEp) marginal epidermal cell; (NC) no cone-shaped silica deposit; (OT) outer periclinal wall (tangential); (Pbr) parenchymatous bridge; (Pxl) protoxylem lacuna; (S) small vascular bundle; (St) stoma; (Stc) substomatal cavity; (SS) sclerenchymatous strands; (Su) subsidiary cell and (T) tannin idioblast. Bars = 10 μm.
Plate 32. Legend on facing page.
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The guard cells of the stomata are variably thickened on the adaxial and abaxial poles of the cell (Plate 32.8-10, Appendix 4). Sub-stomatal cavity size is small in relation to leaf thickness (Table 16, Appendix 3), ranging from no cavities (T. cuspidata) to 19μm (C. hexandra).

The cells that comprise the HSS, girders, as well as sclerenchymatous strands (SS) are small and lignified (Plates 32.1-2, 32.4-7, 32.11-12, 33.1-12 and 34.1-11). The HSS are present adjacent to the adaxial and abaxial epidermal cells in all the Schoeneae species (Table 16, Appendix 3). There are seven different adaxial HSS/girder outlines and five abaxial HSS/girder outlines, whilst there are three SS outlines (Appendix 4). Large numbers of HSS and girders were present in the laminae of the genera Carpha and Cladium (Table 16, Appendix 3). There are generally more abaxial HSS than adaxial HSS, with the exception of Carpha schlechteri (Table 16, Appendix 3). Generally, most species have one abaxial HSS present adjacent to the midrib bundle. Only C. bracteosa has an adaxial HSS present adjacent to the midrib bundle. There are many abaxial HSS present within the midrib of C. schlechteri (Plate 32.11, Table 16 [Appendix 3]).

The HSS of most species are generally not present adjacent to a specific vascular bundle in the leaves of the Schoeneae. The HSS in Cladium mariscus subsp. jamaicense are present between the vascular bundles. The marginal bundles in T. cuspidata are present adjacent to adaxial HSS, whilst the abaxial HSS are present adjacent to all the vascular bundles of the leaf. Many HSS are present within margins of Carpha schlechteri (Plate 32.6), whilst only one large HSS is present in the margins of Cyathocoma hexandra (Plate 34.9).

Girders are present in Carpha glomerata, C. schlechteri, Cladium mariscus subsp. jamaicense (Plates 32.12, 33.12 and 33.4-7) and Cyathocoma hexandra (Plates 32.5, 32.7 and 33.8-10). Adaxial girders are present abutting the intermediate bundles of the margin in Carpha glomerata. The adaxial girders are also present abutting the marginal bundles in Cladium mariscus subsp. jamaicense. Adaxial girders abut the adaxial row of bundles (on the adaxial poles of the bundles) in Cladium mariscus subsp. jamaicense (Plate 33.1-2 and 33.4). Girders are present between the lamina adaxial large bundles, which extend to the abaxial row large or intermediate bundles in Cladium mariscus subsp. jamaicense (Plates 32.12 and 34.6-8). These girders extend across the lamina cavity. The inter-lamina girders in Cladium mariscus subsp. jamaicense are ensheathed in the parenchymatous bridges (Pbr, Plates 32.12 and 34.6-8). Girders also abut the abaxial row of bundles (on the abaxial poles of the bundles) in Cladium mariscus subsp. jamaicense (Plate 33.5-7). Girders are present on the abaxial poles of the large (Plate 33.8), intermediate (Plate 33.9) and a few of the small bundles in Cyathocoma hexandra. Adaxial and abaxial girders (triangular to baculiform) are mostly present on the last two large bundles in the margins of Cyathocoma hexandra.

Generally the HSS and girders are small in size (Table 16, Appendix 3). The girders in Cyathocoma hexandra are much larger than the HSS. The adaxial HSS/girders are generally smaller than the abaxial HSS/girders (Table 16, Appendix 3). Adaxial HSS in both S. nigricans and T. cuspidata are larger than the abaxial HSS. The adaxial HSS/girders range in size from 8μm (Carpha glomerata) to 102μm (Cyathocoma hexandra). The abaxial HSS/girder size ranges from 12μm (Carpha glomerata) to 97μm (Cyathocoma hexandra).
vascular bundles. Present adaxial to these complex's border parenchyma. The sheath parenchymatous bridges are the lamina cavities. The mesophyll complex join. The outer two sheaths of these vascular bundles also join. adaxial epidermis. Abaxial sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by three large metaxylem vessels. (33.2) The long axis of the adaxial intermediate vascular bundles in C. mariisus subsp. jamaicense face the abaxial epidermis. Abutting this vascular bundle is an adaxial girder and abaxial sclerenchymatous strands. Present abutting the sclerenchymatous strands are a few cells of translucent parenchyma. The chlorenchyma adjacent to and abutting the intermediate vascular bundles, is composed of thin-walled, non-radiating cells with many chloroplasts. Thin-walled tannin idioblasts are scattered within the chlorenchyma. The intermediate vascular bundle has three recognisable sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by large metaxylem vessels. (33.3) The cells of the adaxial epidermis in C. mariisus subsp. jamaicense that abuts the girders and hypodermal sclerenchymatous strands has cone-shaped silica deposits. These adaxial epidermal cells are thick-walled in the outer periclinal wall. Some of the adaxial intermediate vascular bundles lie with the xylem long axis parallel to the epidermal surfaces. On the adaxial side of the vascular bundle, are hypodermal sclerenchymatous strands and on the abaxial side of the vascular bundle are sclerenchymatous strands. There are two recognisable sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. (33.4) Shows the adaxial small vascular bundles in C. mariisus subsp. jamaicense have abutting adaxial girders and abaxial sclerenchymatous strand. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (33.5) The abaxial large vascular bundles in C. mariisus subsp. jamaicense face the adaxial epidermis. These large vascular bundles have an abutting abaxial girder. The chlorenchyma present abutting this vascular bundle is composed of thin-walled, non-radiating cells, with small chloroplasts. These large vascular bundles have three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by two large metaxylem vessels. (33.6) The cells of the abaxial epidermis in C. mariisus subsp. jamaicense abutting the girders are larger than those that are present adjacent the girders. The abaxial intermediate vascular bundles face the adaxial epidermis. Abaxial intermediate vascular bundles have an abutting abaxial girder and an abutting adaxial sclerenchymatous strand. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (33.7) The abaxial small vascular bundles in C. mariisus subsp. jamaicense face the adaxial epidermis. Abaxial small vascular bundles have an abutting abaxial girder. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is only present on the phloem side of the vascular bundle. (33.8) The abaxial epidermal cells of Cyathocoma hexandra are thick-walled in the outer periclinal wall. The cells of the abaxial epidermis that abut the girder are larger than the epidermal cells adjacent to the girder. The large vascular bundles have an abutting abaxial girder and abutting adaxial sclerenchymatous strand. Abutting the adaxial sclerenchymatous strand is an adaxial bridge of translucent parenchyma, which extends to the adaxial hypodermis. Present above the intermediate and small vascular bundles, beneath the hypodermis, as well as in between the parenchymatous bridges are the lamina cavities. The mesophyll cells are composed of thin-walled, chlorenchyma that are mostly non-radiating. The vascular bundles have three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by two large metaxylem vessels. Present at the xylem pole of the large vascular bundle, interrupting the sheath of border parenchyma is a protoxylem lacuna. (33.9) The tannin idioblasts in Cyathocoma hexandra are mostly present near the vascular bundles and are thin-walled. The intermediate vascular bundles have an abutting abaxial girder. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by two metaxylem vessels. (33.10) One of the marginal vascular bundles in Cyathocoma hexandra has an adjacent adaxial hypodermal sclerenchymatous strands and an abutting abaxial girder. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by three metaxylem vessels and is composed of large cells. (33.11) The large lamina vascular bundles in Carpha bracteosa have two abutting intermediate vascular bundles. Present adaxial to these complex's of vascular bundles are the lamina cavities. The chlorenchyma surrounding the vascular bundles is thin-walled. The sclerenchymatous strands of the three vascular bundles in the complex join. The outer two sheaths of these vascular bundles also join.

(legend continues on the next facing page)
Plate 33. Legend on facing page.
There are three vascular sheaths in these vascular bundles, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner partial sheath of non-lignified border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The cells of the mestome sheath are almost filled with lignin. The sheath of border parenchyma is limited to the phloem side of the large vascular bundle. The large vascular bundle has a protoxylem lacuna present at the xylem pole abutting the sclerenchymatous strand. (33.12) The large vascular bundles in _C. schlechteri_ each have an abutting intermediate vascular bundle. The adaxial sclerenchymatous strands and outer sheaths of these vascular bundles join. The large vascular bundles also have abutting abaxial sclerenchymatous strands. There are three sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The cells of the mestome sheath are lignified in the inner tangential and radial walls, especially on the phloem sides of the vascular bundle. The sheath of border parenchyma in the large vascular bundle is interrupted by two large metaxylem vessels. In the intermediate vascular bundle, the sheath of border parenchyma is limited to the phloem side of the vascular bundle. There is a large protoxylem lacuna present on the xylem pole of the large vascular bundle, inside the sheath of border parenchyma.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Ca) lamina cavity; (G) girder; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (PS) parenchymatous sheath; (Pbr) parenchymatous bridge; (PxL) protoxylem lacuna; (SS) sclerenchymatous strands; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10 μm.
SS are present in all the leaves of the Schoeneae (Plates. 32.11, 33.1-4, 33.6, 33.8, 33.11-12, 34.1-5 and 34.10), where the SS are present abutting the vascular bundles. The distribution of the SS is complex. SS are present at the xylem pole of the midrib bundle and or large bundles with lateral vascular bundles in Carpha bracteosa (Plate 33.11) and C. schlechteri (Plate 33.12), where these SS join. The SS of some of the vascular bundles in S. nigricans may also join (Plate 34.1). SS are present at the xylem side of the midrib bundle in Carpha glomerata, C. schlechteri, S. nigricans and T. cuspidata (Plate 34.2). SS are present abutting the xylem pole of the large bundles of all species (Plates 33.1, 33.8, 33.11-12, 34.1, 34.3 and 34.5). Xylem pole, SS are also present abutting the intermediate (Plates 33.2-3, 33.8, 33.11-12, 34.4 and 34.10) and small bundles (Plate 33.4) in the genera Carpha, S. nigricans and T. cuspidata. In addition adaxial SS are present at the xylem pole of a few the intermediate bundles in Cyathocoma hexandra. Abaxial SS are present abutting the phloem pole of the large bundles in Carpha glomerata (Plate 34.3), C. schlechteri (Plates 33.12 and 34.5) and T. cuspidata. SS are also noted in the mesophyll, but are not present abutting the vascular bundles. These SS are present within the Pbr of Carpha bracteosa and C. glomerata. SS are also present abutting the hypodermis in Cyathocoma hexandra and appear to be randomly scattered along this surface. SS are also present in the margins of Cyathocoma hexandra and T. cuspidata.

Lignified cells resembling MS/SS cells are present abutting a few of the bundles in Carpha bracteosa, C. schlechteri and Cladium mariscus subsp. jamaicense. These lignified cells (one to five cells) are present outside the outer sheath on the phloem pole of the midrib bundle in Carpha bracteosa (Plate 34.10). Lignified cells (one to four cells) are present abutting the phloem pole of the large and intermediate bundles in Carpha bracteosa. These additional MS cells are also present abutting the phloem pole of the intermediate bundles in C. schlechteri. The marginal bundles of this species have the additional MS cells present at the both the xylem and phloem poles of the bundle (Plate 34.11). These MS cells are present outside the inner sheath in both C. bracteosa and C. schlechteri. Similar lignified cells (three cells) are present inside the second sheath on the phloem side of the large bundles in Cladium mariscus subsp. jamaicense.

Lamina cavities are present in all of the Schoeneae (Plates 32.1, 32.12, 34.6, 34.12 and 35.1-4), with the exception of T. cuspidata. The lamina cavities in Cladium mariscus subsp. jamaicense are present between the vascular bundles and the Pbr (Plates 32.12 and 34.6). Similarly, the cavities in C. bracteosa (Plate 35.2-3), C. schlechteri and Cyathocoma hexandra (Plate 35.1) are present between the Pbr and the lamina bundles but, not between the last two bundles of the margin. The cavities in C. glomerata are not present between the last four bundles of the margin. A large lamina cavity of is present in the centre of the leaf in S. nigricans (Plate 35.4). Present within the lamina cavities is thin-walled, stellate and translucent "blue" parenchyma. The stellate parenchyma is only present within the lamina cavities of Cladium mariscus subsp. jamaicense (Plate 34.7). The size of the lamina cavities is large in relation to the leaf thickness (Table 16, Appendix 3), ranging from 27μm (S. nigricans) to 551μm (Carpha bracteosa). The shape of the lamina cavities vary (Appendix 4).

An adaxial hypodermis is present in Carpha glomerata (plate 34.12), C. schlechteri (Plate 32.1), Cyathocoma hexandra (Plate 35.1) and T. cuspidata (Table 16, Appendix 3). The adaxial hypodermis in Carpha glomerata, Cyathocoma hexandra and T. cuspidata is present in the lamina, whilst the adaxial hypodermis in Carpha schlechteri is present only in the midrib (Plate 32.1). The hypodermis in C. glomerata and T. cuspidata is un lignified, whilst that of Carpha schlechteri and Cyathocoma hexandra is lignified.
Plate 34. Shows structural details of the leaves adaxial and abaxial epidermis, hypodermal sclerenchymatous strands, girders, sclerenchymatous strands, trans-lamina girders, lamina cavity, mesophyll structure, vascular bundle arrangement, vascular bundle spacing, and vascular sheath, as well as vascular tissue structure of the Schoeneae.

(34.1) Shows a large vascular bundle in Schoenus nigricans, which abut an intermediate vascular bundle, where the sclerenchymatous strands and outer vascular sheaths of these vascular bundles join. Abutting these vascular bundles, the chlorenchyma is thin-walled, rectangular and non-radiating. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath is lignified in the inner tangential and radial walls, especially on the phloem poles of the vascular bundle. The sheath of border parenchyma in both vascular bundles is interrupted by two large metaxylem vessels. Also interrupting the sheath of border parenchyma in the large vascular bundles is a protoxylem lacuna, which is present at the xylem pole of the vascular bundle. (34.2) The midrib vascular bundle in Tetraria capensis has abutting adaxial sclerenchymatous strands. There are two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. (34.3) The large vascular bundles in Carpha glomerata have intermediate vascular bundles that are present in close proximity (one to three cells). These large vascular bundles have both abutting adaxial and abaxial sclerenchymatous strands. The intermediate vascular bundles have abutting abaxial sclerenchymatous strands. Present between and around this complex of vascular bundles is translucent parenchyma. The large vascular bundle has a large protoxylem lacuna present at the xylem pole of the vascular bundle. (34.4) An intermediate vascular bundle in C. schlechteri that does not abut the large vascular bundles has adaxial sclerenchymatous strands and a single lignified cell present at the phloem pole of the vascular bundle that interrupts the outer vascular sheath. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner partial non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (34.5) Shows one of the large vascular bundles in C. schlechteri that does not abut other vascular bundles. These large vascular bundles have both abutting adaxial and abaxial sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner partial non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle, as well as abutting the metaxylem vessels. The sheath of border parenchyma is interrupted by the large metaxylem vessels and the protoxylem lacuna. (34.6) The laminae in Cladium mariscus subsp. jamaicense are pseudo-dorsiventral and are characterised by large trans-lamina girders. Abutting these girders are cells of translucent parenchyma that ensheath the girders and form bridges that interrupt the central cavities. In a few instances the girders of the adaxial intermediate vascular bundles extend to large adaxial vascular bundles, where the girders of these large vascular bundles extend to the abaxial large vascular bundles. (34.7) Shows a trans-lamina gird in Cladium mariscus subsp. jamaicense with abutting parenchymatous bridge. In a few instances, cells of stellate parenchyma are present abutting the trans-lamina parenchymatous bridge. (34.8) Illustrates an instance in Cladium mariscus subsp. jamaicense where there are two girders on the adaxial large vascular bundle. The trans-lamina girders extend from the xylem poles of the large vascular bundles. (34.9) Shows the margin in Cyathocoma hexandra where the marginal epidermal cell is larger than the adaxial and abaxial epidermal cells. These cells are lignified and are thick-walled in the outer periclinal wall. Present in the margin are hypodermal sclerenchymatous strands. (34.10) The midrib vascular bundle in Carpha bracteosa has two abutting intermediate vascular bundles, where the sclerenchymatous strands and outer vascular sheaths of these vascular bundles join. There are two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is present only on the phloem side of the vascular bundle and abutting the metaxylem vessels in these vascular bundles. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. On the xylem pole of the midrib vascular bundle is a large protoxylem lacuna. (34.11) Shows the marginal vascular bundle in C. schlechteri, which has lignified cells present on the xylem and phloem poles of the vascular bundle. There are two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is chlorenchymatous, where the chloroplasts are mostly centrifugal in position. The cells of the mestome sheath are thick-walled in the inner tangential and radial walls. (34.12) The adaxial and abaxial epidermal cells in C. golmerata are thick-walled in the outer periclinal wall. Hypodermal sclerenchymatous strands are present at random along the adaxial and abaxial epidermis. The mesophyll is composed of chlorenchyma and translucent parenchyma. Chlorenchyma extends from the abaxial epidermis to the lamina cavities and phloem pole of the vascular bundles with parenchymatous bridges. Translucent parenchyma surrounds the vascular bundles of the lamina and extends from the xylem poles of the vascular bundles to the adaxial hypodermis. Present between the chlorenchyma, the complexes of vascular bundles, hypodermis and parenchymatous bridges are the lamina cavities. In the lamina there are complexes of large vascular bundles with two abutting or close proximity vascular bundles.

(legend continues on the next facing page)
Plate 34. Legend on facing page.
Symbols are as follows: (1) row 1 of adaxial vascular bundles; (2) row 2 of abaxial vascular bundles; (Ab) abaxial epidermis; (AbL) abaxial large vascular bundle; (Ad) adaxial epidermis; (AdL) adaxial large vascular bundle; (BP) border parenchyma; (Ca) lamina cavity; (HSS) hypodermal chlorenchymatous strands; (Hy) hypodermis; (I) intermediate vascular bundle; (L) large vascular bundle; (Li) lignified cell; (MEp) marginal epidermal cell; (MS) mestome sheath; (MX) metaxylem vessel; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (S) small vascular bundle; (SS) chlorenchymatous strands; (SPI) stellate parenchyma and (T) tannin idioblast. Bars = 10 μm.

Plate 35. Shows structural details of the leaves sclerenchymatous strands, lamina cavity, hypodermis, mesophyll structure including parenchymatous bridges, lignified parenchyma, vascular bundle arrangement, vascular bundle spacing, and vascular sheaths, as well as vascular tissues of the Schoeneae.

(35.1) Shows that the adaxial epidermis in Cyathocoma hexandra is thick-walled in the outer periclinal wall. The mesophyll consists of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the abaxial epidermis to the xylem pole of the large vascular bundles and the lamina cavity. Parenchymatous bridges, composed of thin-walled translucent parenchyma extend from the xylem poles of the large vascular bundles to the adaxial hypodermis. The lamina cavities are present between the adaxial hypodermis, the parenchymatous bridges and the chlorenchyma. (35.2) The mesophyll in Carpha bracteosa is also composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the abaxial epidermis to the phloem side of the lamina vascular bundles and vascular bundle groupings. Bridges of translucent parenchyma extend from the xylem pole of the lamina vascular bundles and vascular bundle groupings to the adaxial hypodermis or the other parenchymatous bridges of vascular bundles present near the median of the leaf. The parenchymatous bridges of the median of the leaf join and extend to the adaxial hypodermis. Present between the chlorenchyma, the vascular bundles, the vascular bundle groupings, the parenchymatous bridges and the adaxial hypodermis are the lamina cavities. (35.3) Is the same leaf as in 35.2 of Carpha bracteosa, except from the adaxial epidermis to the parenchymatous bridge of the midrib vascular bundle. It shows the parenchymatous bridges of the lamina vascular bundles and the lamina vascular bundle groupings extending to the adaxial hypodermis and epidermis. Note that the marginal vascular bundle and adjacent vascular bundle do not have an abutting parenchymatous bridge. (35.4) The abaxial epidermis in Schoenus nigricans is thick-walled in the outer periclinal wall. Note that the epidermal cells abutting the hypodermal sclerenchymatous strands are similar in size to those adjacent to the strands. Chlorenchyma extends from the abaxial epidermis to the phloem side of the vascular bundles. A large lamina cavity extends from the xylem side of the vascular bundles and extends to the adaxial epidermis (not in picture). Present within the cavity are cells of translucent "blue" parenchyma. Note also that the sclerenchymatous strands abutting the vascular bundles are present inside the outer sheath, abutting the inner sheath on the xylem sides of the vascular bundle. There are two vascular sheaths present, an outer parenchymatous sheath and an inner lignified mestome sheath. (35.5) The margin in Cladium mariscus subsp. jamaicense, where both the adaxial and the abaxial epidermis are extremely lignified. Lignified translucent parenchyma is present in the margin and extends to the marginal vascular bundle. (35.6) Shows the midrib in C. mariscus subsp. jamaicense where the outer periclinal wall of the epidermal cells is thick-walled. The midrib vascular bundle has an abaxial girder. Present within the midrib abutting the girder are a number of lignified translucent parenchymatous cells. The midrib has three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls. The sheath of border parenchyma is interrupted by two large metaxylem vessels. (35.7) A large vascular bundle in Carpha bracteosa with two abutting intermediate vascular bundles, where the sclerenchymatous strands and outer sheaths join. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem sides of the vascular bundles. The sheath of border parenchyma is interrupted by two large metaxylem vessels in the intermediate vascular bundles and also by the protoxylem lacuna in the large vascular bundle. (35.8) Shows a small vascular bundle in C. schlechteri that does not abut a large vascular bundle. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath is thick-walled not only in the inner tangential and radial walls, but more so at the phloem and xylem poles. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (35.9) A small vascular bundle in Cyathocoma hexandra with two distinct and one indistinct vascular sheaths. The outer sheath is a chlorenchymatous sheath of parenchyma, where the chloroplasts are small and centrifugal in position. The inner distinct sheath is a lignified mestome sheath. An indistinct sheath of border parenchyma is present on the phloem side of the vascular bundle.

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Plate 35. Legend on facing page.

The tannin idioblasts in the Schoeneae appear to scattered randomly throughout the chlorenchymatous tissues of the mesophyll (Plates 32.1-2 and 33.9). Generally there are few tannin idioblasts present within the mesophyll tissues of the Schoeneae. Most of the cells of the mesophyll in T. cuspidata are composed of tannin idioblasts.

The cells of the chlorenchymatous parenchyma of the mesophyll within the Schoeneae are composed thin-walled non-radiate cells. The chlorenchyma cells in both Carpha bracteosa (Plate 35.2-3) and C. glomerata (Plate 34.12), extend from the abaxial epidermis to the xylem side of the vascular bundles. In the leaves of C. schlechteri the chlorenchyma extends from the abaxial epidermis to the phloem and xylem side of the vascular bundles. The
Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (B) translucent "blue" parenchyma; (BP) border parenchyma; (Ca) lamina cavity; (Ch) chlorenchyma; (Gr) vascular bundle groupings; (HSS) hypodermal sclerenchymatous strand; (Hy) hypodermis; (I) intermediate vascular bundle; (L) large vascular bundle; (Ma) marginal vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (Pa) parenchymatous cells; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (S) small vascular bundle and (SS) sclerenchymatous strands. Bars = 10 μm.
Chlorenchyma is interrupted by the cavities of this species. Chlorenchyma in *S. nigricans* extends from the abaxial epidermis to the phloem side of the bundles, where the cavity extends from the xylem side of the vascular bundles to the centre of the leaf (Plate 35.4). The chlorenchyma in *T. cuspidata* extends from the abaxial epidermis to the adaxial epidermis and surrounds the vascular bundles.

The mesophyll composition and distribution of chlorenchyma within the leaves of *Cladium mariscus* subsp. *jamaicense* and *Cyathocoma hexandra* is complex. In *Cladium mariscus* subsp. *jamaicense* the chlorenchyma of is present from the adaxial and abaxial epidermis to the phloem side of the midrib bundle and large bundles (adaxial and abaxial row, Plates 32.12 and 34.6). Chlorenchyma also surrounds the intermediate and small bundles, and extends to the xylem pole of the bundle (adaxial and abaxial row). In the margins the chlorenchyma surrounds the marginal bundle and the adjacent large bundle. The cavities and parenchymatous bridges separate the regions of chlorenchyma. TP (one to three cells) extends from chlorenchyma to the central cavity (Plate 34.6). In *Cyathocoma hexandra* chlorenchyma is present extending from the abaxial epidermis to the xylem poles of the lamina large bundles (Plates 33.8 and 35.1). Most of the intermediate and small bundles are surrounded by chlorenchyma (only one cell on the xylem pole of these bundles, Plate 35.1). A few intermediate and small bundles have chlorenchyma, which extends to the xylem pole of the bundles. Cavities are present above the small and intermediate bundles. These cavities are present between the large bundles of the lamina and the parenchymatous bridges (Plate 35.1). The marginal bundle and adjacent large bundle of the leaf margins are surrounded by chlorenchyma, as was the case in *Cladium mariscus* subsp. *jamaicense*.

Parenchymatous bridges (Pbr) occur in four species, *Carpha bracteosa*, *C. glomerata*, *Cladium mariscus* subsp. *jamaicense* and *Cyathocoma hexandra*. The cells of the Pbr are thin-walled and translucent. In the genus *Carpha* there are many similarities between the Pbr. The Pbr in the genera *Carpha* and *Cyathocoma* are similar. Pbr in the genera *Carpha* and *Cyathocoma* bear little resemblance to the Pbr in the genus *Cladium*. The structure of the Pbr in these species will be discussed separately.

In *Carpha bracteosa* the Pbr extend from the xylem side of the vascular bundles with lateral vascular bundles, with the exception of the margins. These Pbr extend from the midrib and lateral grouping, as well as from the adjacent bundle, where these Pbr meet above the bundles and coalesce (further up towards the adaxial epidermis, Plate 35.2). This coalesced Pbr extends and meets the Pbr from the adjacent vascular bundle groupings extending to the adaxial epidermis (Plate 35.2). In the laminae the Pbr extend from the xylem sides of the bundle to the adaxial mesophyll layer (Plate 35.3). The Pbr in *C. glomerata* are similar in structure to *C. bracteosa*, in that the Pbr are present on the xylem side of vascular bundles with lateral vascular bundles and extend to the adaxial hypodermis (Plate 34.12). Similarly, the Pbr in *Cyathocoma hexandra* abuts the xylem side of the large bundles and extends to the adaxial hypodermis (Plate 35.1).

The Pbr in *Cladium mariscus* subsp. *jamaicense* are present abutting the xylem side of the adaxial row large and intermediate bundles and extend to the large bundles of the abaxial row (Plates 32.12 and 34.6-8). The Pbr ensheath the trans-lamina girder that is present between the two bundles (Plates 32.12 and 34.6-8). These Pbr are present only in the laminae of the leaf and not in the margins or the midrib.
Lignified parenchyma is present in the margins and midrib of *Cladium mariscus* subsp. *jamaicense* (Plate 35.5-6). This lignified TP is present from the margin to the marginal bundle (Plate 35.5). Lignified TP is also present in the midrib on the edge of the girder and extends for three to six cells towards the midrib bundle.

Generally the vascular bundles in the *Schoeneae* are present in one row within the lamina (Plates 33.8, 34.12, 35.1-2 and 35.4). The vascular bundles in *Cladium mariscus* subsp. *jamaicense* occur in two rows, one adaxial and one abaxial (Plates 32.12 and 34.6). Large, intermediate and small bundles are present in the adaxial row (Plate 33.1-4). In addition to the large, intermediate and small bundles, the abaxial row also contained the midrib bundle and marginal bundles ( Plates 33.5-7 and 35.5-6).

Other than in *S. nigricans* and *T. cuspidata*, the minimal cell lateral count, between vascular bundles is larger than four cells (Table 16, Appendix 3), with the exception of the lateral bundles. No midrib bundle occurs in *Cyathocoma hexandra*, *S. nigricans* and *T. cuspidata*. *T. cuspidata* has no intermediate and small bundles. Large and intermediate bundles in *Carpha schlechteri* and *Cladium mariscus* subsp. *jamaicense* are separated by one small bundle. In *Carpha glomerata* two small bundles are present between the large and intermediate bundles of the lamina (Table 16, Appendix 3). There are mostly no recognisable patterns with respect to the numbers of bundles in the laminae of the *Schoeneae* (Table 16, Appendix 3). There are more small bundles than intermediate and large bundles in the laminae of *Carpha schlechteri*.

Vascular bundles are mostly solitary in the *Schoeneae* leaves. The vascular bundles in the genus *Carpha* are present in groupings of vascular bundles, where the midrib bundle and large bundles have one to two lateral vascular bundles (Plates 32.1, 32.11, 33.11-12, 34.3, 34.10, 34.12, 35.2-3 and 35.7). These groupings of vascular bundles are present in the midrib and in the laminae of these species. No groupings of vascular bundles are present in the margins of the leaves.

The midrib bundle and large bundles in *C. bracteosa* have lateral vascular bundles that are present next to the larger bundles (Plates 33.11, 34.10 and 35.7). These lateral vascular bundles are composed of one to two small bundles or intermediate bundles, which abut the larger bundle (Plates 33.11, 34.10 and 35.7). Most of the lateral vascular bundles lacked vascular bundle sheaths on the xylem side of the bundle abutting the large bundle, where these sheaths are also absent, on that side of the large bundle. The xylem tissue of the large bundle and lateral vascular bundle coalesce (Plate 33.11). The outer and inner sheaths are present only on the phloem side of the bundle and the side of the bundle where the vascular tissues do not coalesce.

In *C. glomerata* the vascular bundle groupings have a similar structure as that of *C. bracteosa*, in that the midrib is solitary and that the lateral vascular bundles are mostly composed of small bundles (Plate 34.3 and 34.12). The vascular tissue of the lateral vascular bundles and the large bundle may coalesce, when there is only one lateral vascular bundle. Generally lateral vascular bundles are separated from the larger bundle by one to two cells of translucent parenchyma (TP). The SS of the lateral vascular bundles and larger bundles do not join (Plate 34.3).

Most of the vascular bundles in *C. schlechteri* are solitary. The midrib bundle and a few of the large bundles have one to two lateral vascular bundles (mostly small bundles, Plates 32.1, 32.11 and 33.12). The vascular tissue of the
midrib bundle and large bundles does not coalesce with the lateral vascular bundles. The SS of the lateral vascular bundles and the midrib bundle, as well as large bundles may coalesce (Plates 32.1, 32.11 and 33.12).

The xylem of many intermediate and small bundles faces up towards the adaxial epidermis (Plate 33.4), within the adaxial row of bundles in *Cladium mariscus* subsp. *jamaicense*. However, in many of these bundles the xylem faces up towards the cavity or the abaxial epidermis. A few of the intermediate and small bundles of the adaxial row lie with their long axis parallel to the adaxial epidermis (Plate 33.3). The girder is present on the one side of the long axis and the SS on the other side (Plate 33.3). All the large and intermediate bundles of the adaxial row face the abaxial epidermis (Plate 33.1). Many of the large or intermediate bundles with Pbr have an additional intermediate or small bundle present between the adaxial epidermis and the Pbr. The SS abutting the phloem side of the Pbr bundle abuts the SS of the intermediate or small bundle (Plate 34.6). These intermediate and small bundles also face the cavity or the abaxial epidermis. The xylem of the abaxial row of bundles faces the adaxial epidermis (Plates 32.12 and 33.5-7).

Generally vascular bundles have three vascular sheaths (Plates 33.4-12, 34.1-2, 34.4-5, 34.11 and 35.6-9), an outer parenchymatous sheath (PS), internal to this is a lignified mestome sheath (MS), and an inner sheath of non-lignified border parenchyma (BP). The cells of the PS are translucent and mostly large. The PS cells are mostly two to three times larger than the abutting mestome sheath cells (Plates 33.2-7, 33.9-12, 34.1, 34.4-5, 34.10-11 and 35.6-9). PS cells in *Carpha schlechteri*, *Cladium mariscus* subsp. *jamaicense* and *Cyathocoma hexandra* are chlorenchymatous (Plates 34.11 and 35.9). MS cells are generally small and thick-walled (Plates 33.1-12, 34.1-2, 34.4-5, 34.10-11 and 35.6-9). Lignification is present within the radial walls and inner tangential walls, especially on the phloem side of the vascular bundles (Plates 33.1-2, 33.4-7, 33.9-12, 34.4-5, 34.11, 35.6 and 35.8, Appendix 4). The thickening on the phloem side of the bundles in *Carpha bracteosa*, *C. glomerata* and *C. schlechteri* almost fills the MS cell with lignin (Plates 33.5-6, 33.9-10, 34.4-5, 34.11 and 35.8). The BP of the midrib bundle in *Carpha glomerata* is lignified. The BP of most of the bundles in the *Schoeneae* leaves is interrupted by the metaxylem vessels and the protoxylem lacunae (PxL), where present (Plates 33.8, 33.11-12, 34.1, 34.5 and 35.7). The BP of most of the intermediate, as well as the small bundles in *Carpha glomerata*, *C. schlechteri*, *Cladium mariscus* subsp. *jamaicense* and *Cyathocoma hexandra* is limited to the phloem side of the bundle (Plates 34.4 and 35.8-9). In a few of the small bundles of *Cladium mariscus* subsp. *jamaicense* the BP is absent. The marginal bundles in *Carpha bracteosa*, *C. schlechteri*, *Cladium mariscus* subsp. *jamaicense* and *T. cuspidata* have a BP only on the phloem side of the bundle (Plate 34.11). Generally, the BP cells are thin-walled and small to large (NK-S to NK-L) in size.

Phloem and xylem outlines are variable (Appendix 4). PxL are common in the *Schoeneae* leaves. All species with midrib bundles have a PxL present in the bundle (Plates 32.11 and 34.10). Generally the large bundles of the leaves in the *Schoeneae* have PxL (Plates 33.8, 33.11-12, 34.1, 34.3 and 34.10).

### 8.2.4 Bract Characteristics of the tribe *Schoeneae*

The bracts in the *Schoeneae* are V-shaped (genus *Carpha*, *Cladium mariscus* subsp. *jamaicense* and *T. cuspidata*) and crescentiform (*Cyathocoma hexandra* and *S. nigricans*). V-shaped bracts are either thickly V-shaped (*T. cuspidata*), flanged V-shaped (the genus *Carpha*) or flattened pseudo-dorsiventral V-shaped (*Cladium mariscus*...
subsp. jamaicense). The crescentiform bracts are true crescentiform (Cyathocoma hexandra) to thickly crescentiform (S. nigricans). The crescentiform species lacked a midrib. Trichomes are absent in the Schoeneae bracts. Bracts are both thin and thick in the Schoeneae (Table 17, Appendix 3), ranging from 145µm (T. cuspidata) to 737µm (S. nigricans). All the bract midribs in the Schoeneae are thicker than the laminae, with the exception of Cladium mariscus subsp. jamaicense.

Bulliform cells are present only in the adaxial epidermal cells of the midrib in Carpha bracteosa. The marginal epidermal cells in Carpha schlechteri, Cladium mariscus subsp. jamaicense, Cyathocoma hexandra and T. cuspidata are larger than the adaxial or abaxial epidermal cells (Plate 36.1). Adaxial and abaxial epidermal cell shape is variable. The outer periclinal walls of the adaxial and abaxial epidermal cells are generally thick-walled (Plate 36.1-9, Appendix 4). Adaxial epidermal cells are smaller than the abaxial epidermal cells (Table 17, Appendix 3), with the exception of Cladium mariscus subsp. jamaicense and S. nigricans. The adaxial and abaxial cell size is small (Table 17, Appendix 3), where the adaxial epidermal cell size ranges from 7µm (Cladium mariscus subsp. jamaicense) to 20µm (Cyathocoma hexandra), whilst the abaxial epidermal cell size ranges from 5µm (Carpha schlechteri) to 18µm (Cyathocoma hexandra).

Cone-shaped silica deposits are present in both the adaxial and abaxial epidermal cells of most Schoeneae. Notable exceptions are Carpha bracteosa, Cyathocoma hexandra, S. nigricans and T. cuspidata. As with the leaves, the cells of the epidermis abutting the HSS are smaller than the epidermal cells that are adjacent to the HSS and contained cone-shaped silica deposits. The epidermal cells abutting the HSS in Cyathocoma hexandra lacked these cones and are larger than the epidermal cells adjacent the HSS (Plate 36.4).

Generally, the bract stomata are present in the abaxial epidermis (Plate 36.6-9). In Carpha glomerata, Cladium mariscus subsp. jamaicense and Cyathocoma hexandra (Plate 36.5) stomata are amphistomatous. Generally stomata are flush with the epidermal surfaces (Plate 36.6 and 36.9). Carpha schlechteri (Plate 36.7), Cyathocoma hexandra (Plate 36.5) and S. nigricans have raised stomata, whilst Cladium mariscus subsp. jamaicense has sunken stomata (Plate 36.8). The lignification within the guard cells is present at the adaxial and abaxial poles of the cells, and is variable on either end of the cell (Plate 36.6-9, Appendix 4). The sub-stomatal cavities are small in size relative to the leaf thickness (Table 17, Appendix 3), ranging from 0µm (Carpha bracteosa and Cladium mariscus subsp. jamaicense) to 17µm (Carpha glomerata and C. schlechteri).

HSS, girders and SS are present in most species, where the cells are small and lignified (Plates 36.2-5, 36.10-12, 37.1-12 and 38.1). There are six adaxial HSS outlines and five abaxial HSS outlines, whilst there are three different SS outlines (Appendix 4). Generally there are more adaxial than abaxial HSS/girders. In Carpha glomerata and Cladium mariscus subsp. jamaicense there appears to be more abaxial than adaxial HSS/girders (Table 17, Appendix 3). The HSS are present in larger numbers in the bracts of Cladium mariscus subsp. jamaicense and in small numbers in T. cuspidata (Plate 36.3). The numbers of abaxial HSS/girders in the midrib ranges from one girder in Cladium mariscus subsp. jamaicense and T. cuspidata (one HSS) to nine HSS in Carpha schlechteri.
Plate 36. Shows structural details of the bracts of the Schoeneae in section, including adaxial, abaxial and marginal epidermal cells; stomatal complex arrangement and structure; arrangement and structure of hypodermal sclerenchymatous strands, girders, sclerenchymatous strands, lamina cavities; mesophyll structure; vascular bundle arrangement, and vascular bundle spacing, as well as vascular sheaths.

(36.1) Shows the margin in Cladium mariscus subsp. jamaicense with thick-walled marginal, adaxial and abaxial epidermal cells. The marginal epidermal cell is larger than the adjacent adaxial and abaxial epidermal cells. Lignified translucent parenchymatous cells are present in the margin. (36.2) The adaxial epidermal cells in Carpha schlechteri are larger than the abaxial epidermal cells. The epidermal cells are thick-walled in the outer periclinal wall. The adaxial and abaxial hypodermal sclerenchymatous strands are present at random along the epidermis. The mesophyll is composed of chlorenchyma that is thin-walled, non-radiating, with scattered tannin idioblasts. Lamina cavities are present between the vascular bundles. (36.3) The adaxial epidermal cells in Tetraria cuspidata are also larger than the abaxial epidermal cells, where the outer periclinal wall is thick-walled. Abaxial hypodermal sclerenchymatous strands are present adjacent to the vascular bundles. The mesophyll is composed of non-radiating chlorenchyma. (36.4) The cells of the epidermis abutting the girders in Cyathocoma hexandra are larger than the epidermal cells that are adjacent to the girders. The cells of the epidermis are thick-walled in the outer periclinal wall. There are no cone-shaped silica deposits in the epidermal cells abutting the girders. The large vascular bundles have an abutting abaxial girder and adaxial sclerenchymatous strands. The chlorenchyma present abutting the vascular bundles is non-radiating and has many scattered tannin idioblasts. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The sheath of border parenchyma is interrupted by two large metaxylem vessels and a protoxylem lacuna. (36.5) Shows that the adaxial epidermis in Cyathocoma hexandra has adaxial stomata. The adaxial epidermal cells are thick-walled in the outer periclinal wall. The marginal large vascular bundles have both adaxial and abaxial girders. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The sheath of border parenchyma is interrupted by three large metaxylem vessels. (36.6) The abaxial epidermis in T. cuspidata has a lignified outer periclinal wall. The abaxial stomata are flush with the epidermal surface. Note the thick-walled outer periclinal wall of the subsidiary cells. The guard cells are also thick-walled in both the periclinal walls. (36.7) Shows an abaxial stoma in Carpha schlechteri, which is slightly raised and has a small sub-stomatal cavity. Note the thick-walled outer periclinal wall of the abaxial epidermis and the subsidiary cells. The guard cells are especially thick-walled in both the periclinal walls. (36.8) The abaxial epidermis in Cladium mariscus subsp. jamaicense with lignified sunken stoma and tiny sub-stomatal cavity. The outer periclinal wall of both the epidermal and subsidiary cell are thick-walled, the guard cells are thick-walled in both the periclinal walls. (36.9) Shows that the abaxial epidermis in Cyathocoma hexandra has a lignified outer periclinal wall in both epidermal cells abutting the stoma and the subsidiary cells. Guard cells are especially thick-walled in both the periclinal walls. The stoma has a small sub-stomatal cavity. (36.10) An intermediate vascular bundle in C. hexandra with abutting abaxial girder. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The sheath of border parenchyma is interrupted by two large metaxylem vessels. (36.11-12) The pseudo-dorsiventral bract of Cladium mariscus subsp. jamaicense with two rows of vascular bundles facing each other, separated by large lamina cavities. Girders about the phloem sides of the large vascular bundles, whilst large trans-lamina girders extend from the xylem poles of the large vascular bundles and bridge the lamina cavities. These girders are ensheathed in translucent parenchymatous bridges. Intermediate vascular bundles have translucent parenchymatous cells or small parenchymatous bridges, which extend from the vascular bundles xylem poles to the central cavities.

Symbols are as follows: (1) row 1 of adaxial vascular bundles; (2) row 2 of abaxial vascular bundles; (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Ca) lamina cavity; (G) girder; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (MEp) marginal epidermal cell; (MS) mestome sheath; (NC) no cone-shaped silica deposit; (OT) outer periclinal wall (tangential); (Pbr) parenchymatous bridge; (PxL) protoxylem lacuna; (S) small vascular bundle; (St) stoma; (Stc) sub-stomatal cavity; (SS) sclerenchymatous strands; (Su) subsidiary cell and (T) tannin idioblast. Bars = 10μm.
Plate 36. Legend on facing page.
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The adaxial HSS/girders are mostly larger than the abaxial HSS/girders (Table 17, Appendix 3), whilst the abaxial HSS/girders in Carpha glomerata, C. schlechteri and S. nigricans are larger than the adaxial HSS/girders. The adaxial HSS/girders range from 9μm (Carpha schlechteri) to 147μm (Cyathocoma hexandra), whilst the abaxial HSS/girders size range from 11μm (Carpha glomerata) to 93μm (Cyathocoma hexandra).

The distribution of HSS adjacent bundles is generally complex. The midrib vascular bundle in Carpha glomerata, C. schlechteri, Cladium mariscus subsp. jamaicense and T. cuspidata (Plate 36.3) have an adjacent abaxial HSS. The large bundles in Carpha glomerata, C. schlechteri (Plate 36.2), Cyathocoma hexandra, S. nigricans and T. cuspidata (Plate 36.3) also have an adjacent abaxial HSS. Marginal bundles in Cyathocoma hexandra and T. cuspidata have an adjacent abaxial HSS. A few of the small bundles in Cladium mariscus subsp. jamaicense have an abutting adaxial HSS. The marginal bundles in Cyathocoma hexandra have an adjacent adaxial HSS.

Girders are present in Cladium mariscus subsp. jamaicense (Plates 36.11-12, 37.1 and 37.10) and Cyathocoma hexandra (Plates 36.4-5 and 38.1). The girders in Cladium mariscus subsp. jamaicense are present on the adaxial and abaxial row of bundles (Plates 36.11-12 and 37.1). The trans-lamina girders are ensheathed by a layer of translucent parenchyma (one cell thick) or a Pbr. As in the leaves, girders extend from the abaxial row large bundles in Cladium mariscus subsp. jamaicense to the adaxial row large and intermediate bundles (Plate 36.11-12). Adaxial girders are present abutting the marginal and last two large bundles of the margin in Cyathocoma hexandra (Plate 36.5). Additional abaxial girders are present abutting the large and intermediate bundles in C. hexandra (Plates 36.4, 36.10 and 38.1).

SS are present within specific tissues of the bracts and abut the vascular bundles in the Schoeneae. SS are present abutting the vascular bundles in all the Schoeneae (Plates 36.4 and 37.2-10). The groupings of vascular bundles in Carpha bracteosa and C. schlechteri have an adaxial SS (Plate 37.2). Adaxial SS abut all midrib and large bundles in the Schoeneae bracts (Plates 36.4, 37.2-3, 37.5, 37.7, 37.10 and 38.1-2). Adaxial SS also abut the intermediate bundles in Carpha bracteosa (Plate 37.6), S. nigricans (Plate 37.4) and T. cuspidata, as well as the marginal bundles in C. bracteosa (Plate 37.6 and 37.8).

Abaxial SS are present abutting the phloem pole of the midrib bundles in Carpha glomerata and C. schlechteri (Plate 37.3), as well as with the large bundles in C. bracteosa, C. glomerata and C. schlechteri (Plate 37.7). Abaxial pole SS are also present abutting the intermediate, small and marginal bundles in C. schlechteri. SS are also present in Cladium mariscus subsp. jamaicense abutting the cavity side of the adaxial and abaxial row of intermediate, as well as the small bundles (Plate 37.9). Additional small SS are also present in the Pbr of Carpha bracteosa (Plate 37.11).

Lignified cells resembling MS or SS cells are present abutting the bundles in Carpha bracteosa (Plate 37.8), C. glomerata and Cladium mariscus subsp. jamaicense. Two to three lignified cells resembling the MS are present inside the outer sheath and abut the inner sheath of the marginal bundles in Carpha bracteosa (Plate 37.8). Two lignified cells are present at the phloem pole inside the second sheath of the marginal bundle in Carpha glomerata. These cells interrupt the third sheath. Three un lignified cells are also present inside the second sheath on the phloem pole of the midrib bundle in Cladium mariscus subsp. jamaicense, these cells interrupt the third sheath.
Plate 37. Shows structural details of the bracts girders, sclerenchymatous strands, lamina cavities, hypodermis, mesophyll structure, vascular bundle arrangement, vascular bundle spacing, vascular sheaths and associated vascular tissues structure of the Schoeneae.

(37.1) Shows an abaxial small vascular bundle in Cladium mariscus subsp. jamaicense with abutting abaxial girdle and adaxial cells of translucent parenchyma. The chlorenchyma of the mesophyll is non-radiating. Present above the vascular bundle is the central lamina cavity. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. (37.2) A lamina large vascular bundle in Carpha bracteosa with abutting intermediate vascular bundles, where the adaxial sclerenchymatous strands and outer sheaths join. Present surrounding this complex of vascular bundles are a few cells of translucent parenchyma and the lamina cavities. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is limited to the large vascular bundle. The sheath of border parenchyma is interrupted by two metaxylem vessels and the protoxylem lacuna. (37.3) Shows that the midrib vascular bundle in C. schlechteri has both abaxial and adaxial sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two metaxylem vessels and the protoxylem lacuna. (37.4) An intermediate vascular bundle in Schoenus nigricans with abutting adaxial sclerenchymatous strand. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in all walls. The sheath of border parenchyma is interrupted by two metaxylem vessels and the protoxylem vessels. (37.5) Shows a large vascular bundle in Tetraria cuspidata with abutting adaxial sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is indistinct, but is interrupted by two metaxylem vessels and a protoxylem vessel. (37.6) The marginal and adjacent intermediate vascular bundle in C. bracteosa with abutting adaxial sclerenchymatous strands that join. The mesophyll chlorenchyma is non-radiating and thin-walled. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and periclinal walls. The sheath of border parenchyma is indistinct and limited to the phloem side of the intermediate vascular bundle. (37.7) Shows a large vascular bundle in C. schlechteri, with no abutting vascular bundles, that has abutting adaxial and abaxial sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and periclinal walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two metaxylem vessels and the protoxylem lacuna. (37.8) The marginal vascular bundle in C. bracteosa with adaxial sclerenchymatous strands and lignified cells resembling the second sheath at the phloem pole of the vascular bundle. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls. The sheath of border parenchyma is indistinct but present on the phloem side of the vascular bundle. (37.9) Shows an adaxial small vascular bundle in Cladium mariscus subsp. jamaicense with adaxial hypodermal sclerenchymatous strands and abaxial sclerenchymatous strands. Translucent parenchyma abuts the sclerenchymatous strands extending to the lamina cavity. The lamina cavity is present below the translucent parenchyma. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. (37.10) The midrib vascular bundle in Cladium mariscus subsp. jamaicense with abutting abaxial girdle and adaxial sclerenchymatous strands. Present on the xylem side of the vascular bundle is the adaxial hypodermis. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls, especially abutting the metaxylem vessels. The sheath of border parenchyma is indistinct and interrupted by two metaxylem vessels as well as by a protoxylem vessel. (37.11) Shows sclerenchymatous strands in Carpha bracteosa with a parenchymatous bridge of translucent parenchyma. (37.12) The margin in Cladium mariscus subsp. jamaicense showing lignified translucent parenchymatous cells. The marginal vascular bundle has an abutting adaxial girdle.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Ca) lamina cavity; (G) girdle; (Hy) hypodermis; (I) intermediate vascular bundle; (Ma) marginal vascular bundle; (MS) mestome sheath; (MS2) lignified cell resembling the mestome sheath cells; (MX) metaxylem vessel; (Pa) parenchyma; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (SS) sclerenchymatous strands and (TP) translucent parenchyma. Bars = 10 μm.
Plate 37. Legend on facing page.
Lamina cavities are present in all species of the *Schoeneae* (Plates 36.2, 36.11-12, 37.1-2, 37.9, 38.1 and 38.3-5, Table 17 [Appendix 3]), with the exception of *T. cuspidata*. Distribution of cavities within the bract laminae varies. In *Carpha bracteosa* cavities are present between the vascular bundles with lateral vascular bundles, the hypodermis, the chlorenchyma and the Pbr (Plate 38.3-4). The lamina cavities of *C. glomerata* and *C. schlechteri* are present between the vascular bundles (Plate 36.2). The lamina cavities in *Cladium mariscus* subsp. *jamaicense* are present between the Pbr, the adaxial and abaxial chlorenchyma (Plate 36.11-12). In *Cyathocoma hexandra* lamina cavities are present between the Pbr of the large bundles, the hypodermis and the chlorenchyma (Plate 38.1). In *S. nigricans* cavities abut the xylem side of the bundles and extend to the adaxial chlorenchymatous layer (Plate 38.5, adaxial epidermis not in picture). Lamina cavity size is large in relation to bract thickness (Table 17, Appendix 3), ranging from 42μm (*Carpha schlechteri*) to 418μm (*C. bracteosa*). Generally translucent "blue" parenchyma is present within the lamina cavities of the *Schoeneae* (Plate 38.5).

An adaxial hypodermis is present in *Carpha schlechteri*, *Cladium mariscus* subsp. *jamaicense* (Plates 37.10 and 38.2) and *Cyathocoma hexandra* (Plate 38.1, Table 17 [Appendix 3]). The hypodermis in *Cladium mariscus* subsp. *jamaicense* (Plates 37.10 and 38.2) and *Carpha schlechteri* is present only in the midrib. In *Cyathocoma hexandra* the hypodermis is present throughout the whole lamina (Plate 38.1). The cells of the hypodermis are lignified and translucent.

Many tannin idioblasts are scattered throughout the chlorenchymatous tissues of the mesophyll, especially in the bracts of the *Schoeneae* (Plate 36.2). Few tannin idioblasts are present in the bracts of *Carpha bracteosa*, *S. nigricans* and *T. cuspidata*.

The chlorenchyma of the mesophyll in the *Schoeneae* bracts is composed of thin-walled, non-radiating parenchymatous cells, with small chloroplasts. The distribution of chlorenchyma varies. In *Carpha bracteosa* the chlorenchyma extends from the abaxial epidermis to the phloem side of the vascular bundles (Plate 38.3-4), surrounding the marginal bundles. In *C. glomerata* and *C. schlechteri* the vascular bundles separate the regions of chlorenchyma (Plate 36.2). In *Cladium mariscus* subsp. *jamaicense* (Plate 36.11-12), *Cyathocoma hexandra* (Plate 38.1) and *T. cuspidata* the chlorenchyma arrangement is the same as in the leaves. The chlorenchyma in *S. nigricans* extends from the abaxial epidermis to the phloem side of the vascular bundles and to the lamina cavity (Plate 38.5). Furthermore the chlorenchyma in *S. nigricans* abuts the marginal bundles extends to the other marginal bundle and also abuts the adaxial epidermis. The lamina cavity is present between the adaxial mesophyll layer and the xylem side of the lamina vascular bundles.

Pbr composed of thin-walled translucent cells, are present in *Carpha bracteosa* (Plate 38.3-4), *Cladium mariscus* subsp. *jamaicense* (Plate 36.11-12) and *Cyathocoma hexandra* (Plate 38.1). The site of location of the Pbr is the same as in the leaves.

Additional cells of lignified translucent parenchyma (TP) are present in the margins of *Cladium mariscus* subsp. *jamaicense* abutting the marginal bundles (Plate 37.12), similar to the leaves. Lignified TP also abut the girders of the midrib bundle in this species and extends from the abaxial epidermis to the phloem side of the bundle.
Plate 38. Shows structural details of the bracts of the Schoeneae in section, with lamina cavities, hypodermis, mesophyll structure, vascular bundle arrangement, vascular bundle spacing, and vascular sheath, as well as vascular tissue structure.

(38.1) Shows the adaxial epidermal cells in Cyathocoma hexandra, which are larger than the abaxial epidermal cells. The large vascular bundles have abutting abaxial girder and an abaxial sclerenchymatous strands. Present abutting the sclerenchymatous strands of the large vascular bundles extending to the adaxial hypodermis are bridges of translucent parenchyma. Chlorenchyma extends from the abaxial epidermis to the parenchymatous bridges of the large vascular bundles. The intermediate and small vascular bundles are surrounded by non-radiating chlorenchyma. Present between the chlorenchyma, the adaxial hypodermis and the parenchymatous bridges are the lamina cavities. Vascular bundles are in one row. (38.2) The midrib in Cladium mariscus subsp. jamaicense has an adaxial hypodermis. The midrib vascular bundle also has adaxial sclerenchymatous strands. (38.3-4) The mesophyll in Carpha bracteosa is composed of chlorenchyma and translucent parenchyma, where the chlorenchyma extends from the abaxial epidermis to the phloem side of the vascular bundles. Present at the xylem pole of the lamina vascular bundles are parenchymatous bridges of translucent parenchyma. The midrib and adjacent vascular bundles extend and meet with the bridges of adjacent vascular bundles, which then extend to the adaxial hypodermis. The lamina cavities are present between the chlorenchyma, the parenchymatous bridges and the adaxial hypodermis. A few of the vascular bundles are present in groupings of large vascular bundles with abutting intermediate or small vascular bundles, whilst the midrib vascular bundle has two adjacent intermediate vascular bundles. (38.5) The chlorenchyma of Schoenus nigricans extends from the epidermis to the xylem pole of the large vascular bundles and the xylem pole of the intermediate as well as the small vascular bundles. Abutting the chlorenchyma and extending to the adaxial epidermis (not in picture) is the lamina cavity. Present within the lamina cavity is translucent "blue" parenchyma. Sclerenchymatous strands are present at the xylem poles of the large vascular bundles. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. (38.6) Shows a vascular bundle grouping in C. bracteosa, where the sclerenchymatous strands of one large vascular bundle and abuts one intermediate, and one small vascular bundle. The outer two sheaths of the intermediate vascular bundle join with those of the large vascular bundle. Only the outer sheath of small vascular bundle joins with the large vascular bundle. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The cells of the mestome sheath are thick-walled, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is distinct only in the large vascular bundle, where this sheath is interrupted by two large metaxylem vessels and the protoxylem lacuna. A bridge of translucent parenchyma is present at the xylem pole of the vascular bundle grouping. (38.7) A large vascular bundle in C. glomerata, where there are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The cells of the mestome sheath are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels and a protoxylem vessel. (38.8) Shows a small vascular bundle in Cyathocoma hexandra with three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The cells of the mestome parenchymatous sheath are chlorenchymatous and thick-walled. The cells of the mestome sheath are thick-walled in all walls. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (38.9) A marginal vascular bundle in Carpha schlechteri with three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The cells of the parenchymatous sheath are chlorenchymatous and thin-walled. The cells of the mestome sheath are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is limited to the phloem side of the vascular bundle.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Ca) lamina cavity; (G) girder; (Gr) vascular bundle grouping; (Hy) hypodermis; (I) intermediate vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (S) small vascular bundle and (SS) sclerenchymatous strands. Bars = 10 μm.
Plate 38. Legend on facing page.

The vascular bundles in the Schoeneae generally occur in one row (Plates 36.2-3, 38.1 and 38.2-3). Cladium mariscus subsp. jamaicense has two rows of vascular bundles in the lamina (Plate 36.11-12). The adaxial row of bundles consists of large, intermediate and small bundles. The midrib, large, intermediate, small and marginal bundles are present in the abaxial row. As in the leaves, the vascular bundles of the bracts are mostly not accompanied by lateral vascular bundles and are solitary (Plates 36.2-5, 36.10-12, 37.1, 37.9, 38.1 and 38.5).
The vascular bundles in the genus *Carpha* are accompanied by lateral vascular bundles (Plates 37.2, 37.6, 38.3-4 and 38.6). There are however, no lateral vascular bundles present in the margins of the bracts. The midrib bundle in *C. bracteosa* has two lateral vascular bundles (one small and one intermediate bundle, Plate 38.3). The large lamina bundles have one to two lateral vascular bundles that are either intermediate or small bundles (Plate 37.2). These lateral vascular bundles abut on the xylem side of the bundle, so that the MS of each of the vascular bundles touch. In some of these groupings of vascular bundles with lateral vascular bundles, the MS may be absent and the xylem tissue coalesce at this point (Plate 38.6). The xylem of the small bundle faces the protoxylem of the large bundle. Only one of the marginal bundles and the adjacent large bundle are solitary. A few of the large lamina bundles in *C. glomerata* have one lateral small bundle. The small bundle has all three vascular bundle sheaths intact and is present next to the large bundle. In *C. schlechteri*, the large vascular bundles of the laminae have one to three lateral vascular bundles (these are either small or intermediate bundles). In a few of the lateral vascular bundles the outer sheath is intact, the large bundles, as well as lateral vascular bundles abut. In some groupings with one lateral small bundle, the MS is absent on the xylem side. In these two bundles the xylem coalesces. In a few of the lateral vascular bundles the outer sheath is absent and the second sheaths abut.

The xylem of the lateral vascular bundles in *Carpha bracteosa* face towards the xylem pole of the midrib bundle and the large bundles (Plates 37.2 and 38.6). The xylem of the marginal bundle faces the adaxial epidermis of the midrib. The vascular orientation in *C. schlechteri* is similar to *C. bracteosa*, differing only in that the marginal bundle faces the adaxial epidermis directly above. The vascular orientation of the bracts in *C. glomerata*, *Cyathocoma hexandra* and *T. cuspidata* is the same as in the leaves. The xylem of the bundles of both rows in *Cladium mariscus* subsp. *jamaicense* mostly faces towards the centre of the leaf (Plate 36.11-12), with the exception of a few of the adaxial small bundles, where the bundles lie with their long axis parallel to the epidermis, similar to the leaves. The xylem of the vascular bundles in *S. nigricans* faces the centre of the bract (Plate 38.5).

The maximal cell distal count between vascular bundles of is generally more than five cells (Table 17, Appendix 3). *Cyathocoma hexandra* and *T. cuspidata* have a cell count of 2-4 cells, whilst *S. nigricans* has a cell count of 1-7 cells, between vascular bundles. Both *Cyathocoma hexandra* and *S. nigricans* lacked a midrib bundle, whilst *T. cuspidata* lacked intermediate and small bundles. Generally there is no recognisable pattern with respect to vascular bundle number and position within the laminae in the *Schoeneae* (Table 17, Appendix 3). There is usually one small bundle present between the large and intermediate bundles in *Carpha glomerata*, *C. schlechteri* and *Cladium mariscus* subsp. *jamaicense*. Generally there are no recognisable patterns with respect to the numbers of vascular bundles present within the bract lamina. In *Cyathocoma hexandra* there are more small bundles than intermediate or large bundles (Table 17, Appendix 3).

Within the *Schoeneae*, bracts have three vascular sheaths (Plates 36.4-5, 36.10, 37.2-8, 37.10 and 38.6-9), an outer PS, a middle lignified MS and an inner non-lignified BP. The PS cells are larger than the MS cells (Plates 36.4-5, 36.10, 37.1-10 and 38.5-9). The cells of the PS are thin-walled and chlorenchymatous (Plates 37.3-8 and 38.8-9). Generally the radial walls of the MS are thicker than the inner tangential and radial walls (Plates 37.3, 37.5, 37.7, 38.7 and 38.9, Appendix 4). In the small bundles of *Carpha bracteosa* and the marginal bundles in *T. cuspidata* the MS cells are similarly thickened in all walls. All the walls of the MS in *Cyathocoma hexandra* are similarly thickened (Plates 36.10 and 38.8), whilst the small bundles are relatively thick-walled. The BP of most of the midrib...
bundle and large bundles is bisected by the large metaxylem vessels (Plates 36.4-5, 37.2-3, 37.7, 37.10 and 38.6-7) and by protoxylem lacunae (Plates 36.4, 37.3 and 37.7), in those bundles with protoxylem lacunae (PxL). In most intermediate bundles the BP is interrupted by the large metaxylem vessels (Plates 36.10 and 37.4) or is limited to the phloem side of the bundle (Carpha bracteosa [Plate 37.8], Carpha schlechteri [Plate 38.9], Cladium mariscus subsp. jamaicense, Cyathocoma hexandra, S. nigricans and T. cuspidata). The BP of the marginal bundles is bisected by the large metaxylem vessel and a protoxylem vessel in Cyathocoma hexandra.

The phloem and xylem outlines vary (Appendix 4). The xylem and phloem of the marginal bundles in Carpha glomerata is mixed. Protoxylem lacunae (PxL) are present in all the midrib bundles and large bundles in the Schoeneae bracts (Plates 36.4, 37.2-3, 37.7 and 38.6). The midrib bundle and large bundles in Cladium mariscus subsp. jamaicense (Plates 37.10 and 38.2), as well as the large bundles in T. cuspidata (Plate 37.5) have intact protoxylem vessels and lack protoxylem lacunae.

8.2.5 Culm characteristics of the tribe Schoeneae

Culms shapes are variable. Three basic shapes can be defined, namely thickly crescentiform (Carpha bracteosa, Cladium mariscus subsp. jamaicense and Cyathocoma hexandra), circular (S. nigricans and T. cuspidata) and irregularly scutiform (Carpha glomerata and C. schlechteri). The thickly crescentiform culms can be divided into the species with a wavy outline (Cyathocoma hexandra) and those without (Carpha bracteosa and Cladium mariscus subsp. jamaicense). Similarly the circular species can also be divided into those with a wavy outline (S. nigricans) and those without (T. cuspidata). There are no trichomes present in the culms of the Schoeneae (Table 18, Appendix 3). Culms are large in size (Table 18, Appendix 3), ranging from 465μm (T. cuspidata) to 3653μm (Carpha glomerata).

Epidermal cells are small, especially in relation to culm size (Table 18, Appendix 3), ranging from 5μm (Carpha bracteosa) to 15μm (Cyathocoma hexandra and S. nigricans). Thick-walls are present in the outer periclinal walls of the epidermis, as in the leaves and bracts (Plate 39.1-9). Epidermal shapes vary.

Cone-shaped silica deposits in the epidermal cells that abut the HSS, and girders are mostly absent (Plate 39.1-2 and 39.8). Cone-shaped silica deposits are present only in Carpha bracteosa and Cladium mariscus subsp. jamaicense. The cells of the epidermis abutting the HSS/girders that lacked these cones, are smaller than the epidermal cells adjacent to the HSS/girders, with the exception of S. nigricans. The epidermal cells in S. nigricans abutting the HSS/girders are the same size as the epidermal cells adjacent the HSS/girders (Plate 39.2).

Generally the stomata in the Schoeneae culms are flush with the epidermal surfaces (Plate 39.3 and 39.5). In Cladium mariscus subsp. jamaicense stomata are sunken, whilst in S. nigricans the stomata are raised (Plate 39.4). Only the sub-stomatal cavities in Carpha bracteosa have lignified cells surrounding the cavity (Plate 39.5). The guard cells are variably thickened at the adaxial, as well as abaxial poles of the cells, as with the leaves and the bracts (Appendix 4). The sub-stomatal cavities are small in size, especially when compared to the culm size (Table 18, Appendix 3), ranging from none (T. cuspidata) to 20μm (Cyathocoma hexandra).
Plate 39. Shows structural details of the culms of the Schoeneae in section, illustrating the epidermal cells; stomatal complex; hypodermal sclerenchymatous strands, girders, sclerenchymatous strands, sclerenchymatous tissue structure and arrangement; cavities; ground tissue structure; vascular bundle arrangement; and vascular sheaths, as well as vascular tissues.

(39.1) Shows the epidermis in Cladium mariscus subsp. jamaicense with thick-walled outer periclinal wall. The epidermal cells abutting the hypodermal sclerenchymatous strands have no cone shaped silica deposit. Surrounding the hypodermal sclerenchymatous strands are cells of translucent parenchyma. (39.2) Illustrates the epidermis in Schoenoe nigricans, where the epidermal cells abutting the hypodermal sclerenchymatous strands have no cone-shaped silica deposits. These epidermal cells abutting the hypodermal sclerenchymatous strands are of a similar size to the epidermal cells adjacent to the hypodermal sclerenchymatous strands. Chloroplast and is present from the epidermis to the phloem side of the outer large vascular bundles. (39.3) The epidermis in Carpha glomerata has flush stomata and small sub-stomatal cavities. The subsidiary cells are relatively thin-walled when compared to the adjacent epidermal and guard cells. (39.4) Shows the epidermis in S. nigricans with a lignified raised stoma and a small sub-stomatal cavity. Note the lignified outer periclinal wall of the subsidiary cell. Additionally, note the lignified periclinal walls of the guard cells. (39.5) The epidermis in C. bracteosa has a lignified stoma and a small sub-stomatal cavity. Note particularly the lignified cells surrounding the sub-stomatal cavity. (39.6) Shows the epidermis in C. glomerata is thick-walled in the outer periclinal wall. Hypodermal sclerenchymatous strands are present at random along the epidermis. The ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem pole of the outer row of vascular bundles. In places the chlorenchyma extensions are bridge-like in appearance. Surrounding the outer row of vascular bundles are two layers of translucent parenchyma. Translucent parenchyma extends endarch from the first row of vascular bundles to the centre of the culm. Cavities are present between the outer row of vascular bundles, where the cavities extend in places to the second row of vascular bundles. There are six concentric rows of vascular bundles. (39.7) In Cladium mariscus subsp. jamaicense the hypodermal sclerenchymatous strands are also present at random along the epidermis. Girders abut the outer row of vascular bundles. The sclerenchymatous strands of the xylem sides of the outer row of vascular bundles extend to the sclerenchymatous strands of the phloem sides of the second row of vascular bundles. These sclerenchymatous strands join and form a sheath of sclerenchymatous tissues that in a few places extends to the sclerenchymatous strands on the phloem sides of the third row of vascular bundles. The inner rows of vascular bundles have sclerenchymatous strands on both the xylem and the phloem sides of the vascular bundles. The ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the layer of sclerenchyma. Endarch to the sclerenchymatous layer is translucent parenchyma, which extends to the centre of the culm. (39.8) Shows the epidermis of Tetraga cuspidata, which is thick-walled in the outer periclinal wall. Hypodermal sclerenchymatous strands are present adjacent to each of the vascular bundles. Chlorenchyma extends from the epidermis to the xylem poles of most of the outer row of vascular bundles and the xylem halves of a few of the outer row of large vascular bundles. The chlorenchyma is thin-walled and has a few large tannin idioblasts. Endarch to the chlorenchyma is the central cavity, where translucent "blue" parenchyma is present. (39.9) The hypodermal sclerenchymatous strands, girders and sclerenchymatous layer of Cladium mariscus subsp. jamaicense have translucent parenchyma present abutting the sclerenchymatous layers. The chlorenchyma has thin-walls and numerous small chloroplasts. (39.10) Shows a higher power view of the translucent parenchyma cells that are present abutting the sclerenchymatous tissues in Cladium mariscus subsp. jamaicense. (39.11) The sclerenchymatous strands of a few adjacent outer row vascular bundles in S. nigricans may join. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is lignified in the inner tangential and radial walls. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the protoxylem lacuna. (39.12) Shows an outer large vascular bundle in Carpha bracteosa where a sclerenchymatous strands are present at the xylem pole of the vascular bundle. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential wall, especially on the phloem side of the vascular bundle and abutting the large metaxylem vessels. The sheath of border parenchyma is interrupted by two large metaxylem vessels and a protoxylem vessel. The sheath of border parenchyma is indistinct on the phloem side of the vascular bundle.

Symbols are as follows: (1) row 1 of vascular bundles; (2) row 2 of vascular bundles; (3) row 3 of vascular bundles; (4) row 4 of vascular bundles; (5) row 5 of vascular bundles; (6) row 6 of vascular bundles; (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermis; (HSS) hypodermal sclerenchymatous strands; (l) intermediate vascular bundle; (L) large vascular bundle; (Li) lignified cell; (MS) mestome sheath; (MX) metaxylem vessel; (NC) epidermal cell with no cone-shaped silica deposit; (OT) outer periclinal wall (tangential); (Pa) parenchymatous cell; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (Pxl) protoxylem lacuna; (Sc) sclerenchymatous layer; (SS) sclerenchymatous strands; (St) stoma; (Stc) sub-stomatal cavity and (Su) subsidiary cell. Bars = 10 μm.
Plate 39. Legend on facing page.
The HSS, girder and SS cells are small and thick-walled (Plates 39.1-2, 39.8-12 and 40.1-12). No HSS are present in the culms of *Cyathocoma hexandra*. There are five different HSS outlines present in the culms of the *Schoeneae* (Appendix 4). There are few HSS present in the culms of the *Schoeneae* (Table 18, Appendix 3), with the exception of *Carpha glomerata*. HSS/girder size ranges from 14μm (*Cladium mariscus subsp. jamaicense*) to 156μm (*Cyathocoma hexandra*).

The presence and distribution of HSS is variable in the *Schoeneae* culms. The HSS in *Carpha bracteosa* are present on either side of the stomata, whilst in *C. glomerata* the HSS are present within the Pbr. In *C. schlechteri* the HSS are not present adjacent to the bundles or particular structures, but are present at random along the epidermis. The second row of bundles in *Cladium mariscus subsp. jamaicense* and *S. nigricans* have adjacent to HSS (Plate 39.7). The HSS in *T. cuspidata* are present adjacent all the vascular bundles (Plate 39.8). In *Cladium mariscus subsp. jamaicense* the HSS are ensheathed by a layer of translucent parenchyma cells (1 cell, Plate 39.9).

Massive girders are present in the culms of *Cladium mariscus subsp. jamaicense* (Plate 39.7 and 39.9), *Cyathocoma hexandra* (Plate 40.11) and *S. nigricans*. Most outer row of vascular bundles in *Cladium mariscus subsp. jamaicense* (Plate 39.7 and 39.9) and *S. nigricans* have abutting girders. The massive girders in *Cladium mariscus subsp. jamaicense* are ensheathed by a layer (one cell) of oval translucent parenchyma (Plate 39.10). Girders are present abutting the outer and second row large bundles in *Cyathocoma hexandra* (Plate 40.11).

Generally the SS of the culms in the *Schoeneae* are present abutting the vascular bundles (Plates 39.7, 39.11-12, 40.1, and 40.7-12). SS are present abutting the xylem pole of all large and intermediate bundles in the *Schoeneae* culms (Plates 39.11-12, 40.1, 40.3-4 and 40.8-12). SS abut the phloem pole of the outer row large bundles that do not have girders.

Phloem pole SS abut the inner large bundles in *Carpha glomerata*, *C. schlechteri* (Plate 40.4), *Cladium mariscus subsp. jamaicense* (Plate 39.7) and *Cyathocoma hexandra* (Plate 40.3). SS also abut the xylem pole of the intermediate (*Cladium mariscus subsp. jamaicense* [Plate 40.6]) and small bundles (*Carpha glomerata* [Plate 40.5], *Cyathocoma hexandra* [Plate 40.2] and *S. nigricans*). SS are present abutting the phloem pole of the small bundles in *Carpha glomerata* and *C. schlechteri*. Some of the inner intermediate bundles in *Carpha glomerata* have both phloem and xylem pole SS (Plate 40.7).

The SS of the inner large bundles is extremely thick on the phloem side, in the genus *Carpha* (Plate 40.4 and 40.8), *S. nigricans* and *T. cuspidata*, where the SS resembles a multi-layered MS. This lignification is less pronounced in the outer row large bundles. SS are also present in the Pbr and chlorenchyma of *Carpha glomerata* (Plate 40.7). These SS are similar in structure as the HSS. The SS of some of the bundles in *Carpha bracteosa*, *Cladium mariscus subsp. jamaicense* (Plates 39.7 and 40.6), *Cyathocoma hexandra* (Plate 40.1-2), *S. nigricans* (Plates 39.11 and 40.10) and *T. cuspidata* coalesce. The joining of the SS in *Cladium mariscus subsp. jamaicense* and *Cyathocoma hexandra* is complex and will be discussed separately.
Plate 40. Shows structural details of the culms of the Schoeneae in section, including hypodermal sclerenchymatous strands, girders, sclerenchymatous strands, sclerenchymatous tissue structure and arrangement; cavity arrangement and structure; ground tissue structure; vascular bundle arrangement, and vascular sheaths, as well as vascular tissues.

(40.1) Shows an outer row intermediate vascular bundle, in Cyathocoma hexandra, with sclerenchymatous strands abutting the xylem side. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath cells are thick-walled in all walls, especially on the phloem side of the vascular bundle and abutting the metaxytem vessels. The sheath of border parenchyma is interrupted by two large metaxytem vessels and a crushed protoxytem vessel.

(40.2) An outer row small vascular bundle, in Cyathocoma hexandra, with sclerenchymatous strand abutting the xylem side, and which join with the sclerenchymatous strands of the adjacent vascular bundle. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is limited to the phloem side of the vascular bundle.

(40.3) Shows an inner row large vascular bundle, in Cyathocoma hexandra, with sclerenchymatous strands abutting both the xylem and phloem sides. The inner rows of vascular bundles are surrounded by thin-walled translucent parenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by two large metaxytem vessels and a protoxytem lacuna. (40.4) An inner row large vascular bundle, in Carpha schlechteri, with sclerenchymatous strands abutting both the xylem and phloem sides. There are two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. Note particularly the lignification of the mestome sheath on phloem side of the vascular bundle where cells are almost filled with lignin. The sheath of border parenchyma is interrupted by two large metaxytem vessels and a protoxytem lacuna. The sheath of border parenchyma is indistinct on the phloem side of the vascular bundle.

(40.5) Shows an inner row small vascular bundle, in C. glomerata, with sclerenchymatous strands abutting the xylem side. The vascular bundles are surrounded by a layer of translucent parenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is lignified in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (40.6) A portion of the culm in Cladium mariscus subsp. jamaicense where the sclerenchymatous strands of the first row vascular bundle do not extend to the layer of sclerenchyma and is interrupted by a few cells of translucent parenchyma. These cells of translucent parenchyma abut the sclerenchymatous layer. The vascular bundles present within the sclerenchymatous layer have one distinctive vascular sheath, a lignified mestome sheath. (40.7) An inner row of intermediate vascular bundles in Carpha glomerata, with sclerenchymatous strands abutting both the xylem and phloem poles. Note particularly the sclerenchymatous strands that are present at random within the chlorenchyma. The outer cavities are present between the outer vascular bundles. There are three vascular sheaths, an outer translucent parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (40.8) Shows that the epidermis in C. schlechteri is thick-walled in the outer peridinal wall. Hypodermal sclerenchymatous strands are present at random along the epidermis. Note that the epidermal cells abutting the hypodermal sclerenchymatous strands are smaller than the epidermal cells adjacent to the strands. Sclerenchymatous strands are present on both the xylem and phloem sides of the inner rows of vascular bundles. The ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma abuts the epidermis and extends in bridges across the outer cavities to the inner layer of translucent parenchyma abutting the second row of vascular bundles. The outer cavities are present at random separating the chlorenchyma and translucent parenchyma. Most inner row large vascular bundles have protoxytem lacuna. (40.9) The hypodermal sclerenchymatous strands in C. bracteosa are present at random along the epidermis. Sclerenchymatous strands are present at both the xylem and phloem sides of the inner rows of vascular bundles. The ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem sides of the first and second row vascular bundles. Translucent parenchyma extends from the xylem side of the second row vascular bundles in bridges to the translucent parenchyma layer surrounding the third row of vascular bundles. The translucent parenchyma extends laterally between these third row vascular bundles. The outer cavities are present between the second row vascular bundles, the chlorenchyma and the bridges of translucent parenchyma. Endarch to the translucent parenchyma surrounding the third row of vascular bundles is the central cavity. (40.10) The hypodermal sclerenchymatous strands in Schoeneae nigricans are present adjacent to the second row of vascular bundles. Sclerenchymatous strands are present on the xylem side of the vascular bundles, where these strands are present inside the outer sheath. In places, the strands between vascular bundles may interrupt the outer sheath and join adjacent vascular bundles. Chlorenchyma extends from the epidermis to the phloem sides of the first and second row vascular bundles.

(Legend continues on the next facing page)
Plate 40. Legend on facing page.
Endarch to the chlorenchyma is the central cavity. In younger culms the tissue endarch to the chlorenchyma is translucent "blue" parenchyma. (40.11) The epidermis in Cyathocoma hexandra has a lignified outer periclinal wall. The girders of the second row vascular bundles extend in places to join with the sclerenchymatous strands of the outer row vascular bundles, to form a discontinuous sheath of sclerenchyma. Sclerenchymatous strands are also present at the xylem poles of the second row vascular bundles. Inner rows of vascular bundles have both xylem and phloem pole sclerenchymatous strands. The ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma is present from the epidermis to the phloem sides of the first two rows of vascular bundles. Endarch to the chlorenchyma is thin-walled translucent parenchyma, which extends to the centre of the culm. Tannin idioblasts are present only within the chlorenchyma. (40.12) Shows the merging of the large vascular bundles of the first, second and third row vascular bundles in S. nigricans. Note particularly the three sets of metaxylem vessels. Additionally, note that the phloem tissues of the second vascular bundle appear to be absent. A sclerenchymatous strand is present on the xylem side of the third vascular bundle. The first and second sheaths are continuous and surround the merged vascular bundles. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. In places a third indistinct, interrupted sheath composed of border parenchyma may be recognised.

Symbols are as follows: (1) row 1 of vascular bundles; (2) row 2 of vascular bundles; (3) row 3 of vascular bundles; (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchymatous parenchyma; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxylem; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (S) small vascular bundle; (Sc) sclerenchymatous layer; (SS) sclerenchymatous strands and (TP) translucent parenchyma. Bars = 10 μm.
The SS on the xylem pole of the outer row bundles in Cladium mariscus subsp. jamaicense extend and coalesce with the phloem pole SS of the second row of bundles (Plate 40.6). These SS coalesce to form a sclerenchymatous sheath, which surrounds the second row bundles, extending to the phloem side of these bundle (Plates 39.7 and 40.6). The SS abutting the phloem side of the third row bundles touches or joins with the xylem side SS of the second row. In some cases the xylem side of the second row large and intermediate bundles are surrounded by the SS (Plate 39.7), which is directly adjacent the first row bundles with no SS.

The SS in Cyathocoma hexandra abutting the xylem pole of the intermediate and small bundles is continuous in a sheath or partial sheath (Plate 40.1-2), which joins with the girders and the abaxial SS of the large bundles in the outer row (Plate 40.11).

Cavities are present only in Carpha bracteosa (Plate 40.9), C. glomerata (Plate 39.6), C. schlechteri (Plate 40.8), S. nigricans (Plate 40.10) and T. cuspidata (Plate 39.8). The cavities are present between the outer row of vascular bundles (C. bracteosa [Plate 40.9], C. glomerata [Plate 39.6] and C. schlechteri [Plate 40.8]) and in the centre of the culm (C. bracteosa [Plate 40.9], S. nigricans [Plate 40.10] and T. cuspidata). The outer cavities are small in size compared with the central cavities (Table 18, Appendix 3). The outer cavity size ranges from 25μm (C. schlechteri) to 198μm (C. glomerata). Central cavities are large in size and range from 194μm (T. cuspidata) to 644μm (S. nigricans). The shape of these cavities vary (Appendix 4). Present within all cavities is translucent "blue" parenchyma.

Generally few tannin idioblasts are present within the culms of the Schoeneae. Both Cladium mariscus subsp. jamaicense and T. cuspidata have many tannin idioblasts present in their culm tissue. Generally the tannin idioblasts are present within the chlorenchymatous tissues of the culms in the Schoeneae. The tannin idioblasts in Cladium mariscus subsp. jamaicense are scattered throughout the tissues of the culm.

Three structural variations of ground tissue are present in the culms of the Schoeneae, which will be discussed separately. The first group is present in Carpha bracteosa (Plate 40.9), S. nigricans (Plate 40.10) and T. cuspidata (Plate 39.8). The second structural group is present in C. glomerata (Plate 39.6) and C. schlechteri (Plate 40.8). The third group is present in Cladium mariscus subsp. jamaicense (Plate 39.7) and Cyathocoma hexandra (Plate 40.11).

The chlorenchymatous parenchyma in Carpha bracteosa extends from the epidermis to the phloem side of the large bundles with Pbr (Plate 40.9). The chlorenchyma extends to the xylem pole of bundles with no Pbr. The Pbr extend across the outer cavities and to the second row of vascular bundles (Plate 40.9). Abutting the cavities and Pbr is a layer of TP (Plate 40.9) which extends to the central cavity (six to ten cells). The inner bundles are present in the TP. A variation of this structure is present in S. nigricans and T. cuspidata. The chlorenchyma extends from the epidermis to the phloem side of the first and second row of bundles in S. nigricans (Plate 40.10). A central cavity is present on the xylem side of the first row of bundles and the xylem pole of the second row of bundles (Plate 40.10). The chlorenchyma in T. cuspidata is present from the epidermis to the phloem side of the large bundles, extending to the xylem pole of the intermediate and small bundles (Plate 39.8). Present from the xylem pole of these bundles and the xylem side of the large bundles to the centre of the culm is the central cavity.
In the second structural group, the chlorenchyma is present from the epidermis in *C. glomerata* to the phloem pole of the large, intermediate and small bundles with parenchymatous bridges (Plate 39.6). The chlorenchyma abutting the epidermis and the bundles with Pbr is only two cells thick (Plate 39.6). The Pbr extends from the xylem side of some of the large, intermediate and small bundles, for one to four cells, to the second row of bundles. A few of the Pbr coalesce, forming large bridges of TP. The TP or Pbr extends to the second row of bundles (Plate 39.6). TP is present from the xylem side of the second row of bundles to the centre of the culm. The inner rows of bundles are present in the TP (Plate 39.6). A variation of this ground tissue structure is present in *C. schlechteri*, where chlorenchyma is present from the epidermis to the phloem side of the outer row bundles with lateral vascular bundles, intermediate and small bundles (Plate 40.8). TP is present on the xylem pole of the bundles with lateral vascular bundles, intermediate and small bundles. The cavities are present between the chlorenchymatous Pbr that extend to the first row of bundles (Plate 40.8). The TP extends from the xylem pole of these bundles and the edge of the cavities to the centre of the culm. The inner rows of vascular bundles are present in the TP.

The third structural group is present in the culms of *Cyathocoma hexandra* (Plate 40.11) and *Cladium mariscus* subsp. *jamaicense* (Plate 39.7). In *Cyathocoma hexandra* the chlorenchyma extends from the epidermis to the phloem side of the first row of bundles and to the phloem pole of the second row large bundles with girders. Thin-walled TP abuts the chlorenchyma and extends to the centre of the culm (Plate 40.11). Close to the bundles the TP cells are small and in the centre of the culm these cells are large, with large intercellular spaces. A variation of this structure of the ground tissues is present in *Cladium mariscus* subsp. *jamaicense* (Plate 39.7), where the chlorenchyma extends from the epidermis around the first row of bundles to the sclerenchymatous sheath. From the inner side of the sclerenchymatous sheath to the centre of the culm is TP. The cells of the TP increase in size from the bundles to the centre of the culm, similar to *Cyathocoma hexandra*.

Vascular bundles are generally solitary. In *Carpha bracteosa* and *C. glomerata* the large bundles have lateral vascular bundles. The vascular bundles of most of the Schoeneae are present in one (*T. cuspidata*), two (*Carpha bracteosa* and *S. nigricans*), three (*C. schlechteri*) and seven rows (*Cladium mariscus* subsp. *jamaicense*) within the ground tissues of the culm. There are no concentric rows of vascular bundles in *Carpha glomerata* (except for the first row [Plate 39.6]) and *Cyathocoma hexandra* (except for the first two rows [Plate 40.11]). The outer row of bundles in this species consists of large, intermediate and small bundles, whilst the inner rows are mostly composed of large bundles (Plates 39.6-7 and 40.8). The second row of bundles in *Carpha glomerata* and *C. schlechteri* consists of large, intermediate and small bundles. Large and intermediate bundles are present in the second row of bundles in *Cladium mariscus* subsp. *jamaicense*. The second row of bundles in *Carpha bracteosa*, *Cyathocoma hexandra* and *S. nigricans* consists of large bundles (Plate 40.10-11).

Vascular bundles are generally surrounded by three vascular sheaths (Plates 39.11-12, 40.1-5, 40.7 and 40.12), an outer PS, a middle lignified MS and an inner sheath of non-lignified BP. There are two mestome sheaths surrounding the inner small bundles within the culms of *Cladium mariscus* subsp. *jamaicense*. The PS is absent in the bundles present within the TP (Plate 40.3-4) and the vascular bundles surrounded by sclerenchyma in *Cladium mariscus* subsp. *jamaicense*.
PS cells are larger than the MS and BP (Plates 39.11-12, 40.5 and 40.7). The cells of the PS are thin-walled and translucent, with the exception of *Carpha bracteosa* (Plate 39.12), *Cyathocoma hexandra* (Plate 40.1) and *S. nigricans*, where a few chloroplasts are present. Generally the MS cells are thick-walled (lignified) in the radial and inner tangential walls (Plates 39.12 and 40.5, Appendix 4). All the walls of the MS in *Cyathocoma hexandra* (Plate 40.2) and *S. nigricans* (Plate 39.11) have similar thickening. The lignification of the MS in *Carpha bracteosa* (Plate 39.12), *C. glomerata* (Plate 40.5 and 40.7), *C. schlechteri* (Plate 40.4) and *Cyathocoma hexandra* (Plate 40.1) fills most the MS cells on the phloem side of the bundle.

The BP is composed of thin-walled cells where the presence and site of the BP within the bundles of the culms in the *Schoeneae* is complex. The site and presence of the BP may be divided into two groups, which will be discussed separately.

In the first group the BP cells are bisected by two large metaxylem vessels in the large and intermediate bundles (*Carpha bracteosa* [Plate 39.12], *C. schlechteri* [Plate 40.4], *Cladium mariscus* subsp. *jamaicense*, *Cyathocoma hexandra* [Plate 39.11], *S. nigricans* and *T. cuspidata*). In the large and intermediate bundles of these species the protoxylem vessels or the protoxylem lacunae may also interrupt the BP (Plates 39.12, 40.1 and 40.3-4).

In the second group the BP is limited to either the xylem side of the bundle or to the phloem side of the bundle. The BP of the large bundles in *Carpha glomerata* is present on the xylem side of the bundle. The BP of a few species is present on the phloem side of the intermediate (*Carpha glomerata*, *C. schlechteri* and *Cyathocoma hexandra*) and small bundles (*Carpha bracteosa*, *C. glomerata* [Plate 40.5 and 40.7], *C. schlechteri*, *Cladium mariscus* subsp. *jamaicense* and *Cyathocoma hexandra* [Plate 40.2]).

Vascular bundles with lateral vascular bundles are present in *Carpha bracteosa* and *C. glomerata*. These vascular bundle groupings are present in the outer row of the vascular bundles in both species. In *C. bracteosa* there is a large bundle with one lateral small bundle. Additionally in *C. bracteosa* the PS of a few of the lateral vascular bundles abuts the PS of the large bundle. In some of the lateral vascular bundles, the MS of the xylem pole of both the large and small abut. In between the groupings of vascular bundles in *C. glomerata* there are a few small or intermediate bundles. When there are two lateral vascular bundles, the xylem of the small bundles and the large bundle coalesce at the xylem pole. The MS and PS are absent at this point. In the central region, a few of the large bundles join so that the PxL coalesce and the MS, PS, as well as SS join.

Some of the outer row intermediate and small bundles in *Cladium mariscus* subsp. *jamaicense* coalesce on the xylem side of the bundle. The MS in these bundles is absent at this point and the PS, as well as the MS of the two bundles join. In a few of the first row and second row large bundles of *S. nigricans* the vascular tissues coalesce (Plate 40.12). In these bundles, the xylem of the large bundle of the first row vascular bundles abuts the phloem of the second row large bundle. The MS of these the two bundles join. A SS is present at the xylem pole of the second row bundle (Plate 40.12).

Phloem and xylem tissue outlines vary (Appendix 4). PxL are present in all of the large bundles in the *Schoeneae* (Plate 40.3-4 and 40.8).
9.1. Introduction to the Scirpeae

The tribe Scirpeae is cosmopolitan and contains at least 505 species and 28 genera: Actinoscirpus (Ohwi) Haines and Lye; Androtrichum (Brongniart) Brongniart; Anosporum Nees; Blysmopsis Oteng-Yeboah; Blysmus Panzer ex J.A.Schultes; Bolboschoenus (Ascherson) Palla; Desmoschoenus J.D.Hooker; Dulichium L.C.Richard; Egeria Eiten; Eleocharis R.Brown; Eleogiton Link; Eriophoropsis Palla; Eriophorum Linnaeus; Erioscirpus Palla; Ficinia Schrader; Ficinia Schrader subgen. Sickmannia Nees; Fuirena Rothboel; Isolepis R.Brown; Kylingiella Haines and Lye; Oreobolopsis T.Koyama and Guaglianone; Oxycaryum Nees; Phylloscirpus C.B.Clarke; Pseudoschoenus (C.B.Clarke) Oteng-Yeboah; Schoenoplectus (Reichenbach) Palla; Scirpoides Scheuchzer ex Séguius, Scirpus Linnaeus; Sumatroscirpus Oteng-Yeboah; Trichophorum (Persoon) and Websteria S.H.Wright (Bruhl 1995). Bruhl's (1995) classification of the tribe Scirpeae was one of the most poorly supported and the one tribe that is the most in need of taxonomic effort within the Cyperaceae. Bruhls' (1995) results are similar to those of Goetghebeur and Simpson (1990), as well as Smith and Yatskievych (1996). Goetghebeur and Simpson (1990) investigated Actinoscirpus, Bolboschoenus, Isolepis, Phylloscirpus and Amphiscirpus. Smith and Yatskievych (1996) investigated the genus Scirpus. Muasya et al. (1998) suggested that the tribe Scirpeae is not monophyletic and that the Scirpeae could be divided into three distinct groups, which they referred to as Scirpeae 1-3. Where the genera Ficinia, Hellmuthia, Isolepis and Scirpoides were placed within Scirpeae 1. The genera Actinoscirpus, Bolboschoenus, Eleocharis, Fuirena and Schoenoplectus were placed in Scirpeae 2. The genera Eriophorum, Scirpus and Trichophorum were placed in Scirpeae 3. The investigation of Muasya et al. (1998) also suggested that the Cariceae are a sister group to Scirpeae 2 and that the Cypereae are a sister group to Scirpeae 2.

A number of investigations have been published over the last few years, with most researchers focussing on a particular genus or species within the Scirpeae tribe. Most of the research thus far has looked at morphological aspects of the flowers and fruits. More recently, Muasya et al. (1998), as well as Roalson and Friar (2000) were the first to investigate the genetic information generated using rbcL and ITS data, for classifying Scirpeae species.


The Scirpeae may be divided into two distinct anatomical groups based on photosynthetic type. These are the species with C₃ and C₄ photosynthetic types (Ueno 1988B & 1996). According to Bruhl (1995) the only genus with C₄ species in the Scirpeae is Eleocharis. The C₄ Eleocharis species have eleocharoid anatomy (Ueno et al. 1988B & 1989; Soros and Dengler 1998 & 2001) and are biochemically NAD- Me (Bruhl et al. 1987; Ueno and Samejima 1989; Ueno et al. 1996; Soros and Dengler 1998 & 2001). Until recently the C₃ Cyperaceae were believed to be all biochemically NADP-Me (Brown 1975; Carolin et al. 1977; Ueno et al. 1986; Bruhl et al. 1987; Ueno and Samejima 1989). The C₃ group of plants are characterised as non-Kranz and surrounded by two vascular sheaths, with an outer
parenchymatous sheath and an inner mestome sheath (Brown 1975; Gilliland and Gordon-Gray 1978; Takeda et al. 1980; Ueno and Koyama 1987; Ueno et al. 1989; Bruhl 1995; Bruhl and Perry 1995). Additionally some species may have a sheath of vascular parenchyma present inside the mestome sheath, in the outer portions of the xylem and phloem, where these cells range from small poorly developed cells (NK-S) to medium sized (NK-M) to relatively large or NK-L (Ueno et al. 1989).

Generally the *Scirpeae* have a cosmopolitan distribution, where species are present in habitats within Africa, America, Arctic, East Asia, Australasia, Western Eurasia, West Indies, the Mediterranean, New Guinea, the Pacific and Russia. The genus *Scirpus* is absent in South and Central America, West Indies and the Arctic. Many of the genera are not widely distributed, but are endemic to a particular part of the world. These genera are as follows: *Blysmus* (Mediterranean); *Dulichium* (North America); *Egleria* (South and Central America); *Erioscirpus* (East Asia); *Eriophoropsis* (North America); *Ficinia* (Africa); *Kyllingiella* (East Asia and Africa); *Pseudoschoenus* (Africa) and *Sumatroscripus* (Sumatra). The genera *Anosporum*, *Eleocharis*, *Eleogiton*, *Ficinia*, *Fuirena*, *Isolepis*, *Kyllingiella*, *Schoenoplectus*, *Scirpoides* and *Scirpus* are widely distributed within the African continent. *Bolboschoenus* is present only in the Cape, Madagascar and Mediterranean areas. *Ficinia* subgenus *Sickmannia* and *Pseudoschoenus* are endemic to the Cape. *Oxycaryum* is endemic to the Sudano-Angolan region of Africa (Bruhl 1993). African genera not present within the boundaries of southern Africa were *Anosporum*, *Kyllingiella*, *Oxycaryum*, *Pseudoschoenus* and *Scirpoides* (Arnold and de Wet 1993).


### 9.2. Results

#### 9.2.1 *Scirpeae* species collected in the Eastern Cape

A total of seven genera have been collected in the province so far. These genera were as follows: *Bolboschoenus* (Ascherson) Palla, *Eleocharis* R.Brown, *Ficinia*, Schrader, *Fuirena* Rottboel, *Isolepis* R.Brown, *Schoenoplectus* (Reichenbach) Palla and *Scirpus* Linnaeus. These seven genera were re-collected by the author.

Collection details of all the genera and species mentioned in this paragraph can be found in Appendix one. Only one species in the genus *Bolboschoenus* namely, *B. maritimus* (Linnaeus) Palla was collected. Three *Eleocharis* species were collected, namely *E. dregeana* Steud., *E. limosa* (Schrader) Schultes and *E. pauciflora* R Brown. A total of seventeen *Ficinia* species were re-collected, namely *F. arenicola* Arnold and Gordon-Gray var. *arenicola*, *F. bulbosa* (Linnaeus) Nees, *F. cinnamomea* C.B.Clarke, *F. dura* Turrill, *F. fascicularis* Nees, *F. filiculmea* B.L.Burtt,
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F. filiformis, F. indica var. indica (Lam.) Pfeiffer, F. lateralis (Vahl) Kunth, F. oligantha (Steud.) J.Raynal, F. pinguior C.B.Clarke, F. repens (Nees) Kunth, F. stolonifera Boeck., F. temuifolia Kunth, F. triracteata Boeck. and F. zeyheri Boeck. Three Fairena species were also re-collected, namely F. coerulescens Steud., F. hirsuta (P.J.Bergius) P.L.Forbes and F. pachyrrhiza Ridley. Seven species of Isolepis were re-collected, namely I. cernua (Vahl) Roem. and Schultes, I. costata Hochst ex A.Rich var. macra (Boeck.) B.L.Burtt., I. diabolica (Steud.) Schrader, I. fluitans (Linnaeus) R. Brown, I. natans (Thunb.) D.Dietr., I. pellocolea B.L.Burtt and I. prolifera (Rottboel) R. Brown. Two Schoenoplectus species were re-collected, namely S. decipiens (Nees) J.Raynal and S. paludicola (Kunth) Palla ex J.Raynal. A total of three Scirpus species were re-collected, namely S. falsus C.B.Clarke, S. ficinioideus Kunth and S. nodosus Rottboel.

9.2.2 Distribution and habitats of the Scirpeae

Generally the Scirpeae species were collected from habitats that are inland (Fig. 23). The distribution of habitats of B. maritimus and the genus Ficinia is coastal.

![Figure 23](image_url)

Figure 23: Shows the distribution of inland and coastal habitats for the Scirpeae genera collected in the Eastern Cape. Genus symbols indicate the following: (B) Bolboschoenus; (E) Eleocharis; (F) Ficinia; (Fu) Fairena; (I) Isolepis; (Sch) Schoenoplectus and (Sci) Scirpus.

The Scirpeae were collected from a large range of habitats (Fig. 24). Generally the Scirpeae were collected from hydromorphic to mesomorphic habitats that are on the banks of rivers or streams, in marshes, dams and in streams or rivers (Fig. 24). Bolboschoenus maritimus was mostly collected from the halomorphic to xeric habitats the banks of estuary rivers, in dune slacks and from the marshes of coastal areas. Ficinia species are also present in the mesophytic to xeric environments of grasslands and coastal dune fields. Similar to Ficinia, a few of the Scirpus species were collected from the mesophytic to xeric habitats of grasslands, estuaries and coastal sand dunes. Isolepis species were frequently collected from the shade habitats of forests.
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Habitats

Figure 24: Shows the habitat types that the specimens of the tribe Scirpeae were collected from in the Eastern Cape. Symbols are as follows: (B) Bolboschoenus; (Ba) banks of rivers or streams; (Da) dams; (Dn) dunes; (E) Eleocharis; (Es) estuaries; (Ex) exotic forests; (F) Ficinia; (Fe) indigenous forests; (Fu) Fuirena; (Fy) fynbos; (Gr) grasslands; (I) Isoetes; (Ma) marshes; (RT) riverine thicket; (S) streams and rivers; (Sch) Schoenoplectus; (Sc) Scirpus and (Th) thicket.

Generally the Scirpeae were collected from habitats with wet soils (Fig. 25). Bolboschoenus maritimus and the genus Fuirena were not collected from habitats with dry soils. The species of genus Ficinia were more frequently collected from habitats with dry soils. The Scirpeae species were collected from a wide range of soils (Fig. 26). Generally the Scirpeae species have been collected from habitats with a sandy soil. The genus Eleocharis has been more frequently collected from clay based soils and Scirpus from stony soils (Fig. 26).
Figure 25: Shows the hydration of the soils in the habitats of the Scirpeae collected in the Eastern Cape. Genus symbols are as follows: (B) Bolboschoenus; (E) Eleocharis; (Fi) Ficinia; (Fu) Furena; (I) Isolepis; (Sch) Schoenoplectus and (Sci) Scirpus.

Figure 26: Shows the substratum types that the habitats of the Scirpeae have been collected from in the Eastern Cape. Genus symbols are as follows: (B) Bolboschoenus; (E) Eleocharis; (Fi) Ficinia; (Fu) Furena; (I) Isolepis; (Sch) Schoenoplectus and (Sci) Scirpus.
9.2.3 Leaf Characteristics of the tribe Scirpeae

Leaves are absent in eight of the Scirpeae, namely the genus Eleocharis, Ficinia filiculmea, F. oligantha, F. repens, Isolepis pellocolea and Schoenoplectus decipiens. Leaf shape may be divided into four basic shapes: V-shaped; crescentiform; sub-triangular (adaxially concave, Ficinia cinnamomea and F. pinguior) and circular (Schoenoplectus paludicola). The crescentiform species can be divided into three structural classes, namely thickly crescentiform (F. arenicola var. arenicola, F. dura, F. indica var. indica, F. tenuifolia, Scirpus falsus and S. ficinioides), true crescentiform (F. filiformis, F. tribracteata, Isolepis cernua, I. fluitans, I. natans and I. prolifera) and thinly crescentiform (Fuirena hirsuta and S. nosodus). The V-shaped species may also be divided into three structural classes, namely thick V (Bolboschoenus maritimus, Ficinia bulbosa, F. lateralis, coastal and inland, F. stolonifera, F. zeyheri, Fuirena coerulescens, I. costata var. macra and I. diabolica), thick flanged V (Ficinia fascicularis) and thin-V-shaped (Fuirena pachyrrhiza).

Trichomes are present in the abaxial epidermis of Fuirena coerulescens and the adaxial epidermis in F. hirsuta. The abaxial trichomes in F. coerulescens are present in the abaxial epidermis (Plate 41.1), where these trichomes are multi-cellular and small in size (10-14μm). The adaxial trichomes in F. hirsuta are large in size (205-225μm), multi-cellular, lanceolate and present at the margins of the leaf.

Leaf lamina size ranges from 18μm (F. arenicola var. arenicola) to 722μm (Schoenoplectus paludicola). The genus with the thickest leaves is Schoenoplectus (480-722μm) and the genus with the thinnest leaves is Ficinia (63-265μm). Midribs were generally thicker than the lamina (Plate 41.2, Tables 19A-D [Appendix 3]). In Ficinia bulbosa, F. dura, F. zeyheri, Fuirena coerulescens, F. hirsuta, I. cernua and I. costata var. macra the laminae are thicker than the midribs. No distinctive midribs are present in Ficinia indica, I. prolifera (Plate 41.3), Schoenoplectus paludicola (Plate 41.4) and Scirpus nosodus.

Only Schoenoplectus paludicola is unifacial (circular), lacking an adaxial and abaxial epidermis (Plate 41.4). I. prolifera is the only Scirpeae species that has bulliform cells, which are present in the mid-lamina adaxial epidermis. Most species have different adaxial and abaxial epidermal shapes. Adaxial epidermal cells are larger than the abaxial epidermal cells (Tables 19A-D [Appendix 3], Plate 41.1-5). With the exception of Fuirena hirsuta, Scirpus falsus and S. nosodus. The abaxial epidermal cells are small, ranging from 2μm (Fuirena hirsuta) to 71μm (I. prolifera). Abaxial epidermal cell size is also small, ranging from 3μm (I. costata var. macra) to 28μm (Fuirena hirsuta). Generally the outer periclinal walls of the epidermal cells are thick-walled (Plate 41.1-5). The outer periclinal in Ficinia bulbosa, F. fascicularis, F. filiformis, F. indica var. indica, Fuirena coerulescens (Plate 41.1), F. hirsuta (Plate 41.6), I. natans and S. falsus are relatively thin-walled

Cone-shaped silica deposits are absent only in Fuirena coerulescens, I. cernua var. macra and Schoenoplectus paludicola (Plate 41.7-8). Cones are present in both the adaxial and abaxial epidermal cells (Plate 41.9-10), with the exception of B. maritimus, Ficinia dura, F. stolonifera, F. zeyheri, Fuirena pachyrrhiza, I. prolifera and Scirpus nosodus. The cones of these species are present only in the abaxial epidermal cells (Plate 41.9), with the exception for S. nosodus, where these deposits are present only in the adaxial epidermis.
Plate 41. Shows structural details of the leaves of the Scirpeae in section, including trichome structure and arrangement; adaxial, abaxial and marginal epidermal cell structure; presence or absence of cone-shaped silica deposits; hypodermal sclerenchymatous strands, girdle arrangement and structure; lamina cavities; tannin idioblast arrangement and structure; mesophyll structure; and vascular bundle arrangement, as well as vascular bundle spacing.

(41.1) Shows the abaxial epidermis of Furena coerulescens with a multi-cellular trichome. The outer periclinal wall of the epidermis is thick-walled. The epidermal cells abutting the hypodermal sclerenchymatous strands are smaller than the epidermal cells adjacent to the strand. (41.2) The epidermal cells of the abaxial epidermis in Bolboschoenus maritimus are larger than the abaxial epidermal cells. The midrib vascular bundle has an abutting small vascular bundle present beneath the midrib vascular bundle. Parenchymatous bridges extend from xylem pole of the midrib vascular bundle and adjacent vascular bundles. These parenchymatous bridges join. The joined bridges extend and join with the bridges of the vascular bundles adjacent the vascular bundles near the midrib. These joined bridges extend to the adaxial epidermis. The vascular bundles of the lamina also have parenchymatous bridges, which are present on both the xylem and phloem poles of the vascular bundle. Chlorenchyma is present from the abaxial epidermis to the phloem sides of the vascular bundles with translucent parenchymatous bridges. Lamina cavities are present between parenchymatous bridges and the vascular bundles. (41.3) Adaxial epidermal cells in Isolepis prolifera are elongated and are bulliform in appearance. The adaxial epidermal cells of this species are larger than the abaxial epidermal cells. Abaxial hypodermal sclerenchymatous strands are present adjacent to the vascular bundles. Adaxial girders are present abutting the large vascular bundles. Lamina cavities are present between the vascular bundles. (41.4) Shows that the epidermis in Schoenoplectus paludicola is unifacial and is thick-walled in the outer periclinal wall. The mesophyll is composed of chlorenchyma, translucent parenchyma and stellate parenchyma. The chlorenchyma extends from the epidermis to the phloem side of the vascular bundles. On the xylem pole of the vascular bundles and extending in bridges between the vascular bundles is translucent parenchyma. Present between the chlorenchyma, the vascular bundles and the parenchymatous bridges are the outer cavities. Endarch to the translucent parenchymatous bridges is the central cavity. Present in the central cavity is stellate parenchyma. (41.5) The adaxial and abaxial epidermal cells in I. costata var. macra have a thick-walled outer periclinal wall. The cells of the adaxial epidermis are larger than the abaxial epidermis. Hypodermal sclerenchymatous strands are present at random along the epidermis. The mesophyll is composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem side of the large vascular bundles and the xylem pole of the small vascular bundles. Present at the xylem side of the larger vascular bundles are multicellular, translucent parenchyma bridges, which join. The lamina cavities are present between the large vascular bundles and the parenchymatous bridges. The tannin idioblasts are scattered within the mesophyll, but are mostly present in the chlorenchyma. (41.6) The adaxial epidermal cells in F. hirsuta are bulliform in appearance and are larger than the abaxial epidermal cells. Stomata are slightly raised and present in the abaxial epidermis. The mesophyll is composed of chlorenchyma and translucent parenchyma. The chlorenchyma is non-radiating and interrupted by lamina cavities, as well as by parenchymatous bridges. Translucent parenchymatous bridges extend from the xylem pole of the intermediate and large vascular bundles to the adaxial epidermis. Lamina cavities are present between the lamina vascular bundles. The tannin idioblasts are mostly present in the parenchymatous bridges and in the outer sheath of the vascular bundles. (41.7) The epidermal cells abutting the hypodermal sclerenchymatous strands in S. paludicola are similar in size as the epidermal cells adjacent to the strands and contain no cone-shaped silica deposits. (41.8) The adaxial epidermal cells in I. prolifera abutting the girders are the same size as those cells adjacent to the girders and contain no cone-shaped silica deposits. The outer periclinal wall of the adaxial epidermal cells is thick-walled. The lamina cavities are present between the vascular bundles. (41.9) The abaxial epidermal cells in B. martimimus are thick-walled in the outer periclinal wall. Note that there is a cone-shaped silica deposit in an epidermal cell abutting the hypodermal sclerenchymatous strands. (41.10) Shows the abaxial epidermis in Ficinia arenicola var. arenicola has a cone-shaped silica deposit in the cell abutting the hypodermal sclerenchymatous strands. Abaxial epidermal cells are thick-walled in the outer periclinal wall. (41.11) The marginal epidermal cell in Ficinia arenicola var. arenicola is larger than the abutting adaxial and abaxial epidermal cells. The epidermal cells of the margin are thick-walled in the outer periclinal wall. Present abutting the margin are hypodermal sclerenchymatous strands. (41.12) Present within the margin of F. indica var. indica are a number of marginal epidermal cells, which abut the marginal hypodermal sclerenchymatous strands. Epidermal cells of the margin are thick-walled in the outer periclinal wall.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (C) cone-shaped silica deposit; (Ca) lamina cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (G) girdle; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MEp) marginal epidermal cell; (NC) no cone-shaped silica deposit; (OT) outer periclinal wall (tangential); (Pbr) parenchymatous bridge; (S) small vascular bundle; (Stc) sub-stomatal cavity; (T) tannin idioblast; (TP) translucent parenchyma and (Tr) trichome. Bars = 10 μm.
Plate 41. Legend on facing page.
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Only *I. prolifera* lacked cones abutting the adaxial girders (Plate 41.8). The epidermal cells containing these deposits are relatively thin-walled (Plate 41.9-10). The cells of the epidermis abutting the HSS/girders that lack these cones, are predominantly smaller than the epidermal cells adjacent to the HSS/girders, with the exception of *I. prolifera* (Plate 41.8) and *Schoenoplectus paludicola* (Plate 41.7).

*Ficinia arenicola* var. *arenicola* (Plate 41.11), *F. fascicularis*, *F. indica* var. *indica* (Plate 41.12) and *F. tenuifolia* have large epidermal cells in the margins (two to three times larger than the abutting epidermal cells). In one margin of *F. indica* var. *indica*, three to five epidermal cells in the margin, made the margin appear triangular. In the margins of both *I. prolifera* and *Scirpus nodosus* the adaxial and abaxial epidermis extend to form a multi-cellular trichome-like margin. The adaxial hypodermis is continuous within the trichome-like margin in *S. nodosus* (Plate 42.1). Hypodermal sclerenchymatous strands (HSS) are also present at random within this margin (Plate 42.1).

Stomata are generally flush and present in the abaxial epidermis (plate 41.6). The stomata in *B. maritimus*, *Ficinia indica* (Plate 42.2) and *I. costata* var. *macro* are amphistomatous (Plate 42.3). The stomata in *Ficinia pinguior* and *Fuirena hirsuta* are both slightly sunken. The stomata in *Ficinia fascicularis*, *F. lateralis*costal, *F. tribracteata*, *Fuirena coerulescens* (Plate 42.4), *F. pachyrrhiza* and *I. cernua* are raised. The lignification within the stomata varies, see Plates 42.3-7 and Appendix 4. The inner periclinal side (adaxial) of the subsidiary cells in *Fuirena coerulescens* are additionally lignified and extend into the sub-stomatal cavities (Plate 42.4 and 42.7). The sub-stomatal cavities in many species are large in comparison to the leaf thickness (Tables 19A-D, Appendix 3), ranging from none (*Scirpus ficinoides*) to 53μm (*Fuirena hirsuta*). The genus with the smallest sub-stomatal cavities is *Schoenoplectus* (6-14μm) and *Bolboschoenus* the largest (17-33μm).

The cells that comprise the HSS, girders and sclerenchymatous strands (SS) are small, and lignified (Plates 41.1, 41.3, 41.7-12, 42.2-3, 42.8-12 and 43.1-5). Generally the HSS are present adjacent to the adaxial and abaxial epidermal cells (Tables 19A-D, Appendix 3). Adaxial HSS are absent in *I. prolifera* and *Scirpus nodosus*. There are more abaxial HSS than adaxial HSS in the leaves of the *Scirpeae* (Tables 19A-D, Appendix 3). The adaxial and abaxial HSS outlines of the *Scirpeae* leaves differ (Appendix 4).

Most of the *Scirpeae*, especially in the genus *Ficinia* do not have adaxial or abaxial HSS adjacent to the vascular bundles. The HSS are present at random along the epidermis. In *B. maritimus* (Plate 42.9-12), *Fuirena pachyrrhiza*, *I. prolifera* and *Scirpus ficinoides* an abaxial HSS adjacent to all the bundles in the leaves. The abaxial HSS in *Ficinia pinguior* are present adjacent to the midrib bundle, and large and intermediate bundles. *Fuirena coerulescens* has abaxial HSS adjacent to the midrib bundle, and large and marginal bundles. The midrib bundle and large bundles in *F. hirsuta* have adjacent to abaxial HSS. The abaxial HSS in *I. fluitans* are adjacent to the large, intermediate and marginal bundles. The large and intermediate bundles in *Scirpus falsus* have adjacent to abaxial HSS. Adaxial HSS are present adjacent to the midrib bundle (Plate 43.1 and 43.5) and small bundles in *F. cinnamomea*. The large, intermediate and small bundles in *B. maritimus* have an adjacent adaxial HSS (Plate 43.2-4). *Ficinia lateralis*costal, *F. stolonifera* and *I. natans* have adaxial HSS adjacent to the marginal bundles.
Plate 42. Shows structural details of the leaves of the Scirpaceae in section, including trichome-like margins; adaxial and abaxial epidermis; stomatal complex and associated sub-stomatal cavity; hypodermal sclerenchymatous strands, sclerenchymatous strand structure and arrangement; lamina cavities; tannin idioblast arrangement and structure; mesophyll structure including parenchymatous bridges and stellate parenchyma; vascular bundle arrangement; and vascular sheaths, as well as tissues.

(42.1) Shows the trichome-like margin in Scirpus nodosus with aborting hypodermal sclerenchymatous strands. The lamina hypodermis is continuous within the trichome. (42.2) The outer periclinal wall of the epidermal cells in Ficinia indica is thick-walled. Both the adaxial and abaxial epidermal cells are of similar size. The stomata are amphistomatous, with both adaxial and abaxial stomata. Hypodermal sclerenchymatous strands are present at random along the epidermis. The lamina cavities are present between the vascular bundles. The chlorenchyma is composed of rectangular shaped cells, with thin-walls and many chloroplasts. (42.3) Shows that the cells of the abaxial epidermis in Isolepis costata var. macra are thick-walled in the outer periclinal wall. The cells of the epidermis aborting the hypodermal sclerenchymatous strand are smaller than the epidermal cells adjacent to the strand. The stomata are flush with the epidermal surface. The subsidiary cells of the stoma have thin-walls in the periclinal walls. The guard cells are thick-walled in the periclinal walls. The sub-stomatal cavity is small. (42.4) The stomata in Fuirina coerulescens are raised and have small sub-stomatal cavities. The stoma has hom shaped lignin deposits on the guard cells and lignified adaxial protusions of subsidiary cells, that extend into the sub-stomatal cavity. (42.5) Shows the stomata in S. nodosus are flush with the epidermal surface. The sub-stomatal cavity is large. The subsidiary cells are thick-walled in the outer periclinal wall. The guard cells are thick-walled in both the periclinal walls. (42.6) The stomata in Ficinia dura are flush with the epidermal surface and have a small sub-stomatal cavity. The subsidiary cells are thick-walled in the outer periclinal wall. The guard cells are thick-walled in both the periclinal walls. (42.7) Shows a high power view of the silica and lignin adaxial protusions of subsidiary cells within the sub-stomatal cavity of Fuirina coerulescens. Note that hom shaped lignin deposits on the guard cells of the stoma. Epidermal cells are thick-walled in the outer periclinal wall. (42.8) The cells of the abaxial epidermis in Bolboschoenus maritimus are thick-walled in the outer periclinal wall. The midrib has two hypodermal sclerenchymatous strands present below the midrib. Sclerenchymatous strands are present on the xylem pole of the midrib and adjacent vascular bundles. Parenchymatous bridges extend from the xylem poles of the midrib and adjacent vascular bundles, which merge and join. Non-radiating chlorenchyma extends from the epidermis to the phloem side of the vascular bundles. The cavities of the midrib are present between the parenchymatous bridges and the vascular bundles. Beneath the midrib vascular bundle is a small vascular bundle. The outer sheaths of these two vascular bundles abut. There are two distinct vascular sheaths, an outer translucent parenchymatous sheath and an inner lignified mestome sheath. The midrib vascular bundle has a large protoxylem lacuna present at the xylem pole of the vascular bundle. (42.9) Abaxial hypodermal sclerenchymatous strands are present below the large vascular bundles in B. maritimus. These large vascular bundles have aborting adaxial sclerenchymatous strands. Lamina vascular bundles have both adaxial and abaxial parenchymatous bridges extending from the xylem and phloem poles, respectively. Chlorenchyma is present from the abaxial epidermis and extends to the phloem pole of the lamina vascular bundles, where the chlorenchyma is interrupted by the parenchymatous bridges. Lamina cavities are present between the vascular bundles. Present in the cavities is stellate parenchyma. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is thin-walled and translucent. The mestome sheath is thick-walled in the inner tangential and radial walls. The sheath of border parenchyma is distinctive on the phloem side of the vascular bundle. (42.10) The intermediate vascular bundles in B. maritimus have an abaxial hypodermal sclerenchymatous strand that is present below the intermediate vascular bundles. Intermediate vascular bundles also have aborting adaxial sclerenchymatous strands. The intermediate vascular bundles have both adaxial and abaxial parenchymatous bridges extending from the xylem and phloem poles, respectively. Chlorenchyma is present from the abaxial epidermis and extends to the phloem pole of the lamina vascular bundles, where the chlorenchyma is interrupted by the parenchymatous bridges. The lamina cavities are present between the vascular bundles. There are two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The cells of the parenchymatous sheath are thin-walled, translucent and resemble the cells of the parenchymatous bridge. A third indistinct sheath composed of border parenchyma is limited to the phloem side of the vascular bundle. (42.11) The small vascular bundles of B. maritimus have abaxial hypodermal sclerenchymatous strands present beneath them. The small vascular bundles have both adaxial and abaxial parenchymatous bridges extending from the xylem and phloem poles, respectively. Chlorenchyma is present from the abaxial epidermis and extends to the phloem pole of the lamina vascular bundles, where the chlorenchyma is interrupted by the parenchymatous bridges. The lamina cavities are present between the vascular bundles. There are two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The cells of the parenchymatous sheath are thin-walled, translucent and resemble the cells of the parenchymatous bridge. A third indistinct sheath composed of border parenchyma is limited to the phloem side of the vascular bundle. (42.12) The marginal vascular bundles in B. maritimus also have abaxial hypodermal sclerenchymatous strands present near them. The chlorenchyma extends from the epidermis and surrounds most of the vascular bundle.

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Plate 42. Legend on facing page.
On the xylem pole extending to the adjacent large vascular bundle and the adaxial epidermis is a translucent parenchymatous bridge. Tannin idioblasts in the margin are mostly associated with the outer sheath of the marginal and adjacent large vascular bundle. There is no cavity present between the marginal vascular bundle and the adjacent large vascular bundle. The marginal as well as the adjacent large vascular bundle have two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The cells of the parenchymatous sheath are thin-walled and translucent. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. A third indistinct sheath composed of border parenchyma is limited to the phloem side of the vascular bundle.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (Ca) lamina cavity; (HSS) hypodermal sclerenchymatous strands; (H) horn shaped lignin deposit; (Hy) hypodermis; (I) intermediate vascular bundle; (Li) lignified part of subsidiary cell; (Ma) marginal vascular bundle; (MS) mestome sheath; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (S) small vascular bundle; (SS) sclerenchymatous strands; (St) stoma; (Stc) sub-stomatal cavity; (SIP) stellite parenchyma; (Su) subsidiary cell and (T) tannin idioblast. Bars = 10 μm.

Plate 43. Shows structural details of the leaves of the Scirpeae in section, including adaxial and abaxial epidermal structure; hypodermal sclerenchymatous strands, sclerenchymatous strand arrangement and structure; additional lignified cells; lamina cavity arrangement; mesophyll structure including parenchymatous bridges, stellite and translucent parenchyma; vascular bundle arrangement and spacing; and vascular sheaths, as well as tissues.

(43.1) Shows the adaxial epidermal cells in Ficinia cinnamomea, which are thick-walled in the outer periclinal wall. Adaxial hypodermal sclerenchymatous strands are present adjacent to the midrib vascular bundle. The cells of the adaxial epidermis that abut the hypodermal sclerenchymatous strands are smaller than the epidermal cells that are present adjacent the strands. Chlorenchyma extends to the xylem side of the vascular bundle. The cells of the chlorenchyma are non-radiating, thin-walled and have many small chloroplasts. There are many tannin idioblasts scattered within the chlorenchyma. Present on the phloem side of the vascular bundle is a cavity. (43.2) Present above each lamina large vascular bundle in Bolboschoenus maritimus are adaxial hypodermal sclerenchymatous strands. Sclerenchymatous strands are present on the xylem pole of these vascular bundles. Lamina vascular bundles have large translucent, thin-walled, adaxial parenchymatous bridges. Chlorenchyma is present abutting the adaxial epidermis extending for one to five cells and is interrupted only by the parenchymatous bridges. (43.3) The intermediate vascular bundles in B. maritimus have adaxial hypodermal sclerenchymatous strands present adjacent to the vascular bundle. Sclerenchymatous strands are present on the xylem poles of these vascular bundles. The intermediate vascular bundles have large translucent, thin-walled, adaxial parenchymatous bridges. Chlorenchyma is present abutting the adaxial epidermis and is interrupted only by the parenchymatous bridges. (43.4) The small vascular bundles in B. maritimus have adaxial hypodermal sclerenchymatous strands present adjacent to each vascular bundle. Sclerenchymatous strands are present on the xylem poles of these vascular bundles. The small vascular bundles also have large translucent, thin-walled, adaxial parenchymatous bridges. Chlorenchyma is present abutting the adaxial epidermis and is interrupted only by the parenchymatous bridges. (43.5) The periclinal wall of the epidermal cells in F. cinnamomea is thick-walled. The cells of the adaxial epidermis are larger than the abaxial epidermis. The midrib vascular bundle has one adaxial and two abaxial hypodermal sclerenchymatous strands present near the vascular bundle. Chlorenchyma extends from the adaxial epidermis to the xylem side of the vascular bundles. Chlorenchyma extends also from the abaxial epidermis to the phloem pole of the lamina vascular bundles. The lamina cavities are present between the vascular bundles. The cavity in the midrib is present below the midrib vascular bundles and between the vascular bundles adjacent to the midrib. (43.6) The midrib vascular bundle in Isolaepis fluitans has no sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath is thin-walled and chlorenchymatous. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the protoxylem lacuna. (43.7) The marginal vascular bundle in I. fluitans has no sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath is thin-walled and chlorenchymatous. The mestome sheath is also thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle and abutting the metaxylem vessels. The sheath of border parenchyma is interrupted by two metaxylem vessels and a protoxylem vessel. (43.8) The midrib vascular bundle in I. cernua has adaxial sclerenchymatous strands. There are two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is translucent and appears to be thick-walled. The mestome sheath at the phloem side of the vascular bundle appears multi-layered. There is a protoxylem lacuna present at the xylem pole of the vascular bundle. (43.9) The large vascular bundles in I. cernua have adaxial sclerenchymatous strands. There are two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath.

(Legend continues on the next facing page)
Plate 43. Legend on facing page.
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The parenchymatous sheath is translucent and appears to be thick-walled. The mestome sheath at the phloem side of the vascular bundle appears multi-layered. There is also a protoxylem lacuna present at the xylem pole of the vascular bundle. (43.10) Shows the midrib vascular bundle in F. cinnamomea has adaxial sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath is thin-walled and translucent. The mestome sheath is extremely thick-walled in all walls. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the protoxylem lacuna. Note particularly, that there is a lignified cell present inside the mestome sheath, on the phloem pole of the vascular bundle. This lignified cell interrupts the sheath of border parenchyma. (43.11) The lamina cavity in F. tribracteata is present extending from the adaxial epidermis to the translucent parenchyma on the xylem poles of the vascular bundles. This translucent parenchyma is one cell thick and abuts the xylem poles of the large vascular bundles. Present in association with the lamina cavity is translucent "blue" parenchyma. (43.12) A high power view of a cell of stellate parenchyma present in the lamina cavities of B. maritimus. These cells of stellate parenchyma are thin-walled and chlorenchymatous.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (B) translucent "blue" parenchyma; (BP) border parenchyma; (Ca) lamina cavity; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MS2) lignified cell inside mestome sheath; (MX) metaxylem vessel; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (S) small vascular bundle; (SS) sclerenchymatous strands and (TP) translucent parenchyma. Bars = 10 μm.
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The number of HSS present adjacent the midrib vascular bundle varies from none to two adaxially and abaxially (Table 19A-B, Appendix 3). One adaxial HSS (F. cinnamomea (Plate 43.1), F. dura, the genus Fuirena and I. diabolica) or two adaxial HSS (F. fascicularis, F. filiformis, I costata var. macra, I. natans, Scirpus falsus and S. ficinioides) are present adjacent to the midrib bundle of the Scirpeae leaves. There are no abaxial HSS (Ficinia arenicola var. arenicola, F. fascicularis, F. filiformis, F. tribracteata, the genus Fuirena, I. cernua, I. costata var. macra, I. diabolica, I. fluitans, I. natans, Scirpus falsus and S. ficinioides), one abaxial HSS (B. maritimus, F. dura, F. lateralis, and F. zeyheri) or two abaxial HSS (Ficinia bulbosa, F. cinnamomea [Plate 43.5], F. lateralis, F. pinguior, F. stolonifera and F. tenuifolia) are present adjacent to the midrib bundles in the Scirpeae.

Adaxial girders abut the large bundles in I. prolifera (Plate 41.8). Schoenoplectus paludicola is unifacial and has girders, as well as HSS, where the girders abutted the large and intermediate bundles.

Generally adaxial HSS/girders are larger than the abaxial HSS/girders (Table 19A-D, Appendix 3). However, the abaxial girders/HSS in Ficinia arenicola var. arenicola, F. cinnamomea, F. fascicularis, F. filiformis, F. pinguior, F. zeyheri, Fuirena hirsuta, P. pachyrrhiza, I. costata var. macra, and Scirpus ficinioides are larger than the adaxial HSS/girders. The adaxial HSS sizes range from 5µm (I. fluitans) to 66µm (Fuirena pachyrrhiza). The abaxial HSS sizes range from 6µm (I. natans) to 66µm (Fuirena hirsuta).

SS are present in all Scirpeae species (Plates 43.6-9) except for Ficinia filiformis, I. fluitans (Plate 43.6-7) and I. natans. The site and distribution of SS abutting the various bundles is complex. F. zeyheri and I. cernua have SS abutting the xylem and phloem poles of the midrib bundle (Plate 43.8). I. cernua has additional SS abutting the xylem and phloem poles of the large bundles (Plate 43.9). Adaxial SS are present in most species. The bundles in both B. maritimus (Plates 42.8-11 and 43.2-4) and F. arenicola var. arenicola have SS abutting the xylem poles of all the bundles. Similarly, F. tribracteata has SS abutting the xylem pole of all bundles except the small bundles. Scirpus nodosus has SS abutting all bundles, with the exception of the midrib. Xylem SS abut the vascular bundles of the midrib bundle (Ficinia cinnamomea, Fuirena hirsuta, P. pachyrrhiza, I. costata var. macra, I. diabolica and Scirpus falsus); large bundles (Ficinia bulbosa, F. cinnamomea [Plate 43.10], F. dura, F. indica var. indica, F. lateralis, F. pinguior, F. stolonifera, F. tenuifolia, Fuirena hirsuta, P. pachyrrhiza, I. prolifera, Scirpus falsus and S. ficinioides); intermediate bundles (Ficinia bulbosa, F. dura, F. indica var. indica, F. stolonifera, Fuirena hirsuta, I. prolifera and Scirpus ficinioides) and marginal bundles (Ficinia dura, F. fascicularis, I. cernua, Scirpus falsus and S. ficinioides). On the phloem pole of the vascular bundles in F. cinnamomea is an additional lignified cell (Plate 43.10), similar to Carpha bracteosa and C. schlechteri of the Schoeneae. This lignified cell is present inside the mestome sheath (MS) of the midrib bundle, whilst the lignified cell in both C. bracteosa and C. schlechteri is present outside the MS.

Lamina cavities are common in the Scirpeae, with the exception of the genus Ficinia, where only F. cinnamomea, F. fascicularis, F. filiformis, F. lateralis, F. pinguior and F. tenuifolia have lamina cavities. Generally, the lamina cavities are present between each of the lamina vascular bundles (Plates 41.2-3, 41.5, 42.2 and 42.8). S. paludicola has a central cavity (Plate 41.4). The lamina cavities in both F. dura and F. tribracteata are present above the bundles, extending from the adaxial pole of the large bundles to the adaxial epidermis (Plate 43.11). The lamina cavities in I. costata var. macra are present between the bundles and above the parenchymatous bridges, extending to the mesophyll abutting the adaxial epidermis (Plate 41.5). The cavities in F. indica var. indica, are
Plate 44. Shows structural details of the leaves of selected Scirpeae in section, including the adaxial and abaxial epidermis, hypodermal sclerenchymatous strands, sclerenchymatous strands, lamina cavities, hypodermis, tannin idioblast arrangement and structure, mesophyll structure, vascular bundle arrangement, vascular bundle spacing, and vascular sheath, as well as tissue structure.

(44.1) Shows epidermal cells in *Ficinia tenuifolia* with thick-walled outer periclinal wall. Adaxial epidermal cells are larger than abaxial epidermal cells. Epidermal cells abutting the hypodermal sclerenchymatous strands are smaller than the epidermal cells adjacent to the strands. The abaxial hypodermal sclerenchymatous strands are present adjacent to the lamina vascular bundles and are present between the vascular bundles. Chlorenchyma extends from the epidermis to the xylem and phloem poles of the vascular bundles. Tannin idioblasts are scattered within the chlorenchyma. The lamina cavities are present between the vascular bundles. An adaxial hypodermis extends from the midrib to the margin and is composed of translucent thin-walled cells. (44.2) The margin in *Fuirena coerulescens* where the epidermal cells are thick-walled in the outer periclinal wall. The adaxial epidermal cells are larger than the abaxial epidermal cells. Abaxial hypodermal sclerenchymatous strands are present adjacent to the marginal and lamina vascular bundles. The mesophyll is composed of chlorenchyma and translucent parenchyma. The chlorenchyma has thin-walls and surrounds the marginal vascular bundle, as well as being adjacent to the large vascular bundle. Translucent parenchymatous bridges extend from the lamina vascular bundle’s xylem pole to the adaxial epidermis. Lamina cavities are present between the lamina vascular bundles. Tannin idioblasts are mostly present abutting the hypodermal sclerenchymatous strands and the vascular bundles. (44.3) Shows a large vascular bundle in *F. coerulescens* with adjacent abaxial hypodermal sclerenchymatous strands. Adaxial epidermal cells are larger than abaxial epidermal cells. Non-radiating chlorenchyma extends from the adaxial epidermis to the abaxial epidermis, and is interrupted only by the lamina cavities. Translucent parenchymatous bridges extend from the xylem pole of the large vascular bundles to the adaxial epidermis. Lamina cavities are present between the vascular bundles. Tannin idioblasts are mostly present abutting the hypodermal sclerenchymatous strands and the parenchymatous bridges. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The sheath of border parenchyma is composed of large cells that are interrupted by two large metaxylem vessels and a protoxylem lacuna. (44.4) The midrib vascular bundle in *Ficinia fascicularis* has abutting adaxial sclerenchymatous strands. Extending from the adaxial epidermis to the sclerenchymatous strands of the midrib vascular bundles is a translucent parenchymatous bridge. There are two distinctive vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is composed of thin-walled translucent cells. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. (44.5) The adaxial epidermal cells of *F. pinguicula* are larger than the abaxial epidermal cells. The abaxial hypodermal sclerenchymatous strands are present adjacent to the vascular bundles and are also present between the vascular bundles. The mesophyll is composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem side of the vascular bundles and is interrupted by the lamina cavities. Translucent parenchymatous bridges extend from the xylem poles of the lamina and midrib vascular bundles. These bridges join and meet in the centre of the leaf extending to the adaxial layer of chlorenchyma. The lamina cavities are present between the parenchymatous bridges of the lamina, the midrib vascular bundle and the adjacent vascular bundles. (44.6) Shows a small vascular bundle in *Fuirena hirsuta* with a few cells of translucent parenchyma present abutting the outer vascular sheath. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The sheath of border parenchyma is distinctive only on the phloem side of the vascular bundle.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Ca) lamina cavity; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (L) large vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (Pxl) protoxylem lacuna; (S) small vascular bundle; (SS) sclerenchymatous strands; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10 µm.
present between the large bundles, and extend above the small bundles (i.e. closer to the adaxial surface) that are present between these large bundles. In *F. cinnamomea* the cavity is present between the vascular bundles adjacent to the midrib, in the lamina, extending below the midrib, surrounding the phloem side of the midrib bundle (Plate 43.5). The lamina cavities in *B. maritimus* (Plate 42.12), *F. pinguior, Fuirena hirsuta* and *I. prolifera* are not present between the marginal bundle and the abutting bundle.

Present within the cavities is mostly thin-walled translucent "blue" parenchyma (Plate 43.11), whilst stellate chlorenchyma is present within the lamina cavities in *B. maritimus* (Plates 42.9 and 43.12) and the central cavity in *S. paludicola* (Plate 41.4). Lamina cavities are large in size when compared with lamina thickness (Tables 19A-D, Appendix 3), ranging from 26µm (*Ficinia indica* var. *indica*) to 533µm (central cavity in *Schoenoplectus paludicola*).

An adaxial hypodermis is present only in *Ficinia arenicola* var. *arenicola, F. bulbosa, F. dura, F. temuifolia* (Plate 44.1), *I. prolifera* and *Scirpus nodosus* (Tables 19A-D, Appendix 3). The hypodermis is generally present in the lamina, whilst the hypodermis in *F. temuifolia* is present only in the midrib (Plate 44.1). The thickest hypodermis was present in *F. bulbosa* (one to five cells) and the thinnest in *I. prolifera* (one cell). The cells of the hypodermis are thin-walled and translucent.

Generally, the tannin idioblasts of the *Scirpaceae* do not appear to be present at a specific site within the leaf tissue (Plate 44.1). The tannin idioblasts in the genus *Fuirena* are mostly present abutting the vascular bundles (Plates 41.6
and 44.2-3). Many of these tannin idioblasts are present in the Pbr abutting the xylem poles of the bundles. Additionally tannin idioblasts are also present but mostly within the margins (Fuirena hirsuta) and abutting the abaxial epidermis (S. falsus). However, there are few tannin idioblasts present in the leaves of the Scirpeae. Tannin idioblasts are absent in Ficinia bulbosa, F. filiformis, I. cernua and Schoenoplectus paludicola. (Plate 41.4). Many tannin idioblasts are present in the leaves of F. cinnamomea (Plate 43.1), F. fascicularis, F. lateraliscostata. F. tenuifolia (Plate 44.1), F. zeyheri and I. natans.

The mesophyll of the Scirpeae species is composed of thin-walled, non-radiating parenchymatous cells, with small chloroplasts (Plates 41.6, 42.2, 42.7, 42.12, 43.1, 43.5-7, 43.10 and 44.2-6). The mesophyll in S. paludicola may be divided into an outer layer composed of thin-walled chlorenchymatous parenchyma and an inner layer of translucent parenchyma (Plate 41.4). The vascular bundles are present within the chlorenchyma. The translucent parenchyma (TP) abuts the xylem pole of the large bundles and surrounds the SS of these bundles (Plate 41.4). Abutting the TP and extending to the centre of the leaf is the central cavity. Stellate parenchyma is present within the central cavity (Plate 41.4).

Parenchymatous bridges (Pbr) are present in nine species, namely B. maritimus (Plates 42.8-12 and 43.2-4), Ficinia fascicularis (Plate 44.4), F. pinguior (Plate 44.5), F. zeyheri, genus Fuirena (Plates 41.6 and 44.2-3), I. costata var. macra (Plate 41.5), I. diabolica and Scirpus nodosus. The cells of the parenchymatous bridges are large and thin-walled. The structure and site of these bridges is complex and will be discussed separately.

Pbr in B. maritimus are present at the abaxial and adaxial pole of the lamina bundles (Plates 42.9-11 and 43.2-4). The bridges ensheath the bundles and extend from the adaxial epidermis to the abaxial epidermis. The bundles present within these bridges only have one vascular bundle sheath. The abaxial bridges are smaller than the adaxial. Within the midrib, the structure and site of the bridges differ to the lamina (Plates 41.2 and 42.8). The midrib bundle only has adaxial bridges and no abaxial bridges. In the places where the parenchymatous bridge of the midrib bundle joins with the bridges of the adjacent small bundles, these merge and join the bridges of the intermediate bundles, which are adjacent to the small bundles. These combined bridges coalesce and extend to the adaxial epidermis. In the margins the Pbr are present on the adaxial pole of the marginal bundle and the adjacent large bundle (Plate 42.12). At this point the outer sheath of the marginal and adjacent large bundles abut. The bridges are composed of translucent "blue" and translucent parenchyma.

In F. fascicularis the Pbr are thin-walled and composed of TP cells, and extend from the xylem pole of the midrib bundle to the adaxial epidermis (Plate 44.4). Pbr in Ficinia pinguior are present abutting the adaxial poles of the midrib bundle, and the large and intermediate bundles (Plate 44.5). These bridges extend and meet near the centre of the leaf, where the bridges coalesce and extend to the mesophyll layer abutting the adaxial epidermis. The cells of these bridges abut the cavities. The parenchymatous bridges in F. zeyheri are present abutting the adaxial pole of the vascular bundles. These bridges extend to the adaxial epidermis.

The Pbr in Fuirena coerulescens are mostly present at the adaxial and abaxial poles of the lamina large bundles (Plate 44.3). These Pbr are mostly composed of tannin idioblasts. Pbr were not present at the abaxial pole of the large bundle nearest the margin. The Pbr are also present at the abaxial pole of a few lamina intermediate bundles. The Pbr in F. hirsuta are present abutting the adaxial pole of the large bundles and a few intermediate bundles (Plate
These bridges extend from the adaxial pole of the bundles to the adaxial epidermis. Pbr are also present on the adaxial and abaxial poles of the large and intermediate bundles in *F. pachyrrhiza*. As with *F. coerulescens*, the Pbr are mostly composed of tannin idioblasts. The cells of the Pbr ensheathe the HSS and abut the bundles.

In *I. costata* var. *macra* the Pbr are present abutting the adaxial poles of the lamina bundles, and join above the bundles (Plate 41.5). These bridges extend to the SS of the midrib bundle. The cavities of this species are present in between the bridges. Pbr in *I. diabolica* are present on the adaxial pole of the midrib bundle and the large bundles, these Pbr coalesce and extend to the hypodermis. As with *I. diabolica*, the Pbr in *S. nodosus* are present on the adaxial pole of the large and intermediate bundles, extending to the adaxial hypodermis.

Additional TP cells are present in *F. tribracteata*, where these cells extend from the SS and are present between the chlorenchymatous parenchyma of the mesophyll and the cavities (Plate 41.11). Abutting the adaxial and abaxial poles of a few of the vascular bundles in *Fuirena hirsuta*, are a few thin-walled TP cells (Plate 44.6). On the adaxial pole of the vascular bundles of *I. natans* extending to the centre of the leaf are a few TP cells.

Generally vascular bundles are present in a median row within the leaf mesophyll. *B. maritimus* has two rows of vascular bundles. The abaxial row consists of the midrib bundle, large, intermediate, small and marginal bundles. The adaxial row is composed of only small bundles. The vascular bundles of *S. paludicola* are present in one row, close to the epidermis, surrounded by the chlorenchyma (Plate 41.4). A midrib bundle is absent in *I. prolifer* (Plate 41.3), *S. paludicola* (Plate 41.4) and *Scirpus nodosus*.

Most of the vascular bundles of the *Scirpeae* are more than four cells apart. *Ficinia arenicola* var. *arenicola*, *F. bulbosa*, *F. dura*, *F. lateralis*, *F. stolonifera*, *F. zeyheri*, *Fuirena coerulescens*, *I. cernua*, *I. diabolica*, *Schoenoplectus paludicola*, *Scirpus ficinioides*, and *S. nodosus* have a maximal cell distal count of less than four cells.

*F. fascicularis*, *F. filiformis* and *F. stolonifera* only have a midrib bundle and marginal bundles. *F. lateralis* (inland and coastal) lacking intermediate bundles in the leaves. Similarly *F. arenicola* var. *arenicola*, *F. bulbosa*, *F. cinnamomea*, *F. lateralis*, and *F. pinguio* lack small bundles within the leaf tissues. Patterns with respect to number and location of vascular bundle within the laminae of the *Scirpeae* are uncommon (Tables 19A-D, Appendix 3). In *F. dura* and *Fuirena hirsuta* there is one small bundle present between the large and intermediate bundles. In the midrib of *B. maritimus* there is one small bundle present below the midrib bundle (Plates 41.2 and 42.8), similar to the genus *Kyllinga* and *C. semitrigonum* var. *semitrigonum* of the *Cypereae*. *B. maritimus* is the only species within the *Scirpeae* with this type of vascular bundle composition within the midrib.

Generally vascular bundles have two vascular bundle sheaths (Plates 42.8, 42.12, 43.8-9 and 44.3), an outer parenchymatous sheath (PS) and an inner lignified mestome sheath (MS). A third additional bundle sheath is present in *B. maritimus*, *F. cinnamomea*, *F. fascicularis*, *F. lateralis*, *F. pinguio*, the genus *Fuirena*, *I. fluitans*, *I. prolifer* and *Schoenoplectus paludicola*. This third, inner sheath is composed of non-lignified border parenchyma (BP, Plates 43.6-7, 43.10, 44.3 and 44.6).
The cells of the PS are large, thin-walled and chlorenchymatous. The PS cells in Ficinia indica, F. pinguior, I. costata var. macra and Scirpus fexioides lack chloroplasts. The cells of the parenchymatous sheath are generally larger than the abutting mestome sheath cells (Plates 42.8, 42.12, 43.8-7 and 44.3).

The walls of the MS cells have thick-walls generally in the radial and inner-tangential walls (Plate 43.6-7, Appendix 4). The thickening in most species is pronounced abutting the phloem side of the bundle. The walls of the MS in Schoenoplectus paludicola are relatively thin-walled in the small and intermediate bundles. A few species have similar lignification in all the MS walls, namely Ficinia cinnamomea (Plate 43.10), F. stolonifera, F. tenuifolia, F. zeyheri, genus Fuirena and Schoenoplectus paludicola (large bundles).

The cells of the BP are thin-walled. A BP is present on the phloem side of the bundles in F. fascicularis, F. lateralsalens, F. pinguior and Schoenoplectus paludicola. The BP of the midrib bundle, the large and intermediate bundles in B. maritimus, F. cinnamomea (Plate 43.10), the genus Fuirena (Plate 44.3), I. fluitans and I. prolifera is bisected by the large metaxylem vessels, as well as by the protoxylem lacunae or by a protoxylem vessel (Plates 42.9, 43.6-7, 43.10 and 44.3), where present. Additionally the small bundles in B. maritimus, the genus Fuirena (Plate 44.6) and I. prolifera have a BP present on the phloem side of the small and marginal bundles. The cells of the BP are small to medium sized.

Phloem and xylem shapes vary, see Appendix 4 for detail. Protoxylem lacunae (PxL) are common in the Scirpeae leaves. Nineteen species have PxL present in the midrib bundles, namely B. maritimus (Plate 42.8), Ficinia bulbosa, F. cinnamomea (Plate 43.10), F. dura, F. filiformis, F. lateralscostata, F. lateralssalens, F. pinguior, F. tenuifolia, F. zeyheri, Fuirena coerulescens, F. hirsuta, F. pachyrrhiza, I. cernua (Plate 43.8), I. costata var. macra, I. diabolica, I. fluitans (Plate 43.6), I. natans and Scirpus falsus. Twenty species have PxL present in the large bundles, namely B. maritimus (Plate 43.3), Ficinia arenicola var. arenicola, F. bulbosa, F. cinnamomea, F. dura, F. lateralsalens, F. pinguior, F. tenuifolia, F. trinbracteata, Fuirena coerulescens, F. hirsuta, F. pachyrrhiza, I. cernua (Plate 43.9), I. costata var. macra, I. diabolica, I. fluitans, I. natans, Schoenoplectus paludicola, Scirpus falsus and S. nodosus. Only five species have PxL present in the marginal bundles, namely F. lateralsalens, F. tenuifolia, F. stolonifera, F. zeyheri and Fuirena pachyrrhiza.

9.2.4 Bract Characteristics of the tribe Scirpeae

Eight species of the Scirpeae lack bracts. These are Eleocharis dregana, E. limosa, E. pauciflora, Ficinia bulbosa, F. filiculmea, F. tenuifolia, I. fluitans and I. pellecole. Bract outline of the Scirpeae may be divided into five shapes: V-shaped (most species); crescentiform (F. cinnamomea, Ficinia lateralsalens, F. repens, I. costata var. macra, I. diabolica and I. prolifera); triangular (F. pinguior, F. zeyheri and I. natans), circular (F. stolonifera and Schoenoplectus paludicola) and curved rectangular (Schoenoplectus decipiens). The V-shaped bracts may be divided into three sub-groups, namely true V-shaped (B. maritimus), thinly V-shaped (Fuirena pachyrrhiza and I. cernua) and thickly V-shaped (most species). The crescentiform bracts may be divided into two sub-groups, namely true crescentiform (Ficinia lateralsalens, I. diabolica and I. prolifera) and thickly crescentiform (F. cinnamomea, F. repens and I. costata var. macra). The triangular bracts may be divided into two sub groups, namely sub-triangular (adaxially concave, F. pinguior) and true triangular (I. natans [adaxially concave], F. zeyheri). Bracts ranged from 66µm (F. oligantha) to 1408µm (Schoenoplectus paludicola) in size. No distinctive midribs are present in Ficinia.
repens, F. stolonifera and Schoenoplectus paludicola. Midribs are generally thicker than the lamina (Table 20A-D, Appendix 3), with the exception of F. arenicola var. arenicola, F. indica var. indica, F. tribracteata, I. cernua, I. costata var. macra and I. diabolica.

Multi-cellular trichomes are present in Fuirena coerulescens, F. hirsuta, I. diabolica and I. prolifera (Table 20A-D, Appendix 3, Plate 45.1-3). The trichomes in Fuirena coerulescens, I. diabolica (Plate 45.1) and I. prolifera are present at the margins of the bracts. The trichomes are formed as a continuation of the adaxial and abaxial epidermis at the margin (Plate 45.1). Adaxial trichomes are present at random along the adaxial epidermis in F. coerulescens (Plate 45.2). The trichomes in F. hirsuta are present in the abaxial epidermis of the midrib (Plate 45.3), similar to the papillate cells of the genus Carex.

Both F. stolonifera and Schoenoplectus paludicola are unifacial (circular). The outer periclinal walls of the epidermal cells are thick-walled (Plates 45.1-12, 46.1-12 and 47.1-3). Only F. lateraliscomul and I. prolifera have bulliform cells present in the adaxial epidermis. The bulliform cells in F. lateralis are present in the midrib, whilst I. prolifera lacks a midrib and the bulliform cells are present in the mid-lamina region. The bracts of the Scirpeae species have different adaxial and abaxial epidermal shapes. The adaxial epidermal cells of the Scirpeae bracts are larger than abaxial epidermal cells (Plate 45.4, Tables 20A-D, Appendix 3), with the exception of F. repens, F. zeyheri, I. prolifera and Scirpus ficinioides. The adaxial epidermal cell size range from 3μm (F. fascicularis) to 80μm (I. prolifera). The abaxial epidermal cell size, range from 5μm (F. fascicularis and F. repens) to 28μm (Fuirena hirsuta). Large marginal epidermal cells are present in B. maritimus and Scirpus ficinioides (Plate 45.5 and 45.7), where these cells are larger than the abutting cells of the adaxial and abaxial epidermis.

Cone-shaped silica deposits are present in both the adaxial and abaxial epidermal cells of most of the Scirpeae (Plate 45.5). Neither I. natans nor Schoenoplectus paludicola (Plate 45.6) have cone-shaped silica deposits present in the bracts. The species with only adaxial cones are F. stolonifera and I. costata var. macra. Abaxial cones are only present in F. cinnamomea, F. lateraliscomul, F. repens, F. tribracteata, F. zeyheri, I. cernua, I. diabolica, I. prolifera and Scirpus nodosus. The structure and location of cells that contain these deposits is the same as that of the leaves. Similarly the structure and location of the cells abutting these cells containing the silica deposits is also the same as that of the leaves.

The stomata of the Scirpeae bracts are generally present in the abaxial epidermis (Plate 45.9-12). The bracts in B. maritimus (Plate 45.8), Ficinia arenicola var. arenicola, F. pinguisor, F. repens, F. tribracteata and I. costata var. macra are amphistomatous. Generally the stomata in the bracts of the Scirpeae are flush with the epidermal surfaces (Plate 45.11). Scirpus nodosus has slightly sunken stomata (Plate 45.9). The stomata in F. lateralis (Plate 45.10), F. oligantha, Fuirena coerulescens, F. pachyrhiza and Schoenoplectus decipiens are raised. The lignification of the stomata is variable, see Plates 45.9-12 and Appendix 4. Sub-stomatal cavity size is small in relation to the bract thickness (Tables 20A-D, Appendix 3), ranging from less than 1μm (Schoenoplectus decipiens) to 91μm (Scirpus nodosus). Horn-shaped lignifications are also present on the adaxial poles in F. filiformis and Schoenoplectus paludicola (Plate 45.12), which are also present at the abaxial pole of the guard cells in the genus Fuirena and Scirpus falsus. Both Fuirena coerulescens and F. pachyrhiza have bulbous silica ensheathed lignified extensions of the subsidiary cells that protrude into the sub-stomatal cavities (Plate 46.1).
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Plate 45. Shows structural details of the bracts of the *Scirpeae* in section, including trichome structure and arrangement; adaxial, abaxial and marginal epidermis structure; stomatal complexes and sub-stomatal cavity arrangement and structure; hypodermal sclerenchymatous strand structure and arrangement; hypodermis; mesophyll structure; vascular arrangement; and vascular spacing, as well as vascular sheaths.

(45.1) Shows the multicellular trichome present at the margin in *Isolepis diabolica* with abutting marginal hypodermal sclerenchymatous strands. (45.2) An adaxial unicellular trichome in *Fuirena coerulescens* with thick-walled outer periclinal wall. (45.3) Shows a papillate, abaxial unicellular trichome in *F. hirsuta* with thick-walled outer periclinal wall. (45.4) The adaxial epidermal cells in *Scirpus nodosus* are larger than abaxial epidermal cells. Abaxial hypodermal sclerenchymatous strands are present between vascular bundles. Chlorenchyma extends from the adaxial epidermis to the phloem side of the lamina vascular bundles and midrib vascular bundle. Chlorenchyma however, surrounds all the marginal vascular bundles. A large adaxial hypodermis extends from the adaxial epidermis to the xylem side of the lamina and midrib vascular bundles. (45.5) Shows that the marginal epidermal cells in *S. flaciioides* are larger than the abutting adaxial and abaxial epidermal cells. The outer periclinal wall of the epidermal cells is thick-walled in the outer periclinal wall. Note the cone-shaped silica deposit in the abaxial epidermal cell abutting the hypodermal sclerenchymatous strands. (45.6) The abaxial epidermal cells in *Schoenoplectus paludicola* that abut the hypodermal sclerenchymatous strands have no cone-shaped silica deposits.

Note that the epidermal cells abutting the hypodermal sclerenchymatous strands are smaller than the adjacent epidermal cells. Epidermal cells are thick-walled in the outer periclinal wall. (45.7) The epidermal cells in *Bolboschoenus maritimus* are thick-walled in the outer periclinal wall. Note that the marginal epidermal cell is larger than the adjacent adaxial and abaxial epidermal cells. Present in the margin of this species is a single group of hypodermal sclerenchymatous strands. (45.8) Shows a flush abaxial stoma in *Bolboschoenus maritimus*. Epidermal cells are thick-walled in the outer periclinal wall. The marginal vascular bundle has an adjacent group of adaxial hypodermal sclerenchymatous strands. Chlorenchyma extends from the adaxial epidermis to the abaxial epidermis, surrounding the marginal vascular bundle. The chlorenchyma is composed of thin-walled cells with many chloroplasts. Tannin idioblasts are present mostly abutting the vascular bundles. The marginal vascular bundle has two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is thin-walled and chlorenchymatous. (45.9) The stomata in *Scirpus nodosus* are present in the abaxial epidermis. The epidermal cells and subsidiary cells abutting the guard cells are thick-walled in the outer periclinal wall. Guard cells are thick-walled in the periclinal walls. Stomata have large sub-stomatal cavities. (45.10) Shows the stomata of *Ficinia lateralis* are present in the abaxial epidermis, where the stomata are slightly raised. Stomata have small sub-stomatal cavities. Epidermal cells abutting the stomata and the subsidiary cells of the stomata are thick-walled in the outer periclinal wall. The guard cells are thick-walled in the periclinal walls. (45.11) The stomata in *F. arenicola* var. *arenicola* are present in the abaxial epidermis, where the stomata are flush with the epidermis. Epidermal cells abutting the stomata and the subsidiary cells of the stomata are thick-walled in the outer periclinal wall. The guard cells are thick-walled in the periclinal walls. The sub-stomatal cavities of the stomata are small. (45.12) Shows that the stomata in *Schoenoplectus paludicola* are present in the abaxial epidermis and are flush to slightly sunken. The outer periclinal wall of the subsidiary cells and the abutting epidermal cells are thick-walled. The guard cells are thick-walled in the periclinal walls. Additionally, there are horn shaped lignin deposits on the abaxial pole of guard cells.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (C) cone shaped silica deposit; (H) horn shaped lignin deposit; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (Ma) marginal vascular bundle; (MeP) marginal epidermal cell; (MS) mestome sheath; (NC) no cone shaped silica deposit in epidermal cell; (OT) outer periclinal wall (tangential); (PS) parenchymatous sheath; (St) stoma; (Stc) sub-stomatal cavity; (Su) subsidiary cell and (Tr) trichome. Bars = 10 μm.
Plate 45. Legend on facing page.
Plate 46. Shows structural details of the bracts of the Scirpaceae in section, including adaxial and abaxial epidermis; stomatal complex structure; hypodermal sclerenchymatous strands, girders, sclerenchymatous strand arrangement and structure; lamina cavity arrangement; tannin idioblast arrangement and structure; mesophyll structure including parenchymatous bridges and translucent parenchyma; vascular bundle arrangement and spacing; and vascular sheaths, as well as tissues.

(46.1) Shows the stomata in Fuirena coerulescens are present within the abaxial epidermis, where they are raised above the surface. The epidermal cells abutting the stomata have thick-walls in the outer periclinal wall. As with the leaves, there are silica and lignin adaxial expansions of the subsidiary cells, which extend into the sub-stomatal cavity. The subsidiary cells are relatively thin-walled when compared to the guard cells and the abutting epidermal cells. (46.2) The adaxial epidermal cells in F. coerulescens are larger than the abaxial epidermal cells. The intermediate vascular bundles have an abaxial girder. The mesophyll is composed of thin-walled, non-radiating chlorenchyma, which surrounds the vascular bundles. Tannin idioblasts are mostly present in the outer sheath of the vascular bundles. Intermediate vascular bundles have three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and a partial non-lignified sheath of border parenchyma. The cells of the parenchymatous sheath are thin-walled and some are chlorenchymatous. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (46.3) The epidermal cells in Isolepis cernua are thick-walled in the outer periclinal wall. Hypodermal sclerenchymatous strands are present at random along the epidermis. Large translucent and chlorenchymatous cells surround the midrib and extend to the xylem poles of the marginal vascular bundles. Smaller chlorenchymatous cells extend from the epidermis to the phloem side of the marginal vascular bundles and the central large cells surrounding the midrib. Tannin idioblasts are present mostly abutting the adaxial epidermis. (46.4) Both the adaxial and abaxial hypodermal sclerenchymatous strands are present adjacent to the large vascular bundles in the lamina of Bolboschoenus maritimus. The large vascular bundles of the lamina have abutting adaxial sclerenchymatous strands. Extending from the adaxial hypodermal sclerenchymatous strands, ensheathing the lamina vascular bundles to the abaxial hypodermal sclerenchymatous strands is a parenchymatous bridge. The cells of this bridge are thin-walled and translucent. Chlorenchyma extends from the adaxial epidermis to the abaxial epidermis and is interrupted by the parenchymatous bridges. The cells of the chlorenchyma are thin-walled, are mostly rectangular and have numerous small chloroplasts. There are two vascular sheaths, an outer lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the protoxylem lacuna. (46.5) The intermediate vascular bundles in B. maritimus have adjacent adaxial and abaxial hypodermal sclerenchymatous strands. The intermediate vascular bundles of the lamina have abutting adaxial sclerenchymatous strands. Extending from the adaxial hypodermal sclerenchymatous strands, ensheathing the lamina vascular bundles to the abaxial hypodermal sclerenchymatous strands is a parenchymatous bridge. Tannin idioblasts mostly abut the parenchymatous bridges. Chlorenchyma extends from the adaxial epidermis to the abaxial epidermis, where the chlorenchyma is interrupted by the parenchymatous bridges. The cells of the chlorenchyma are thin-walled, are mostly rectangular and have numerous small chloroplasts. There are two vascular sheaths, an outer lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. (46.6) In the lamina of Ficinia cinnamonoea the abaxial hypodermal sclerenchymatous strands are present adjacent to the vascular bundles. A few of the vascular bundles also have adaxial hypodermal sclerenchymatous strands adjacent to the vascular bundles. Epidermal cells abutting the hypodermal sclerenchymatous strands are smaller than the epidermal cells adjacent to the strand. The small vascular bundles have two distinctive vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is composed of thin-walled chlorenchymatous cells. The mestome sheath is lignified in all walls, especially on the phloem side of the vascular bundle. (46.7) The adaxial epidermal cells in F. cinnamonoea are larger than the abaxial epidermal cells. Most of the large vascular bundle have adjacent adaxial and abaxial hypodermal sclerenchymatous strands. The lamina cavities are present between vascular bundles. The large vascular bundles have three distinctive vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheaths are thick-walled in all the walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels. (46.8) Shows that the large vascular bundles in the lamina of Scirpus ficioides have two abaxial hypodermal sclerenchymatous strands present adjacent to the vascular bundle. Present on the adaxial pole of these vascular bundles are abutting sclerenchymatous strands. The mesophyll is composed of chlorenchyma, which extends from the epidermis to the phloem and xylem sides of the vascular bundles. The lamina cavities are present between the vascular bundles. The large vascular bundles have three distinctive vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled translucent cells. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by three large metaxylem vessels and a protoxylem vessel.

(Legend continues on the next facing page)
Plate 46. Legend on facing page.
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(46.9) The outer periclinal wall of the epidermal cells in *Schoenoplectus paludicola* are thick-walled. The intermediate vascular bundles have abutting hypodermal sclerenchymatous strands. On the xylem pole of the vascular bundle is a sclerenchymatous strand. The mesophyll is composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the xylem pole of the vascular bundle. Abutting the sclerenchymatous strands of the vascular bundle are two cells of translucent thin-walled parenchyma. Endarch to the translucent parenchyma and the chlorenchyma is a central cavity. There are two distinctive vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is composed of large, thin-walled, translucent cells, except at the phloem pole of the vascular bundle, where these cells are small and chlorenchymatous. The mestome sheath is composed of small, thick-walled cells in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. On the xylem side of the vascular bundle the cells are larger than on the phloem side and are relatively thin-walled. (46.10) Shows the small vascular bundle in *B. maritimus* with adjacent abaxial hypodermal sclerenchymatous strands. Present on the adaxial pole of the small vascular bundle are abutting sclerenchymatous strands. Parenchymatous bridges extend from both the xylem and phloem poles of the vascular bundles, to the adaxial epidermis and abaxial hypodermal sclerenchymatous strands, respectively. The thin-walled, rectangular chlorenchyma is interrupted only by the parenchymatous bridges. Tannin idioblasts are mostly present abutting the outer sheath of the vascular bundles. This small vascular bundle has two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is thin-walled and chlorenchymatous. (46.11) The margin in *F. cinnamomea* with adaxial epidermal cells, which are larger in size than the abaxial epidermal cells. There are two groups of marginal hypodermal sclerenchymatous strands. The marginal vascular bundle has two groups of adjacent abaxial hypodermal sclerenchymatous strands. Thin-walled chlorenchyma is present in the margin and is interrupted only by the lamina cavity, which is present between the vascular bundles. The marginal vascular bundle has two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is thin-walled and chlorenchymatous. The mestome sheath is thick-walled in all the walls, especially on the phloem side of the vascular bundle. (46.12) The midrib vascular bundle in *F. cinnamomea* with two groups of adjacent abaxial hypodermal sclerenchymatous strands. The midrib has three distinctive vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheaths cells are thick-walled in the all the walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by three metaxylem vessels and a protoxylem vessel.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Ep) epidermal cell; (HSS) hypodermal sclerenchymatous strands; (Li) lignified part of subsidiary cell; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (OT) outer periclinal wall (tangential); (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (SS) sclerenchymatous strands and (T) tannin idioblast. Bars = 10 μm.
The HSS, girders and SS are composed of small lignified cells of variable outline (see Appendix 4, Plates 45.6-8, 46.2, 46.4-12 and 47.2-5). There are no adaxial HSS in the species *Ficinia lateralis*, *F. oligantha*, *F. zeyheri*, *I. natans*, *I. prolifera* and *Scirpus nodosus*. The unifacial species *Schoenoplectus paludicola* has girders abutting the large and intermediate bundles. Girders are also present in *Fuirena coerulescens*, where they are present on the adaxial pole of the marginal bundles. These girders are also present at the abaxial pole of the midrib bundle, as well as the large and intermediate bundles (Plate 46.2).

Generally HSS are present between the bundles (Plate 46.3). The vascular bundles of a few species have adjacent adaxial and abaxial HSS. Adaxial and abaxial HSS are present adjacent to the midrib bundle (*Ficinia pinguior*), the large bundles (*B. maritimus* [Plate 46.4]) and intermediate bundles (*B. maritimus* [Plate 46.5] and *F. pinguior*). The marginal bundles in *B. maritimus, Fuirena coerulescens, F. hirsuta, F. pachyrrhiza* and *Scirpus falsus* have adjacent adaxial HSS. Generally, species have an abaxial HSS adjacent the vascular bundles. The large bundles (*Ficinia cinnamomea* [Plate 46.7], *F. indica* var. *indica*, *Fuirena coerulescens*, *F. pachyrrhiza*, *Schoenoplectus paludicola*, *S. ficinioides* [Plate 46.8] and *S. nodosus*), intermediate bundles (*Ficinia cinnamomea*, *Fuirena coerulescens*, *Schoenoplectus paludicola* [Plate 46.9] and *S. ficinioides*), small bundles (*B. maritimus* [Plate 46.10], *Fuirena coerulescens* and *Schoenoplectus paludicola*) and marginal bundles (*Ficinia cinnamomea* [Plate 46.11], *F. fascicularis*, *F. indica* var. *indica*, *F. repens*, *F. zeyheri*, *Fuirena coerulescens*, *F. pachyrrhiza* and *S. falsus*) have an adjacent abaxial HSS. Adjacent the midrib there are one abaxial HSS (*Ficinia lateralis*, *F. pinguior*, *F. zeyheri*, the genus *Fuirena, I. cernua, I. costata* var. *macra*, *I. prolifera* and *Scirpus ficinioides*), two abaxial HSS (*Ficinia arenicola* var. *arenicola*, *F. cinnamomea* [Plate 46.12], *F. dura*, *F. indica* var. *indica*, *F. lateralis*, *F. trirhacteata*, *I. natans*, *Schoenoplectus decipiens*, *Scirpus falsus* and *S. nodosus*) or three abaxial HSS (*B. maritimus, F. fascicularis, F. filiformis, F. oligantha* and *I. diabolica* [Plate 47.1]).

The *Scirpeae* have more abaxial HSS/girders than adaxial HSS/girders (Tables 20A-D, Appendix 3). Generally the adaxial HSS/girders are larger than the abaxial HSS/girders (Tables 20A-D, Appendix 3). Abaxial HSS/girders are larger than the adaxial in *Ficinia cinnamomea*, *F. fascicularis*, *Fuirena hirsuta*, *F. pachyrrhiza*, *I. cernua* and *I. costata* var. *macra*. The adaxial HSS sizes range from 7μm (*I. cernua*) to 65μm (*Scirpus falsus*). The abaxial HSS sizes range from less than 1μm (*B. maritimus*) to 75μm (*S. nodosus*).

Most *Scirpeae* species lack SS in the laminae of the bracts. SS are present in *B. maritimus, Ficinia arenicola* var. *arenicola*, *F. cinnamomea*, *F. dura*, *F. indica* var. *indica*, *F. fascicularis*, *F. lateralis*, *F. stolonifera*, *F. trirhacteata*, *F. zeyheri*, *Fuirena pachyrrhiza*, *I. prolifera*, genus *Schoenoplectus, Scirpus falsus* and *S. ficinioides*. The SS mostly abut the xylem pole of the vascular bundles (Plate 46.9). In *Schoenoplectus paludicola* SS are also present abutting the phloem poles of a few of the large, intermediate and small bundles. The SS in *Ficinia lateralis*, *F. trirhacteata* and *S. paludicola* are present inside the outer sheath. The SS abut the xylem pole of the midrib bundle (*B. maritimus* [Plate 47.2], *Ficinia arenicola* var. *arenicola*, *F. dura*, *F. fascicularis*, *F. lateralis*, *F. trirhacteata*, *F. zeyheri*, *Fuirena coerulescens*, *F. pachyrrhiza*, and the genus *Scirpus* [Plate 46.8]), the large bundles (*B. maritimus* [Plates 46.4 and 47.3], *Ficinia arenicola* var. *arenicola*, *F. dura*, *F. stolonifera*, *Fuirena coerulescens, I. prolifera*, *Schoenoplectus decipiens* and the genus *Scirpus*), the intermediate bundles (*B. maritimus* [Plates 46.5 and 47.5], *Ficinia arenicola* var. *arenicola, F. dura, Schoenoplectus decipiens* and the genus *Scirpus*), small bundles (*B. maritimus* [Plates 46.10 and 47.5]) and the marginal bundles (*Ficinia arenicola* var. *arenicola*, *F. dura*, *F. fascicularis* and the genus *Scirpus*).
Plate 47. Shows structural details of the bracts of selected Scirpeae in section, including the following: adaxial and abaxial epidermis; hypodermal sclerenchymatous strands, girders and sclerenchymatous strand arrangement; lamina cavity structure and arrangement; hypodermis; tannin idioblast arrangement and structure; mesophyll structure including parenchymatous bridges and stellate parenchyma; vascular bundle arrangement and spacing; and vascular sheaths, as well as tissues.

(47.1) Shows the abaxial epidermal cells in Isolepis diabolicola, which are thick-walled in the outer periclinal wall. The midrib vascular bundle with adjacent abaxial hypodermal sclerenchymatous strands. Extending from the xylem pole of the vascular bundle to the adaxial epidermis is a parenchymatous bridge, composed of thin-walled translucent parenchyma. Thin-walled, rectangular chlorenchyma surrounds the vascular bundles, interrupted only by the parenchymatous bridges. There are two distinctive vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is thin-walled and chlorenchymatous. (47.2) The midrib vascular bundle in Bolboschoenus maritimus with abutting adaxial sclerenchymatous strands. Tannin idioblasts abut the outer sheath of the vascular bundle. The midrib vascular bundle has three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled, chlorenchymatous cells. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the protoxylem lacuna. (47.3) Shows a large vascular bundle in B. maritimus with adjacent adaxial hypodermal sclerenchymatous strand and abutting adaxial sclerenchymatous strands. A parenchymatous bridge extends from the sclerenchymatous strands to the adaxial epidermis and the adaxial hypodermal sclerenchymatous strands. The large vascular bundle has three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled translucent cells. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels. (47.4) A high power view of an intermediate vascular bundle in B. maritimus with abutting adaxial sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels. (47.5) Shows a high power view of a small vascular bundle in B. maritimus with abutting adaxial sclerenchymatous strands. The small vascular bundle has two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. (47.6) The mesophyll in Schoenoplectus paludicola is composed of chlorenchyma, translucent parenchyma and stellate parenchyma. The chlorenchyma extends from the epidermis to the xylem pole of the vascular bundles. Endarch to the chlorenchyma is a layer of translucent parenchyma, which extends for one to five cells to the central cavity. Present in the cavity are large stellate parenchyma cells. (47.7) The lamina cavity in Ficinia dura extends from the adaxial epidermis to the transversal parenchyma, which is present at the xylem pole of the vascular bundles. A few cells of translucent parenchyma abut the vascular bundles. Present within the lamina cavity are a few cells of translucent "blue" parenchyma. The large vascular bundles have an adaxial sclerenchymatous strand present between the translucent parenchyma and the xylem poles of the vascular bundles. The midrib vascular bundle has three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle and abutting the metaxylem vessels. The sheath of border parenchyma is interrupted by two large metaxylem vessels and a protoxylem vessel. (47.8) Shows a high power view of thin-walled, translucent stellate parenchymatous cell in S. paludicola. (47.9) The midrib in B. maritimus with larger adaxial epidermal cells than abaxial epidermal cells. The epidermal cells are thick-walled in the outer periclinal wall. The midrib vascular bundle has two adjacent abaxial hypodermal sclerenchymatous strands and abutting adaxial sclerenchymatous strands. Extending from the adaxial epidermis to the midrib vascular bundle and adjacent small vascular bundle is an adaxial hypodermis composed of thin-walled translucent cells. Chlorenchyma extends from the abaxial epidermis to the vascular bundles and the hypodermis. (47.10) The adaxial epidermal cells of Scirpus nodosus are larger than abaxial epidermal cells. A large adaxial hypodermis extends from the adaxial epidermis to the xylem side of the midrib and large vascular bundles, as well as to the xylem pole of the small vascular bundles. Chlorenchyma surrounds the marginal vascular bundles. The hypodermis consists of large, thin-walled and lignified cells. There are two rows of vascular bundles. The abaxial row consists of small and intermediate vascular bundles. The adaxial row consists of the midrib, large, intermediate and marginal vascular bundles. (47.11) Shows the margin in Fuirena pachyrrhiza where the epidermal cells are thick-walled in the outer periclinal wall. Marginal hypodermal sclerenchymatous strands are present adjacent to the marginal vascular bundle and extend to form a girdle on the adaxial large vascular bundle. The mesophyll consists of chlorenchyma that is non-radiating and composed of mostly rectangular, thin-walled cells. Note particularly that the tannin idioblasts are mostly present abutting the sclerenchymatous tissues. Both the marginal vascular bundle and the adjacent large vascular bundle have a large protoxylem lacuna.

(Legend continues on the next facing page)
Plate 47. Legend on facing page.
(47.12) The midrib vascular bundle in Ficinia tribracteata has a parenchymatous bridge, which extends from the xylem pole to the adaxial epidermis. Vascular bundles are present in one row and are two to three cells apart.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Ca) lamina cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (G) girder; (HSS) hypodermal sclerenchymatous strands; (Hy) hypodermis; (I) intermediate vascular bundle; (L) large vascular bundle; (Ma) marginal vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (S) small vascular bundle; (SS) sclerenchymatous strands; (StP) stellate parenchyma; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10 μm.
Lamina cavities are present in 13 species (Plates 46.6-8, 46.11-12 and 47.6-7), namely *Ficinia arenicola* var. *arenicola*, *F. cinnamomea* (Plate 46.6-7 and 46.11-12), *F. dura* (Plate 47.7), *F. fascicularis*, *F. jiliformis*, *Fuirena coerulescens*, *F. hirsuta*, *F. pachyrrhiza*, *I. natans*, *I. prolifera*, *Schoenoplectus paludicola* (Plates 46.8 and 47.6), *Scirpus falsus* and *S. jicinioides*. Three types of cavities are present, where the first occurs between the vascular bundles (most species, Plate 46.6-7 and 46.11-12) and the second near the centre of the bract (*Schoenoplectus paludicola* [Plate 47.6]). The third occurs above the bundles, extending to the adaxial epidermis (*F. dura* [Plate 47.7]). There are eight different cavity outlines (these are detailed in Appendix 4). Central cavities are the largest in size. Lamina cavities are small, but large in relation to the thickness of the bracts (Tables 20A-D, Appendix 3), ranging from 23 μm (*Fuirena coerulescens*) to 438 μm (*Schoenoplectus paludicola*).

The tissue present within the cavities is generally lobed translucent "blue" parenchyma (Plate 47.7). Whilst TP is present within the cavities of *Ficinia cinnamomea*, *Fuirena pachyrrhiza* and *I. prolifera*. Stellate parenchyma is present only in the central cavities of *Schoenoplectus paludicola* (Plate 47.6 and 47.8).

An adaxial hypodermis is present in the bracts of *B. maritimus* (Plate 47.9), *Ficinia arenicola* var. *arenicola*, *F. dura*, *F. lateralis*, *Scirpus decipiens*, *Scirpus falsus*, *S. fiicinoides* and *S. nodosus* (Tables 20A-D [Appendix 3], Plates 45.4 and 47.10). The hypodermis is present in most species abutting the epidermis from the margin to the midrib (Plates 45.4 and 47.10). In the bracts of *B. maritimus* (Plate 47.9), *F. lateralis*, *Scirpus decipiens* and *Schoenoplectus decipiens* the hypodermis is only present in the midrib. The hypodermis in *F. indica* var. *indica* extends to the xylem side of the bundles and abuts the cavities. Similarly within the lamina of *Scirpus nodosus* the hypodermis extends from the adaxial epidermis to the xylem side of the bundles (Plates 45.4 and 47.10). The cells of the adaxial hypodermis are composed of lignified, translucent cells, with the exception of *B. maritimus*, *F. dura* and *Scirpus fiicinoides*, where the cells are not lignified.

Tannin idioblasts are absent in the laminae of *F. filiformis*, *I. natans*, *I. prolifera* and *Schoenoplectus paludicola* (Plate 47.6). Generally tannin idioblasts are scattered throughout the mesophyll. Tannin idioblasts in *B. maritimus* are mostly present within the parenchymatous bridges (Plate 46.4-5). The tannin idioblasts in *Fuirena jiliformis* are present abutting the vascular bundles. Tannin idioblasts in *F. pachyrrhiza* are present abutting the sclerenchymatous tissues of the bract (Plate 47.11). The tannin idioblasts in both *I. costata* var. *macro* and *Scirpus falsus* are present abutting the abaxial epidermis. Tannin idioblasts in *Ficieina lateralis* abutted the adaxial epidermis. Generally there are few tannin idioblasts present in the laminae. In *Ficieina fascicularis* and *F. oligantha* there are many tannin idioblasts.

With the exception of the species with Pbr and cavities adaxial to the bundles, chlorenchymatous parenchyma surrounds the vascular bundles of the Eastern Cape *Scirpei*. The cells of the chlorenchymatous parenchyma are thin-walled and non-radiating. Pbr are present in *B. maritimus* (Plates 46.4-5, 46.10 and 47.3), *Ficieina filiformis*, *F. tribracteata*, *Fuirena hirsuta* (plate 48.1), *I. diabolica* (Plate 48.2-3) and *I. natans*. These Pbr are mostly composed of thin-walled translucent parenchyma (TP). The cells of the TP are much larger than the chlorenchyma cells. The Pbr in *B. maritimus* are present on the adaxial and abaxial poles of the large, intermediate and small bundles (Plates 46.4-5, 46.10 and 47.3). These Pbr extend from the adaxial HSS to the abaxial HSS ensheathing the vascular bundles. Many of the Pbr do not ensheathe the bundle and extend only from the HSS to the xylem or phloem poles of the bundles. The Pbr in *Ficieina filiformis* are present on the adaxial pole of the midrib bundle. This bridge interrupts...
Plate 48. Shows structural details of the bract girders, sclerenchymatous strands, lamina cavities, parenchymatous bridges, translucent parenchyma, vascular sheath and tissue structure of few of selected Scirpeae.

(48.1) Shows a large vascular bundle in *Fuirena hirsuta* with abutting abaxial girdler. A parenchymatous bridge extends from the adaxial pole of the vascular bundle to the adaxial epidermis. Tannin idioblasts are mostly present around the vascular bundles. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the protoxylen lacuna. (48.2) The midrib vascular bundle in *Isoepis diabolica* has an adaxial parenchymatous bridge, which extends from the xylem pole to the adaxial epidermis. The cells of the bridge are thin-walled and translucent. The cells of the chlorenchyma surrounding the vascular bundle and the translucent parenchyma are thin-walled and contain numerous chloroplasts. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels. (48.3) Shows an intermediate vascular bundle in *I. diabolica* with an adaxial parenchymatous bridge composed of thin walled translucent parenchyma extending from the xylem pole to the adaxial epidermis. In the midrib vascular bundle, there are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels. (48.4) The midrib vascular bundle in *Ficinia dura* with abutting adaxial sclerenchymatous strands and translucent parenchyma. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the protoxylen lacuna. (48.5) Shows the midrib vascular bundle in *I. costata* var. *maera* has partial vascular sheaths and mixed vascular tissues. Only on the abaxial side of the vascular bundle are two sheaths recognisable, an outer parenchymatous sheath and an inner mestome sheath. (48.6) The marginal vascular bundle in *I. costata* var. *maera* has partial vascular sheaths and mixed vascular tissues. Only on the abaxial side of the vascular bundle are two sheaths recognisable, an outer parenchymatous sheath and an inner mestome sheath. A small amount of phloem can be recognised inside the two sheaths on the abaxial pole of the vascular bundle.

Symbols are as follows: (Ad) adaxial epidermis; (BP) border parenchyma; (Ca) lamina cavity; (G) girder; (MS) mestome sheath; (MX) metaxylem vessel; (P) phloem; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (PxL) protoxylen lacuna; (SS) sclerenchymatous strands; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10 \( \mu \text{m} \).
the cavity and abuts the adaxial mesophyll. The Pbr in *F. tribracteata* extend from the xylem pole of the midrib bundle to the adaxial epidermis. This Pbr abuts the xylem poles of the marginal bundles (Plate 47.12). The Pbr in *Fuirena* *hirsuta* extend from the adaxial poles of the midrib bundle and the intermediate bundles to the adaxial epidermis (Plate 48.1). In *I. diabolica* the Pbr are present on the xylem pole of the midrib bundle and large bundles extending to the adaxial epidermis (Plate 48.2-3). The site of the Pbr in *I. natans* is complex. The Pbr extend from the xylem poles of the midrib bundle and the marginal bundles, to meet in the centre of the leaf. The cavities are present between the vascular bundles, and between the two marginal bundles.

*Plate 48. Legend on facing page.*

*F. dura* has additional parenchymatous tissues, other than the Pbr and the chlorenchyma, where one to three cells of TP are present in a crescent on the xylem side of the midrib bundle (Plate 47.7 and 48.4). The composition and location of tissues within *Schoenoplectus paludicola* is the same as in the leaves (Plate 47.6).

Generally the vascular bundles of the *Scirpeae* are present in a median row within the lamina. The vascular bundles in *Schoenoplectus paludicola* are present close to the epidermis in the chlorenchymatous tissues of the lamina. *Ficinia stolonifera* and *Scirpus nodosus* have two rows of vascular bundles. The intermediate and small bundles in *F. stolonifera* are present close to the abaxial epidermis. The large bundles of this species are present in a row inside the abaxial row, closer to the centre of the leaf. The midrib bundle, large, intermediate and marginal bundles in *S. nodosus* are present in an abaxial row closest to the abaxial epidermis. The small bundles are present in an adaxial row, closest to the adaxial epidermis. In the margins of *Ficinia arenicola* var. *arenicola* the long axis of the marginal and adjacent bundle face the centre of the bract. This makes the xylem face the abaxial epidermis of the midrib.
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Generally vascular bundles have a minimal cell lateral count of three or more cells (Tables 20A-D, Appendix 3). *F. dura, F. lateralis*, *F. oligantha, F. pinguior, F. stolonifera, F. tribracteata, F. zeyheri, I. cernua, I. costata var. macra* and *Scirpus nodosus* have a maximal cell distal count of three or less cells.

Not all the sizes of vascular bundles are present in the bracts of the Scirpeae (Tables 20A-D, Appendix 3). Only midrib bundle and marginal bundles are present in *Ficinia fascicularis, F. filiformis, F. oligantha, F. zeyheri, I. cernua, I. costata var. macra* and *I. natans*. Large vascular bundles are absent in *F. pinguior, F. tribracteata* and *I. diabolica*. Similarly, *F. indica var. indica, F. repens* and *F. tribracteata* lack intermediate bundles. Small bundles are absent in *F. cinnamomea, F. lateralis*, *F. pinguior, F. repens, I. diabolica, Scirpus falsus* and *S. ficianoides*. Generally the Scirpeae have no recognisable pattern with respect to numbers of bundles in the laminae (Tables 20A-D, Appendix 3). Patterns with respect to vascular bundle number and location occur in *B. maritimus, Fuirena hirsuta, F. pachyrrhiza, I. prolifera, Schoenoplectus decipiens* and *Scirpus nodosus*, where one small bundle is present between the large and intermediate bundles of these species.

Generally vascular bundles have three vascular sheaths (Plates 46.2, 46.7-8, 46.12, 47.2-4 and 48.2-4), namely an outer PS, a middle lignified MS and an inner non-lignified BP. The bundles in *F. repens* lack vascular bundle sheaths surrounding the vasculature. The vascular bundles sheaths in *I. costata var. macra* are only present on the phloem side of the bundle (Plate 48.5-6). Both *F. stolonifera* and *I. prolifera* lack the third sheath.

The cells of the PS are generally larger than the MS and BP sheaths (Plates 45.8, 46.2, 46.4-12, 47.1-5, 47.7 and 48.1-4). The PS cells mostly surround the whole vascular bundle. The PS cells are thin-walled, with the exception of *Ficinia cinnamomea*. Most of the Scirpeae have chlorenchymatous PS cells. The PS cells in *Ficinia indica, F. pinguior, I. costata var. macra* (Plate 48.5-6), *Schoenoplectus paludicola* (Plate 46.9) and *Scirpus ficianoides* (Plate 46.8) are translucent and lack chloroplasts. The chloroplasts of the PS are all smaller than the chloroplasts of the mesophyll.

Generally the MS cells ensheath the xylem and phloem (Plates 45.8, 46.4-6, 46.9-11, 47.1, 47.5, 47.7 and 48.1). In *I. costata var. macra* and *Schoenoplectus paludicola* the MS cells are absent on a few of the sides of the vascular bundles (Plate 48.5-6). All the bundles in *I. costata var. macra* have the MS present at the phloem poles (Plate 48.5-6). The intermediate and small bundles in *S. paludicola* have the MS lignified at the xylem and phloem poles (Plate 46.9). In many of the small bundles of this species the MS is absent. Generally, the walls of the MS are thick-walled in the radial and inner tangential walls (See Appendix 4 for detail), which is more pronounced on the phloem side of the bundle and abutting the metaxylem vessels (Plates 46.8, 47.4, 47.7 and 48.2). In *I. natans* the MS cells are thick-walled in the inner tangential and radial walls. Where the thickening in these walls is similar in all the cells of the MS surrounding the whole bundle, in the midrib bundle and marginal bundles. Thick-walls are present in all the walls, not just the radial and inner tangential walls in *Ficinia zeyheri, Fuirena coerulescens, F. hirsuta, F. pachyrrhiza* and *Scirpus nodosus*, especially abutting the phloem side of a few bundles. The most lignified MS cells are present in *Ficinia arenicola var. arenicola, F. cinnamomea* (Plate 46.6-7 and 46.11-12), *F. lateralis*, *F. oligantha, Scirpus falsus* and *S. nodosus*. 

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The BP similar to the PS is absent at certain places around the vascular bundle and the location of the BP is complex. The BP of most species is bisected by the metaxylem vessels in the midrib bundle, and the large and intermediate bundles. The BP of the midrib bundle and the large bundles is bisected by two large metaxylem vessels, on either side of the vascular bundle, as well as by the PxL or by a protoxylem vessel (Plates 46.8, 46.12, 47.2, 48.2 and 48.4), where present. The intermediate bundles of most of the *Scirpeae* are also bisected by two large metaxylem vessels, with the exception of *B. maritimus*, *Ficinia pinguior*, *Fuirena coerulescens* and *I. diabolica*, where the BP is limited to the phloem side of the bundle (Plates 46.2, 47.4 and 48.3). The BP in *B. maritimus* (Plate 47.5), *Ficinia cinnamomea*, *F. lateralis*, *F. trbracteata*, *Fuirena coerulescens*, *F. hirsuta*, *Schoenoplectus decipiens*, *S. paludicola* and *Scirpus nodosus* have a BP on the phloem side of the small bundles. The BP of many marginal bundles are not similar in structure within the same bract. The BP of a marginal bundle in *Ficinia fascicularis*, *F. filiformis*, *F. indica var. indica*, *F. lateralis* subsp., *F. pinguior*, *F. trbracteata*, *F. zeyheri*, the genus *Fuirena*, *I. cernua*, *I. costata* var. *macra*, *I. natans*, *Schoenoplectus decipiens* and the genus *Scirpus* is interrupted by metaxylem vessels. In *B. maritimus*, *Ficinia arenicola* var. *arenicola*, *F. lateralis* subsp., *F. oligantha*, *F. pinguior*, *F. zeyheri*, *I. costata* var. *macra* and *I. diabolica*, the BP of a marginal bundle is present on the phloem side of the bundle. Generally BP cells of the *Scirpeae* bracts range from small cells to large cells. Most species have medium sized BP cells. The BP cells in *B. maritimus* and *I. diabolica* are small to medium sized (Plates 47.2-4 and 48.2-3). *Ficinia arenicola* var. *arenicola*, *F. lateralis* subsp., *F. oligantha*, *F. zeyheri*, *Fuirena pachyrhiza*, *Schoenoplectus decipiens*, and *Scirpus falsus* have medium to large BP cells, whilst those of *F. trbracteata* are large.

Phloem and xylem outlines vary (Appendix 4). The xylem of the midrib bundle in *I. costata* var. *macra* and large bundles in *F. repens* are mixed (Plate 48.5-6). The xylem of the marginal bundles in *I. costata* var. *macra*, *F. repens* and *S. decipiens* is also mixed. All the species have a protoxylem lacunae in the midrib bundle (Plates 47.2 and 48.4), with the exception of *F. lateralis* subsp. *Schoenoplectus decipiens* and *Scirpus nodosus*. The large bundles in *B. maritimus*, *F. arenicola* var. *arenicola*, *F. cinnamomea*, *F. dura*, *F. lateralis* subsp., the genus *Fuirena*, the genus *Schoenoplectus* and *Scirpus nodosus* have a protoxylem lacunae (Plates 46.4, 47.11, 48.1 and 48.4). Only the marginal bundles in *Fuirena pachyrhiza* have protoxylem lacunae (Plate 47.11).

### 9.2.5 Culm characteristics in the tribe *Scirpeae*

There are nine different culm outlines present in the *Scirpeae*. Generally culms are oval, with a wavy outline. The genus *Eleocharis*, *Ficinia pinguior*, *I. costata* var. *macra*, *I. fluviatans* and *Schoenoplectus paludicola* have oval culms that lacked wavy outlines. The culms shapes are as follows: oval to rectangular (*I. pellucolae*); rectangular (*Fuirena pachyrhiza*); heptagonal (*Ficinia filicum*) hexagonal (*I. natans*); true triangular (*B. maritimus*); obtusely triangular (*Fuirena coerulescens*, *F. hirsuta*, *I. cernua* and *S. decipiens*); and acutely triangular (*Scirpus nodosus*). There are no trichomes present in the culms of the *Scirpeae* (Tables 21A-D, Appendix 3). The culm size is variable in the *Scirpeae* (Tables 21A-D, Appendix 3), ranging from 59μm (*Ficinia filiformis*) to 1884μm (*Scirpus nodosus*).

The thickening of the outer periclinal wall of the epidermis is variable (Plate 49.1-8), ranging from thin-walls (*Fuirena hirsuta* [Plate 49.1], *I. cernua* and *Scirpus nodosus*) to thick-walled (*Schoenoplectus paludicola*). *E. pauciflora*, *F. coerulescens*, *Schoenoplectus decipiens* and *S. paludicola* have unusual bulbiform lignifications present on the outer periclinal wall of the epidermis.
Plate 49. Shows structural details of the culms of the Scirpeae in section, including epidermal cells structure; stomatal complexes and sub-stomatal cavities; hypodermal sclerenchymatous strands, girders, sclerenchymatous strand arrangement and structure; ground tissue structure, and vascular sheaths, as well as tissues. (49.1) Shows the thin-walled epidermal cells in Fuirena hirsuta. (49.2) The epidermal cells in Eleocharis pauciflora with thick-walled outer periclinal wall. Stomata are flush with the epidermal surfaces and have small sub-stomatal cavities. Subsidiary cells have a thick-walled outer periclinal wall. Guard cells are thick-walled in both the periclinal walls. The cells of the epidermis abutting the hypodermal sclerenchymatous strands are smaller than the epidermal cells adjacent to the strand. (49.3) The outer periclinal wall of epidermal cells in F. coerulescens have additional lignification present adjacent to the middle lamellae of abutting cells. (49.4) The epidermal cells in Isolepis pellioceae are thick-walled in the outer periclinal wall. The epidermal cells abutting the hypodermal sclerenchymatous strands are smaller than the epidermal cells adjacent to the strands and have cone-shaped silica deposits. Stomata are slightly sunken and have small sub-stomatal cavities. Subsidiary cells have a thick-walled outer periclinal wall. Guard cells are thick-walled in both the periclinal walls. (49.5) The outer periclinal wall of the epidermal cells in Scirpus ficinioides is thick-walled. Epidermal cells abutting the hypodermal sclerenchymatous strands are larger than the epidermal cells adjacent to these strands, and have no cone-shaped silica deposits. (49.6) Shows a sunken stoma in Bolboschoenus maritimus with a small sub-stomatal cavity. The abutting epidermal cells and the subsidiary cells are thick-walled in the outer periclinal wall. The guard cells are thick-walled in the periclinal walls. (49.7) A raised stoma in F. natans with large sub-stomatal cavity. Epidermal cells and subsidiary cells are thin-walled. The guard cells are thick-walled in the periclinal walls. (49.8) Shows a slightly sunken stoma in Ficinia cinnamomea with sub-stomatal cavity. The guard cells are present exarch to the subsidiary cells. Subsidiary cells are relatively thin-walled when compared to the epidermal cells and the guard cells. (49.9) An outer large vascular bundle in B. maritimus with an abutting abaxial girder and adaxial sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is also composed of thin-walled translucent cells. The sheath of border parenchyma is interrupted by two large metaxylem vessels and the prooxytem lacuna. (49.10) Shows an outer intermediate vascular bundle in B. maritimus with phloem pole girder and xylem pole sclerenchymatous strands. Ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the sclerenchymatous strands of this vascular bundle. Translucent parenchyma is present exarch to the chlorenchyma. Tannin idioblasts are present mostly abutting the outer sheath of the outer vascular bundles. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled translucent cells. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (49.11) A small vascular bundle in B. maritimus with phloem side girder. There are two vascular sheaths, an outer parenchymatous sheath and an inner mestome sheath. The parenchymatous sheath is composed of thin-walled translucent cells. (49.12) Shows the hypodermal sclerenchymatous strands in E. dregeana, where the group of strands is so small that it is approximately the same size as the adjacent epidermal cells. Abutting this strand is a small epidermal cell with a cone-shaped silica deposit.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (EpC) epidermal cell with cone-shaped silica deposit; (G) girder; (HSS) hypodermal sclerenchymatous strands; (MS) mestome sheath; (MX) metaxylem vessel; (NC) no cone shaped silica deposit in the epidermal cell; (OT) outer periclinal wall (tangential); (PS) parenchymatous sheath; (PxL) prooxytem lacuna; (SS) sclerenchymatous strands; (St) stoma; (Stc) sub-stomatal cavity; (Su) subsidiary cell and (TP) translucent parenchyma. Bars = 10 μm.
Plate 49. Legend on facing page.
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These bulbiform deposits are present adjacent to the middle lamellae of each cell (Plate 49.3). Epidermal cell size is small in relation to culm size (Tables 21A-D, Appendix 3), ranging from 4μm (*Ficinia repens, I. diabolica and I. pellocolea*) to 26μm (*E. limosa* and *F. filiculmea*).

Cone-shaped silica deposits in the epidermal cells that abut the HSS are present in most of the *Scirpeae* (Plate 49.4). Cone-shaped silica deposits are absent in *Ficinia filiformis, F. lateralis*, *F. tenuifolia*, the genus *Fuirena*, *Scirpus ficinioides* (Plate 49.5) and *S. nodosus*. The epidermal cells abutting the HSS, that lack these cones are mostly smaller than the epidermal cells adjacent to the HSS. In *S. ficinioides* and *S. nodosus* the epidermal cells are larger abutting the HSS than the cells adjacent to the HSS (Plate 49.5), similar to *Cyathocoma hexandra* of the *Schoeneae*.

Stomata are usually flush with the epidermal surface (Plate 49.2), whilst *B. maritimus*, *Ficinia filiformis* and *Scirpus nodosus* have sunken stomata. The stomata in *E. dregeana, E. limosa, F. cinnamomea* (Plate 49.8), *F. lateralis*, *F. oligantha*, *F. tenuifolia*, *F. zeyheri*, *Fuirena coerulescens*, *F. pachyrrhiza*, *I. cernua*, *I. natans* (Plate 49.7), *I. prolifera* and *S. falsus* are raised. The lignification within the guard cells is present at the adaxial and abaxial end of the guard cells. The degree of lignification at the adaxial and abaxial pole varies (Appendix 4). With the exception of *E. limosa* (52-184μm) and *Fuirena hirsuta* (147-177μm), sub-stomatal cavities are small in size (Tables 21A-D, Appendix 3), ranging from less than 1μm (*Ficinia fascicularis*) to 56μm (*Scirpus nodosus*).

HSS, girders and SS, are composed of small thick-walled cells (Plates 49.9-12 and 50.1-11). The HSS and girder cells in *F. hirsuta* are not as thick-walled as the rest of the *Scirpeae* (Plate 50.12). The wavy outline of the culms occurs where the HSS are present along the epidermis, especially in *Ficinia arenicola var. arenicola, F. bulbosa, F. cinnamomea, F. dura, F. fascicularis, F. indica var. indica, F. lateralis, F. oligantha, F. stolonifera, F. tenuifolia, F. zeyheri, Fuirena pachyrrhiza, Scirpus ficinioides* (Plate 49.5) and *S. nodosus*. HSS are also present in the pentagonal corners of the culms in *F. filiculmea*. The HSS in *E. dregeana* (Plate 49.12), *E. limosa* and *I. cernua* are so small that the HSS are not much larger than the adjacent epidermal cells. A single small epidermal cell is present abutting this HSS (Plate 49.12). The HSS and SS outline varies (Appendix 3).

HSS are generally not present adjacent to the vascular bundles. In *B. maritimus*, *E. pauciflora*, the genus *Fuirena*, *I. prolifera* and *Scirpus ficinioides* the HSS are present adjacent to the outer row of vascular bundles. The HSS in *Ficinia dura, F. lateralis*, *F. oligantha, F. tenuifolia, F. trbracteata* and *Scirpus falsus* are present adjacent to the outer row large bundles. Girders are present in *B. maritimus, Fuirena coerulescens* and *F. pachyrrhiza*, where the girders abut a few of the outer row bundles (Plate 49.9-11).

The HSS and girders are small in comparison with culm size and range from 8μm (*E. dregeana*) to 95μm (*F. tenuifolia*, Tables 21A-D, Appendix 3). With the exception of *E. limosa* (162), there are few HSS/girders present in the culms of the *Scirpeae* (Tables 21A-D, Appendix 3), ranging from 4 (*I. natans*) to 82 (*Schoenoplectus paludicola*).
Plate 50. Shows structural details of the culms of selected Scirpeae in section, including epidermal structure; hypodermal sclerenchymatous strands, girders, sclerenchymatous strand arrangement and structure; cavity arrangement; ground tissue structure; vascular bundle arrangement; and vascular sheaths, as well as tissues.

(50.1) Shows the epidermal cells in Ficinia dura, which are thick-walled in the outer periclinal wall. Hypodermal sclerenchymatous strands are present at random along the epidermis. Ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to phloem sides of the second row of vascular bundles. The chlorenchyma is thin-walled and mostly rectangular in shape. Translucent parenchyma is endarch to the chlorenchyma and abuts the xylem sides of the vascular bundles. (50.2) An outer row large vascular bundle in Eleocharis pauciflora with no sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled, chlorenchymatous cells. The mestome sheath cells are thick-walled in the inner tangential and radial walls. The sheath of border parenchyma is interrupted by two large metaxylem vessels. (50.3) Shows an outer row of intermediate vascular bundle in Isolepis cernua with no sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. But the mestome sheath cells are relatively thin-walled and the sheath of border parenchyma is limited to the phloem side of the vascular bundle. (50.4) An outer row intermediate vascular bundle in E. pauciflora with no sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheath cells are thick-walled in the inner tangential and radial walls. The sheath of border parenchyma is interrupted by two large metaxylem vessels and one to two protoxylem vessels. (50.7) An inner row large vascular bundle in Bolboschoenus maritimus with abutting the xylem side and phloem pole sclerenchymatous strands. The vascular bundle is surrounded by the central region of translucent parenchyma. The cells of the translucent parenchyma are thin-walled. There are two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of border parenchyma is interrupted by three large metaxylem vessels and a large protoxylem lacuna. (50.8) Shows a corner of the triangular culm of B. maritimus where the sclerenchymatous strands of adjacent outer row vascular bundles join. Inner large vascular bundles have both adaxial and abaxial sclerenchymatous strands. Outer vascular bundles have only adaxial sclerenchymatous strands. Ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the xylem poles of the outer vascular bundles. Endarch to the chlorenchyma is translucent parenchyma, which extends to the centre of the culm. Translucent parenchyma also extends from the phloem side of the large vascular bundle in the corner of the culm to the hypodermal sclerenchymatous strands of the corner (not in picture). (50.9) A large vascular bundle in I. diabolica with abutting xylem pole sclerenchymatous strand. Ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to phloem side of the vascular bundle to the epidermis. The translucent parenchyma extends from the xylem pole of the vascular bundles to the centre of the culm. Cavities are present between most of the vascular bundles. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled chlorenchymatous cells. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels and a protoxylem lacuna. (50.10) Shows outer row vascular bundles in F. indica var. indica where the sclerenchymatous strands of adjacent vascular bundles join. The large vascular bundles have two distinctive vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. (50.11) Sclerenchymatous strands are present in parenchymatous bridges of Schoenoplectus paludicola, which separate the cavities. (50.12) Shows the sub-stomatal cavities in Fuirena hirsuta are continuous with the cavities. These cavities separate the outer row of vascular bundles. Ground tissues are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the xylem pole of the outer large vascular bundles and surrounds the adaxial end of the cavities (one cell thick in this position). Endarch to the chlorenchyma is the central region of translucent parenchyma. Tannin idioblasts are present mostly in the chlorenchyma surrounding the cavities. The outer large vascular bundles have girders of exit and entry point of the cavities.

Symbols are as follows: (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (G) girder; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (Pxl) protoxylem lacuna; (S) small vascular bundle; (SS) sclerenchymatous strands; (St) stoma; (T) tannin idioblast and (TP) translucent parenchyma. Bars = 10 μm.
Plate 50. Legend on facing page.
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Plate 51. Shows structural details of the culm structures including the cavity arrangement, ground tissue structure with parenchymatous bridges, vascular bundle arrangement, vascular sheaths and tissue structure of selected Scirpeae in section.

(51.1) Ground tissues in Eleocharis limosa are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem side of the vascular bundles. On the xylem poles of the vascular bundles is a translucent parenchymatous bridge that extends and joins with the bridges of the other vascular bundles. The chlorenchyma is composed of rectangular, thin-walled cells. Cavities are present between the parenchymatous bridges, the vascular bundles and the chlorenchyma. (51.2) The ground tissues in Isoeplis cernua are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem side of the large vascular bundles and to the xylem poles of both the intermediate and the small vascular bundles. Translucent parenchyma abuts the xylem side of the large vascular bundles and extends in bridges, to meet with the bridges of other large vascular bundles, in the centre of the culm. The cavities are present between the large vascular bundles, the chlorenchyma and the bridges. (51.3) The ground tissues in Scirpus fischerioides are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem side of the vascular bundles. Present on the xylem side of the larger vascular bundles and the xylem pole of the smaller vascular bundles is translucent parenchyma, which extends to the centre of the culm. The cavities are present between the vascular bundles, the translucent parenchyma and the chlorenchyma. (51.4) The ground tissues in Ficinia tricolor consist of chlorenchyma, translucent parenchyma and translucent “blue” parenchyma. The chlorenchyma extends from the epidermis to phloem side of the large vascular bundles and the xylem poles of the intermediate, as well as small vascular bundles. Translucent parenchyma extends from the xylem sides of the large vascular bundles and is endarch to the chlorenchyma extending to the central cavity. Present within the cavity are a few cells of translucent “blue” parenchyma. (51.5) The ground tissues in E. pauciflora are composed of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the xylem pole of a few of the outer row of vascular bundles, the xylem side of a few outer row vascular bundles and to the phloem side of the second row of large vascular bundles. Endarch to the chlorenchyma is translucent parenchyma, which extends to the centre of the culm. (51.6) Shows an outer large vascular bundle in F. lateralis with abutting xylem pole sclerenchymatous strands. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The sheath of parenchyma is composed of thin-walled, chlorenchymatous cells. The mestome sheath cells are thick-walled, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels and a few protoxylem vessels. The sheath of border parenchyma is indistinct on the phloem side of the vascular bundle.

Symbols are as follows: (B) translucent “blue” parenchyma; (BP) border parenchyma; (Ca) cavity; (Ch) chlorenchyma; (Ep) epidermal cell; (I) intermediate vascular bundle; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (Pbr) parenchymatous bridge; (PS) parenchymatous sheath; (S) small vascular bundle; (SS) sclerenchymatous strands and (TP) translucent parenchyma. Bars = 10 μm.
No SS abut the vascular bundles in eight species (Plate 50.2-4), namely the genus Eleocharis (Plate 50.2 and 50.4), Ficinia filiculmea, F. filiformis, I. cernua (Plate 50.3), I. fluitans and I. natans. All the vascular bundles with abutting SS in the culms of the Scirpeae have SS present at the xylem side of the large bundles (Plates 49.9 and 50.5-10). Only the inner large bundles in B. maritimus (Plate 50.7-8), F. stolonifera, F. tenuifolia and Scirpus nodosus have SS on the phloem pole of the bundle. Xylem pole SS (where present) are found on the intermediate bundles of B. maritimus (Plate 49.10), Ficinia cinnamomea, F. dura, F. indica var. indica, F. lateralis, F. tenuifolia, F. tridentata, F. zeyheri, the genus Fuirena, Schoenoplectus decipiens and S. paludicola. No small bundles in the culms of the Scirpeae have abutting SS. The SS in I. costata var. macra, I. diabolica, Schoenoplectus decipiens and S. paludicola are present inside the outer sheath abutting the inner sheath. The SS of some of the outer row intermediate bundles in B. maritimus join and extend to the SS at the phloem pole of the second row large bundles (Plate 50.8), especially near the corners of the triangular culm. The SS of the outer row large bundles in Ficinia bulbo, F. indica var. indica (Plate 50.10), F. lateralis and F. pinguor extend and join with adjacent SS. Additional SS are also present in the Pbr of the aerenchyma of Schoenoplectus decipiens and S. paludicola (Plate 50.12).

Plate 51. Legend on facing page.

Cavities are present in E. dregeana, E. limosa (Plate 51.1), Ficinia dura, F. filiculmea, F. pinguor, F. repens, F. tenuifolia, F. tridentata (Plate 51.4), Fuirena coerulescens, F. hirsuta (Plate 50.12), I. cernua (Plate 51.2), I. costata var. macra. I. diabolica, I. fluitans, I. pelliolea, I. prolifera, the genus Schoenoplectus, Scirpus falsus and S. ficinioides (Plate 51.3, Tables 21A-D [Appendix 3]). The cavities are mostly present between the vascular
bundles of the outer row (Plates 50.12, 51.1 and 51.3). The cavities in \textit{I. cernua} are present above the outer row bundles and between the Pbr (Plate 51.2). The cavities in \textit{F. dura}, \textit{F. pinguior}, \textit{F. stolonifera}, \textit{F. tenuifolia}, \textit{F. tribracteata} (Plate 51.4), \textit{Fuirena coerulescens} and \textit{Schoenoplectus decipiens} are present at the centre of the culm. Cavities in \textit{Fuirena hirsuta} extend to the central TP region and are surrounded by the chlorenchyma (Plate 50.12). The cavities in \textit{B. maritimus} are present above the first row of large bundles and extend to the second row of large bundles. Cavities in \textit{F. arenicola} var. \textit{arenicola} are present around the outer row of small bundles on the xylem side of the bundle. Additional cavities are also present between the second row of large bundles. The sub-stomatal cavities in both \textit{Ficinia filiculmea} and \textit{Fuirena hirsuta} (Plate 50.12) are continuous with the culm cavities. Translucent "blue" parenchyma is mostly present within the cavities. There are ten different outlines of cavity present in the culms of the \textit{Scirpeae} (Appendix 4). The central cavities are largest cavities in the culms (Table 21A-D, Appendix 3). Culm size ranges from 6\(\mu\)m (\textit{I. fluitans}) to 542\(\mu\)m (\textit{F. dura}).

There are generally few tannin idioblasts present in the culms of the \textit{Scirpeae}. Tannin idioblasts are absent in the culms of \textit{Ficinia filiformis}, \textit{F. lateralis}, \textit{I. cernua}, \textit{I. fluitans}, \textit{I. natans} and \textit{I. prolifera}. Many tannin idioblasts are present in \textit{F. oligantha}, \textit{F. repens}, \textit{F. tenuifolia}, the genus \textit{Fuirena} and \textit{Scirpus nodosus}. Tannin idioblasts are present scattered within the chlorenchymatous tissues of the culms, whilst the tannin idioblasts in \textit{B. maritimus} and the genus \textit{Fuirena} are present abutting the vascular bundles (Plate 50.12). In addition to the tannin idioblasts abutting the bundles in the genus \textit{Fuirena} they also abut the HSS.

The composition and location of the ground tissues within the culms of the \textit{Scirpeae} is complex. There are three main structural variations or structural groups in the culms of the \textit{Scirpeae}.

The first structural group is present in \textit{E. pauciflora} (Plate 51.5), \textit{Ficinia arenicola} var. \textit{arenicola}, \textit{F. bulbosa}, \textit{F. cinnamomea}, \textit{F. fascicularis}, \textit{F. filiculmea}, \textit{F. indica} var. \textit{indica}, \textit{F. lateralis}, \textit{F. oligantha}, \textit{F. zeyheri} and \textit{Scirpus nodosus}. After a description of the basic structure of this first group, three slight variations will be discussed. In these species thin-walled chlorenchymatous parenchyma is present extending from the epidermis to the phloem side of the outer row of bundles. Thin-walled TP is present from the xylem side to the centre of the culm. The first variation of this group is present in \textit{F. filiformis}, where the TP extends from the chlorenchyma and is continuous with the centre of the culm. The vascular bundles are present in the TP layer. A second variation of the first group is present in \textit{Fuirena hirsuta} (Plate 50.12), where the chlorenchymatous parenchyma is present in columns, abutting the HSS around the vascular bundles. This layer extends to the xylem pole of the large bundles. TP abuts the xylem pole of these bundles and extends to the centre of the culm. These cavities separate the regions of chlorenchyma. The TP region forms a bridge to the intermediate and small bundles, where present. A third variation of the first structural group is present in \textit{I. costata} var. \textit{macra}, \textit{I. diabolica}, \textit{I. fluitans}, \textit{Scirpus falsus} and \textit{S. ficinoides} (Plate 51.3), where chlorenchymatous parenchyma was present up to the phloem side of the outer row of bundles. TP is present from the xylem pole to the centre of the culm.

The second structural group is present in \textit{E. dregeana}, \textit{E. limosa} (Plate 51.1), \textit{Ficinia repens}, \textit{I. natans} and \textit{I. pellilocolea}, where the outer chlorenchymatous layer is present from the epidermis to the phloem side of the outer row of bundles. Following the description of basic structure of this second group, two variations will be discussed. TP is present from the xylem pole of the vascular bundles, forming a bridge, which meets with the bridges of the inner vascular bundles. Some of the small bundles lack bridges. In \textit{I. cernua} (Plate 51.2) the TP forms bridges that
meet in the centre of the culm. The chlorenchyma is present around the outer bundles to the xylem pole of the large bundles with bridges. A first variation is present in *Fuirena coerulescens* and *F. pachyrhiza*, where the chlorenchyma is present from the epidermis to the xylem pole of the outer row of bundles. Pbr of TP connects the outer sheath of the second row of bundles. The cavities occur between the Pbr and vascular bundles. TP is present from these bundles to the centre of the culm. The cavities of this species are present between these bridges and the large vascular bundles of the first and second row of bundles. The TP in the centre forms an aerenchymatous network, with large inter-cellular spaces present between the TP cells. The HSS within the chlorenchymatous regions are ensheathed in a layer of parenchymatous cells (one cell thick). A second complex variation of this group is present in the genus *Schoenoplectus*. The chlorenchyma occurs from the epidermis to the xylem pole of the outer row bundles. TP is present from the xylem pole of the large bundles to the second row of large bundles or inner SS in line with the second row of bundles. The bridges of TP cross the centre of the culm and meet with the Pbr of the second row of bundles on the opposite side of the culm. Between the Pbr are the cavities. The bundles in *S. decipiens* are present in this aerenchymatous network and are surrounded by two layers of parenchyma (double parenchymatous sheath). The inner bundles in *S. paludicola* are not surrounded by two sheaths of parenchymatous cells but by one PS layer. The cells of the Pbr in *S. paludicola* are larger than *S. decipiens*.

The third structural group is present in *Ficinia dura*, *F. pinguior*, *F. stolonifera*, *F. tenuifolia* and *F. trirracteta* (Plate 51.4). After a description of basic structure of this third group, the single variation to it will be discussed. The chlorenchyma in *F. pinguior* is present from the epidermis to the phloem side of the outer row of bundles. Abutting the xylem side of the vascular bundles is the central cavity. Within the central cavity are a few cells of translucent "blue" parenchyma, which are continuous from the xylem side of the bundles to the centre. The only variation of this group is present in the culms of *Ficinia dura*, *F. stolonifera*, *F. tenuifolia* and *F. trirracteta* (Plate 51.4), where the chlorenchymatous layer is present from the epidermis to the phloem side of the outer row of large and intermediate bundles. The chlorenchyma is present up to the xylem pole of the small bundles. A layer of TP abuts the chlorenchyma, extending to the central cavity, where a few cells of translucent "blue" parenchyma are present. Generally, the TP is not lignified. Lignified TP cells are present in *E. pauciflora*, *Ficinia arenicola var. arenicola*, *F. bulbosa*, *F. dura*, *F. fascicularis*, *F. filiculmea*, *F. indica var. indica*, *F. lateralis*, *F. zeyheri*, and the genus *Scirpus*.

The bundles of most the *Scirpeae* species are present in one row (Plate 51.1-4, Tables 21A-D, Appendix 3), consisting of large, intermediate and small bundles. The large bundles interrupt the chlorenchyma, whilst the intermediate and small bundles are present in the chlorenchyma. The bundles in *B. maritimus* (Plate 50.8), *Ficinia arenicola var. arenicola*, *F. bulbosa*, *F. dura*, *F. indica var. indica*, *Fuirena coerulescens*, *F. pachyrhiza*, *I. pellucollae*, the genus *Schoenoplectus* and *Scirpus nodosus* are present in two rows. The outer row consists of large, intermediate and small bundles, whilst the inner row contains only large bundles. *Ficinia fascicularis*, *Fuirena hirsuta* (Plate 50.12) and *I. prolifer* have three rows of vascular bundles. The inner two rows are composed of large bundles, whilst the outer row has large, intermediate and small bundles. The vascular bundles of the second ring large bundles in *Fuirena coerulescens* lie at right angles to the large bundles of the first row. Many of these second row bundles are one to two cells from the first row bundles.

Most of the *Scirpeae* have large, intermediate and small bundles (Tables 21A-D, Appendix 3). Large bundles are absent in *I. natans*, *Ficinia bulbosa*, *F. oligantha*, *F. tenuifolia* and *I. Fluitans*, and lack intermediate bundles. Small
bundles are absent in *E. dregeana*, *E. limosa*, *F. filiformis*, *F. oligantha*, *F. tenuifolia*, *F. zeyheri*, *Fuirena coerulescens* and *I. diabolica*.

Vascular bundles have three vascular sheaths (Plates 49.10, 50.2-6, 50.9 and 51.6), an outer PS, a middle lignified MS and an inner non-lignified BP. The third sheath is not present in the culms of *I. fluitans*. The PS is absent in the vascular bundles within the Pbr and the TP (Plate 50.7-8).

PS cells are larger in size than the abutting MS cells (Plates 49.9-11, 50.2-6, 50.9-10 and 51.6). The MS cells in *F. cinnamomea*, *F. oligantha*, *F. lateralis* var. *costalis*, *F. stolonifera*, *F. tenuifolia*, *F. zeyheri* and *S. ficinioides* are so large that they are almost the same size as the PS cells. The PS cells are generally thin-walled and chlorenchymatous (Plate 50.2-4 and 50.9). In *B. maritimus*, *E. limosa*, *Ficinia filiformis*, *F. pinguior*, *F. repens*, the genus *Fuirena*, *I. pellocolea*, *Schoenoplectus paludicola*, *Scirpus falsus* and *S. ficinioides* chloroplasts are absent.

The lignification within the walls of the MS and the degree of the lignification varies (Appendix 4). Generally the MS cells of the *Scirpeae* are thick-walled in the inner tangential walls, especially on the phloem side of the bundles (Plate 50.2 and 50.4-6). The MS cells in *E. dregeana*, *E. limosa*, *Fuirena hirsuta* and *F. pachyrrhiza* are generally thin-walled. The thickening of the MS cells in *B. maritimus*, *Ficinia arenicola* var. *arenicola*, *F. cinnamomea*, *F. oligantha*, *F. lateralis* var. *costalis* (Plate 51.6), *F. stolonifera*, *F. tenuifolia*, *F. zeyheri*, *Fuirena coerulescens* and *Scirpus nodosus* is similar in all the walls of the MS, especially on the phloem side of the bundle. In the MS cells of *Ficinia cinnamomea*, *F. dura*, *F. filiculmea*, *F. oligantha*, *F. lateralis* var. *costalis*, *F. repens*, *F. stolonifera*, *F. tenuifolia*, *F. zeyheri*, *Scirpus falsus* and *S. ficinioides* the lumen is highly reduced (Plate 51.6).

Generally the BP is thin-walled, bisected by two large metaxylem vessels, as well as by the PxL or protoxylem vessels, in all the large bundles (Plates 50.2, 50.5, 50.7, 50.9 and 51.6), where present. In the large bundles of *Fuirena hirsuta* the BP is limited to the xylem pole of the bundle. In the intermediate bundles the BP is bisected by two large metaxylem vessels (Plate 50.6). The BP of the intermediate bundles in *F. repens* is limited to the phloem side of the bundle. In the small bundles of *B. maritimus*, *Ficinia arenicola* var. *arenicola*, *F. bulbosa*, *F. indica* var. *indica*, *F. lateralis* var. *pinnata*, *F. repens*, *F. tribracteata*, *Fuirena pachyrrhiza*, *I. fluitans*, *Scirpus falsus* and *S. ficinioides* the BP is limited to the phloem side of the bundle.

On the phloem pole of the large bundles inside the MS, in the phloem tissues in *F. arenicola* var. *arenicola*, *F. bulbosa*, *F. dura*, *F. stolonifera*, *F. tribracteata* and *F. zeyheri*, there are one or two lignified cells of MS. These lignified MS cells are also present in the phloem of the intermediate bundles of *F. stolonifera*.

Phloem and xylem outline varies (Appendix 4). Protoxylem lacunae are present in the large bundles of the culms of all the *Scirpeae* (Plates 49.9, 50.7, 50.9-10). The xylem of the small bundles in *B. maritimus* in the corners of the triangle faces towards the epidermis and not the centre of the culm (Plate 49.11).
10.1 Introduction to the Sclerieae

The tribe Sclerieae falls within the sub-family Caricoideae and has two genera, namely Acriulus Ridly and Scleria Bergius (Bruhl 1995). Muasya et al. (1998) suggested that the Sclerieae are possibly monophyletic, based on rbcL generated data sets. Goetghebeur (1985) and Bruhl (1995) suggest that the Sclerieae may be closely related to the Cariceae.

Koyama (1967) stated that classification systems should not be based wholly on gross floral morphological characters, but should also use anatomical characters in conjunction with the floral morphology. This is born out in the research of Metcalfe (1971), who together with Koyama was able to delimit the Sclerieae into genera, based largely on anatomical characteristics. Koyama (1967) classified the Sclerieae into five genera based on the arrangement of chlorenchyma in the mesophyll, namely Becquerelia, Bisboekeleria, Calyptrocarya, Diplacrum and Scleria. He divided the Sclerieae into three groups based on the structure of the mesophyll. He called these groups simply A, B and C. Within group A, species have undifferentiated mesophyll. Group B, has palisade and spongy mesophyll, but with cells of similar shape. Group C, has mesophyll differentiated into palisade and spongy mesophyll, where the palisade cells are defined as longitudinally rectangular or oblong, whereas the spongy mesophyll cells were defined as lobate to stellate with a few to several arms. The spongy mesophyll cells were described as having large intercellular spaces. The genus Becquerelia has bulliform cells accompanied by a hypodermis that lies adjacent the lateral veins of the lamina. In Diplacrum, bulliform cells are limited to the midrib, whilst the hypodermis is absent. In Calyptrocarya, bulliform cells are observed in the adaxial epidermis above the vascular bundles. The genus Scleria is noted in have an advanced multi-layered hypodermis.

Metcalfe (1971) concurred with Koyama (1967). Metcalfe (1971) also noted the presence or absence of silica deposits within the leaves, which were important factors in his anatomical classification. His classification is based on the presence or position of conical and/or warty silica deposits. Metcalfe (1971) also noted the presence of trichomes and bulliform cells. Hennessy (1985) confirmed the presence of the silica deposits in the South African members of the Sclerieae, and stated that these silica deposits are present in the walls of the bulliform cells located above the mechanical tissues associated with the ribs of the leaves. Bruhl's (1995) classification does not mention the presence or absence of Koyama's (1967) mesophyll groups, but does note the presence of globular silica deposits, bulliform cells and hypodermal layers.

The genus Acriulus is endemic to Africa and is the only Sclerieae genus that Bruhl (1995) described, which originated from Africa. Acriulus has not been reported as present within the borders of South Africa (Arnold and De Wet 1993). The genus Scleria is cosmopolitan in distribution with 200 species and occurs throughout the world (Metcalfe 1971; Hennessy 1985). Metcalfe (1971) described ten species from Zambia and two from Nigeria. In Koyama's (1967) anatomical classification of the Sclerieae, he did not describe any African species. Twenty three Scleria species have been recorded from within the boundaries of southern Africa (Hennessy 1985), with most of Hennessy's (1985) descriptions relating to floral morphology, with a few brief notes of the anatomical features of the leaves and culms.
10.2 Results

10.2.1 Sclerieae species collected in the Eastern Cape

Two species of the Sclerieae were collected by the author, both are from the genus Scleria P.J.Bergius, namely *S. melanomphala* Kunth (Appendix 1) and *S. natalensis* C.B.Clarke (Appendix 1). The collection of *S. natalensis* from Kromdraai, near Humansdorp is the first in the Eastern Cape Province.

10.2.2 Distribution and habitat of the Sclerieae

The Sclerieae occur in coastal habitats (Fig. 27), both are absent inland. The habitats of both species differ (Fig. 28). *S. melanomphala* is most frequently collected from coastal dune slacks, grasslands and marshes. *S. natalensis* was collected from the river-banks of coastal pine forests. These species also were collected from differing substratum, where *S. melanomphala* was collected from mostly from wet (Fig. 29), sandy soils (Fig. 30). *S. natalensis* was collected from dry (Fig. 29), stony soils (Fig. 30).

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Figure 27: Shows the distribution of the habitats of *S. melanomphala* and *S. natalensis* collected in the Eastern Cape. Symbols are as follows: (Sm) *S. melanomphala* and (Sn) *S. natalensis*.
Figure 28: Shows the habitats that *S. melanomphala* and *S. natalensis* were collected from in the Eastern Cape. Symbols are as follows: (Ba) banks of rivers or streams; (D) sand dunes; (Fe) exotic (pine) forests; (Gr) grassland; (Ma) marshes; (O) open areas with no vegetation; (Sm) *S. melanomphala* and (Sn) *S. natalensis*.

Figure 29: Shows the hydration of the soils in the habitats of *S. melanomphala* and *S. natalensis* within the Eastern Cape. Symbols are as follows: (Sm) *S. melanomphala* and (Sn) *S. natalensis*. 
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10.2.3 Leaf Characteristics of the tribe Sclerieae

The leaves of the Sclerieae are flanged and V-shaped, with no trichomes. The Sclerieae have thin leaves (Table 22, Appendix 3). The leaves of *S. melanomphala* are thicker than *S. natalensis* (Table 22, Appendix 3). The midribs of both species are thicker than the laminae (Table 22, Appendix 3). The outer periclinal surface of the adaxial and abaxial epidermal cells of both species is mostly thick-walled (Plates 52.1-12, 53.1-3). Bulliform cells are present in the midribs of *S. melanomphala* (Plate 52.1-2) and in the flanges of both species (Plate 52.5). The adaxial epidermal cells are larger than the abaxial (Table 22, Appendix 3). The adaxial epidermal cell size in the Sclerieae range from 13\(\mu\)m (*S. natalensis*) to 69\(\mu\)m (*S. melanomphala*). The abaxial epidermal cells range from 6\(\mu\)m (*S. natalensis*) to 21\(\mu\)m (*S. melanomphala*).

Cone-shaped silica deposits are present in both species. Cones are only absent in the adaxial epidermal cells abutting the adaxial HSS in *S. natalensis* (Plate 52.5). Generally the cells that abut the cells with the cones adjacent the HSS or girders are also smaller than the cells of the epidermis that lie between the HSS or girders (Plate 52.5 and 52.7).

The stomata in the Sclerieae are flush with the epidermal surfaces (Plate 52.2-4). *S. melanomphala* has amphistomatous stomata, whilst *S. natalensis* has hypostomatous stomata present in the abaxial epidermis. The substomatal cavity size in both species is small (Table 22, Appendix 3). The guard cells of the stomata are variable thickened (Appendix 4).
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**Plate 52.** Shows structural details of the leaves of *S. melanomphala* and *S. natalensis* in section, illustrating adaxial and abaxial epidermis structure, bulliform epidermal cell arrangement, stomatal complexes with associated sub-stomatal cavity arrangement and structure, hypodermal sclerenchymatous strands, guard cells, sclerenchymatous strand arrangement and structure, tannin idioblast, mesophyll structure, vascular bundle arrangement and spacing; and vascular sheaths, as well as tissues.

(52.1) Shows the adaxial epidermal cells in *S. melanomphala*, which are larger than the abaxial epidermal cells. Elongated bulliform epidermal cells are present in the midrib. An adaxial girdle abuts the midrib vascular bundle. The mesophyll is composed of thin-walled, non-radiating chlorenchyma. Tannin idioblasts are scattered within the chlorenchyma. The vascular bundles are present in a median row. (52.2) The midrib in *S. melanomphala*, with large adaxial bulliform cells. The outer periclinal wall of the adaxial and abaxial epidermis is thick-walled. The stomata are hypostomata and are present in the abaxial epidermis. The midrib vascular bundle has abutting adaxial and abaxial girders. All lamina vascular bundles have abaxial girders, (52.3) Shows a stoma in *S. melanomphala*, which is flush with the epidermal surface and has a small sub-stomatal cavity. The outer periclinal wall of the epidermal cells abutting the stoma is thick-walled. The subsidiary cells are relatively thick-walled. The guard cells however, are thick-walled in the periclinal walls. (52.4) The stomata in *S. natalensis* are flush with the epidermis and have small sub-stomatal cavities. Likewise, the outer periclinal wall of the epidermal cells abutting the stoma is thick-walled. The subsidiary cells are relatively thin-walled. The guard cells are also thick-walled in the periclinal walls. (52.5) Shows a large vascular bundle of the flange in *S. natalensis* with abutting abaxial girdle, adjacent adaxial hypodermal sclerenchymatous strands and abutting adaxial sclerenchymatous strands. The adaxial epidermal cells are larger than the abaxial epidermal cells. The epidermal cells abutting the hypodermal sclerenchymatous strands and the girders are smaller than the cells adjacent to the strands or girders. The mesophyll is composed of thin-walled, non-radiating chlorenchyma. The large vascular bundles of the lamina all have a protophloem present at the xylem pole of the vascular bundle. (52.6) The midrib vascular bundle in *S. natalensis* with abutting adaxial and abaxial girders. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignifed sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in all walls, especially on the phloem side of the vascular bundle and abutting the metaxylem vessels. The sheath of border parenchyma is interrupted by the two large metaxylem vessels. (52.7) Shows a lamina large vascular bundle in *S. melanomphala* with adaxial and abaxial girders. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in all walls, especially on the phloem side of the vascular bundle and abutting the metaxylem vessels. The sheath of border parenchyma is interrupted by the two large metaxylem vessels. (52.8) A lamina intermediate vascular bundle in *S. melanomphala* with adaxial and abaxial girders. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignifed sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. Mestome sheath cells are large. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (52.9) Shows a lamina small vascular bundle in *S. melanomphala* with abaxial girders. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignifed sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. Mestome sheath cells are large. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (52.10) A lamina small vascular bundle in *S. natalensis* with abaxial girders. The mesophyll is composed of non-radiating chlorenchyma and appears two-layered. The upper layer is thin-walled, rectangular, with the long axis of the cell lying at right angles to the adaxial epidermis and has many chloroplasts. The lower layer is composed of rounded or polygonal chlorenchyma with thin-walls. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignifed sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. Mestome sheath cells are large. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (52.11) The marginal vascular bundle in *S. natalensis* with adaxial girders. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignifed sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. Note that there is a single xylem vessel present in the vascular bundle. (52.12) The marginal vascular bundle in *S. natalensis* with abaxial girders. The mesophyll in *S. melanomphala* that appears two-layered with adaxial palisade-like parenchyma and abaxial sateate parenchyma. The parenchyma, which is palisade in appearance, is rectangular in shape with the long axis of the cells at right angles to the adaxial epidermal surface.

(Legend continues on the next facing page)
Plate 52. Legend on facing page.
Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Bu) bulliform epidermal cells; (G) girder; (HSS) hypodermal sclerenchymatous strands; (L) large vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (OT) outer periclinal wall (tangential); (PP) palisade parenchyma; (PS) parenchymatous sheath; (PxL) protoxylem lacuna; (S) small vascular bundle; (SIP) stellate parenchyma; (St) stoma; (Stc) sub-stomatal cavity; (SS) sclerenchymatous strands; (Su) subsidiary cell; (T) tannin idioblast and (X) xylem vessel. Bars = 10 μm.
Small, lignified adaxial hypodermal sclerenchymatous strands (HSS) are present only in the flanges of the flanged V-shaped leaves in *S. natalensis* (Plate 52.5). Girders are present on the xylem and phloem poles of the large and the intermediate bundles in the *Sclerieae* leaves (Plate 52.2 and 52.6-8), with the exception of the large bundles in the flanges of *S. natalensis* (Plate 52.5). In the flanges of this species there was only an abaxial girder present on the large bundle (Plate 52.5). There is a girder present at the xylem and phloem poles of the midrib vascular bundle in both species (Plate 52.1-2 and 52.6). Adaxial girders are present on the xylem side of the marginal bundles in *S. natalensis* (Plate 52.11). Girders are also present on the phloem poles of the small bundles of both species (Plate 52.9-10). The HSS/girders are large in size (Table 22, Appendix 3). The adaxial HSS/girders range from 5μm (*S. natalensis*) to 85μm (*S. melanomphala*), whilst the abaxial girders range from 10μm (*S. natalensis*) to 50μm (*S. melanomphala*). Small, lignified sclerenchymatous strands (SS) are only present abutting the xylem pole of the large bundles in the flanges of *S. natalensis* (Plate 52.5).

There are no lamina cavities in the *Sclerieae* leaves, though the cells of the mesophyll have large intercellular spaces. There are also no hypodermal layers present in the leaves of the *Sclerieae*.

The structure of the mesophyll differs for both species. The leaves in *S. melanomphala* broadly resemble dicot leaves (Plate 52.12), similar to Koyama’s (1967) C group. Rectangular mesophyll abuts the adaxial epidermis and extends one to two cells to the xylem side of the bundles. Abutting the phloem side of the bundle, extending to the abaxial epidermis is stellate parenchyma. The mesophyll in *S. natalensis* is not as distinctively dicot-like, but a rectangular (palisade) arrangement is present abutting the adaxial epidermis extending to the xylem side of the bundles (Plate 53.1), similar to Koyama’s (1967) B group. The phloem side of the bundle extending to the abaxial epidermis has rectangular to polygonal mesophyll that lies with the long axis of the cell parallel to the abaxial surface. The mesophyll cells of both species are thin-walled, with many small chloroplasts.

There are few tannin idioblasts present in the leaves of the *Sclerieae*. The tannin idioblasts in *S. melanomphala* are mostly present in the stellate chlorenchyma (Plate 52.12). The tannin idioblasts in *S. natalensis* are present only near the midrib bundle.

All vascular bundles are solitary and present in a median row (Plate 52.1-2). The minimal cell lateral count in both species is over four cells (Table 22, Appendix 3). All the *Sclerieae* leaves have a midrib bundle, large, intermediate, small and marginal bundles. There is one to three small bundles present between the large and intermediate bundles of the laminae in *S. melanomphala* (Table 22, Appendix 3). The vascular bundles generally have three bundle sheaths (Plates 52.6-11 and 53.2-3), an outer parenchymatous sheath (PS), a middle lignified mestome sheath (MS) and an inner sheath composed of non-lignified border parenchyma (BP). The cells of the PS are thin-walled, chlorenchymatous and generally larger than the abutting mestome sheath cells (Plates 52.6-11 and 53.2-3). The walls of the MS are lignified in all the walls of the cell. Thick-walls within the MS cells are mostly present in the midrib bundle, the large, intermediate and small bundles in *S. melanomphala* on the phloem side of the bundle, as well as abutting the large metaxylem vessels (Plates 52.7). All the bundles in *S. natalensis* have relatively thin-walled MS cells (Plate 52.11). The cells of the BP are thin-walled and present in the midrib bundle and large bundles in both species (Plate 52.6-7), where the large metaxylem
Plate 53. Shows structural details of the leaves of *S. melanomphala* and *S. natalensis* in section illustrating tannin idioblast arrangement and structure, mesophyll structure, and vascular sheaths, as well as vascular tissue structure.

(53.1) Shows the mesophyll in *S. natalensis*, which is composed of non-radiating chlorenchyma and appears two-layered. The upper layer is thin-walled, rectangular, where the long axis of the cells is lying at right angles to the adaxial epidermis and contains numerous chloroplasts. The lower layer is composed of rounded or polygonal chlorenchyma with thin walls, with the long axis of the cells at right angles to the upper layer. (53.2) A lamina small vascular bundle in *S. melanomphala*, with no girders. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath cells are chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially on the phloem side of the vascular bundle. (53.3) A marginal vascular bundle in *S. melanomphala* with no girders. As with the small vascular bundle in 53.2, there are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath cells are chlorenchymatous and thin-walled.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Me) mesophyll; (MS) mestome sheath; (PS) parenchymatous sheath and (T) tannin idioblast. Bars = 10 μm.
vessels and protoxylem lacunae (PxL) interrupt the BP in these bundles (Plate 52.6-7). In the intermediate, small and marginal bundles in the Sclerieae leaves, the BP is limited to the phloem side of the bundle (Plates 52.8-11 and 53.2-3).

Plate 53. Legend on facing page.

There are six phloem and five xylem outlines present in the bundles of the Sclerieae leaves (Appendix 4). Protoxylem lacunae are present in the midrib bundle and large bundles in both species (Plates 52.5-7) Within the xylem of most small bundles there is usually one large xylem vessel (Plates 52.9-11).

10.2.4 Bract Characteristics of the tribe Sclerieae

The bracts of the Sclerieae are V-shaped and lack trichomes. The bracts in S. melanomphala are true V-shaped, whilst S. natalensis are flanged V-shaped, similar to the leaves. The bracts in the Sclerieae are thin (Table 23, Appendix 3). Midribs are thicker than the laminae (Table 23, Appendix 3).

The outer periclinal wall of the epidermis is thick-walled (Plate 54.1-11). Bulliform cells are present in the midribs and the flanges of S. natalensis (Plate 54.1 and 54.4). The epidermal cell size is small in comparison to the bract thickness, whilst the adaxial epidermal cells are mostly larger than the abaxial (Plate 54.7 and 54.9, Table 23 [Appendix 3]).

Cone-shaped silica deposits are absent only in the adaxial epidermal cells abutting the adaxial HSS in S. melanomphala. The structure of cells that contain these deposits is the same as in the leaves.

The stomata in the Sclerieae bracts are flush with the epidermal surfaces (Plate 54.2). The stomata in S. melanomphala are amphistomatous (Plate 54.3), whilst the stomata in S. natalensis are present only in the abaxial epidermis (Plate 54.2). The sub-stomatal cavities are large in size when compared to the leaf thickness (Table 23, Appendix 3). The guard cells of the stomata have variable thickening at the adaxial and abaxial poles (Appendix 4).
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Plate 54. Shows structural details of the bracts of Scleria melanomphala and S. natalensis in section, illustrating abaxial and abaxial epidermis structure; bulliform cell arrangement; stomatal complex arrangement and structure; structure and arrangement of hypodermal sclerenchymatous strands, girders, sclerenchymatous strands; tannin idioblast arrangement; mesophyll structure; vascular bundle arrangement and spacing; vascular sheaths and tissues.

(54.1) Shows the midrib in S. natalensis with adaxial bulliform cells and small abaxial epidermal cells. Stomata are hypostomatic. The midrib vascular bundle has an abutting adaxial and abaxial girders. The mesophyll is composed of non-radiating chlorenchyma. The midrib vascular bundle has a large protoxylem lacuna present at the xylem pole of the vascular bundle. (54.2) The stomata in S. natalensis are flush with the abaxial epidermal cells and have large sub-stomatal cavities. Abaxial epidermal cells abutting the stomata are thick-walled in the outer periclinal wall. The subsidiary cells are relatively thin-walled. The guard cells are thick-walled in the periclinal walls. (54.3) Shows S. melanomphala has amphistomatous stomata. Epidermal cells are thick-walled in the outer periclinal wall. Adaxial epidermal cells are a similar size as the abaxial epidermal cells. (54.4) The flange in S. natalensis with large vascular bundle, which has adjacent adaxial hypodermal sclerenchymatous strands, and abutting adaxial sclerenchymatous strands and an abutting abaxial girder. Adaxial epidermal cells are larger than the abaxial epidermal cells. The epidermal cells abutting the hypodermal sclerenchymatous strands and girder are smaller than the epidermal cells adjacent to the strands or girder. The mesophyll is composed of thin-walled, non-radiating chlorenchyma. The large vascular bundles have a protoxylem lacuna present at the xylem pole of the vascular bundle. (54.5) Shows a lamina large vascular bundle in S. melanomphala with abutting adaxial and abaxial girders. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in all walls, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by the two large metaxylem vessels. (54.6) A lamina large vascular bundle in S. natalensis with abutting adaxial and abaxial girders. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially abutting the girders. The sheath of border parenchyma is interrupted by the two large metaxylem vessels and is indistinct on the phloem side of the vascular bundle. (54.7) Shows a lamina intermediate vascular bundle in S. natalensis with abutting adaxial and abaxial girders. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled in the inner tangential and radial walls, especially abutting the girder. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (54.8) The midrib vascular bundle in S. melanomphala with abutting adaxial and abaxial girders. Epidermal cells are thick-walled in the outer periclinal wall. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is translucent and thin-walled. The sheath of border parenchyma is interrupted by two large metaxylem vessels and is indistinct on the phloem side of the vascular bundle. (54.9) Shows a lamina small vascular bundle in S. melanomphala with abutting abaxial girder. The mesophyll appears to be two-layered. The upper layers of cells are rectangular in shape, with the long axis of the cells at right angles to the adaxial epidermis. The lower layer of cells is composed of stellate parenchyma. The small vascular bundles have three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. Mestome sheath cells are thick-walled in all walls, especially abutting the girder. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (54.10) A lamina small vascular bundle in S. natalensis with abutting abaxial girder. As with the small vascular bundle in 54.9, there are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of non-lignified border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. Mestome sheath cells are also thick-walled in all walls, especially abutting the girder. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. There is a single vessel of xylem present in the vascular bundle. (54.11) Shows the margin in S. melanomphala with marginal vascular bundle and adjacent intermediate vascular bundle. The marginal vascularbundle has two vascular sheaths, an outer parenchymatous sheath and an inner partial sheath of border parenchyma. Both sheaths are chlorenchymatous. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (54.12) A small vascular bundle in S. melanomphala with no girder. There are two distinct vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is chlorenchymatous and thin-walled.

Symbols are as follows: (Ab) abaxial epidermis; (Ad) adaxial epidermis; (BP) border parenchyma; (Bu) bulliform epidermal cells; (G) girder; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (L) large vascular bundle; (Md) midrib vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (OT) outer periclinal wall (tangential); (PS) parenchymatous sheath; (PXL) protoxylem lacuna; (S) small vascular bundle; (St) stoma, (Stc) sub-stomatal cavity; (Su) subsidiary cell; (T) tannin idioblast and (X) xylem vessel. Bars = 10 µm.
Plate 54. Legend on facing page.
As in the leaves, HSS are present only abutting the adaxial epidermis of the flanges in *S. natalensis* (Plate 54.4). Girders abut most of the bundles in the laminae of both species. Both adaxial and abaxial girders abut the midrib bundles in both species (Plate 54.1 and 54.8). Adaxial girders are present abutting the large bundles in both species (Plate 54.5) as well as the intermediate bundles in *S. natalensis* (Plate 54.7). The large, intermediate and small bundles in both species have an abaxial gider (Plate 54.4-10). As in the leaves, there are more abaxial girders than adaxial (Table 23, Appendix 3). Adaxial HSS/girders are larger than abaxial girders (Table 23, Appendix 3). SS are absent in the *Sclerieae* bracts.

Similar to the leaves, there are no lamina cavities in the bracts of the *Sclerieae*. There are also no hypodermal layers adaxially or abaxially in the bracts of the *Sclerieae*. The structure of the mesophyll of the bracts is the same as it was for the leaves. The location and site of tannin idioblast for the bracts is also the same as in the leaves, where the tannin idioblasts in *S. melanomphala* are mostly present in the stellate chlorenchyma and in *S. natalensis* are present only near the midrib bundle.

All vascular bundles are present in a median row within the bract lamina, similar to the leaves. All vascular bundles have a minimal cell lateral count of over three cells (Table 23, Appendix 3).

The bracts in both species contain a midrib bundle, large, intermediate, small and marginal bundles (Table 23, Appendix 3). One vascular bundle is present between the large and intermediate bundles in the laminae of *S. melanomphala*. There is no recognisable pattern with respect to the bundle numbers or location of bundles in the bracts of *S. natalensis*, similar to the leaves.

All vascular bundles have three vascular sheaths (Plate 54.5-10 and 54.12), an outer PS (Plate 55.1), a middle lignified MS and an inner sheath non-lignified BP. The PS of the marginal bundles is absent on the xylem side of the bundle in both species (Plate 55.2-3). The MS in the marginal bundles is absent in *S. melanomphala* (Plate 55.2) and at the xylem side of the vascular bundle in *S. natalensis* (Plate 55.3).

The cells of the PS are generally larger than the abutting mestome sheath cells (Plate 54.6-11, 54.8-9 and 54.11-12). The cells of the PS are thin-walled and chlorenchymatous. All the walls of the MS have similar lignification. The MS cells of most bundles for the *Sclerieae* are relatively thin-walled. The large, intermediate and small bundles in *S. natalensis* are thick-walled on the phloem side of the bundle, as well as abutting the large metaxylem vessels. A BP is present in few bundles of the *Sclerieae* bracts, where a BP was present in the midrib bundle and large bundles of both species (Plate 54.5-6 and 54.8). This BP is bisected by the large metaxylem vessels and the protoxylem lacunae (PxL). A BP is also present on the phloem side of the intermediate, small and marginal bundles in *S. natalensis* (Plate 54.7 and 54.10). The BP of the marginal bundles in *S. melanomphala* is present on the phloem side of one bundle (Plate 54.12) and bisected by the metaxylem vessels in the other.

There are 5 different phloem and 6 different xylem outlines in the bracts of the *Sclerieae* (Appendix 4). As in the leaves, protoxylem lacunae are present in the midrib bundle and large bundles of both species (Plate 54.1 and 54.4). As with the leaves, a single large xylem vessel is prominent at the adaxial pole of the small bundles (Plates 54.10).
Plate 55. Shows structural details of the bracts of *S. melanomphala* and *S. natalensis* in section, illustrating vascular sheath structure.

(55.1) Shows a small vascular bundle of the lamina in *S. natalensis*. The small vascular bundle has two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath is thick-walled in the inner tangential and radial walls, especially on the phloem pole of the vascular bundle. (55.2) A marginal vascular bundle in *S. melanomphala* with one recognisable vascular sheath of parenchyma. This parenchymatous sheath is chlorenchymatous and thin-walled. (55.3) Shows a marginal vascular bundle in *S. natalensis* with partial vascular sheaths. There are two vascular sheaths, an outer parenchymatous sheath and an inner mestome sheath. The parenchymatous sheath is chlorenchymatous and surrounds the whole vascular bundle. The mestome sheath is partial and present in places on the phloem side of the vascular bundle.

Symbols are as follows: (Ad) adaxial epidermis; (BP) border parenchyma; (MS) mestome sheath and (PS) parenchymatous sheath. Bars = 10 μm.
10.2.5 Culm Characteristics of the tribe Sclerieae

Both species have triangular shaped culms. The culms in *S. natalensis* have wavy outlines. There are no trichomes present in the culms of the *Sclerieae*. The culms of this genus are large (Table 24, Appendix 3).

The epidermal cells are small (Table 24, Appendix 3) and variably shaped. As with the leaves and the bracts, the outer periclinal wall of the epidermis is thick-walled (Plate 56.1-2).

Cone-shaped silica deposits are present in the epidermal cells abutting the HSS and girders. The shape and structure of the cells that contain these deposits is the same as the bracts (Appendix 4).

The stomata in *S. melanomphala* are raised above the epidermal surfaces (Plate 56.1), while those in *S. natalensis* are flush with the epidermal surface (Plate 56.2). Sub-stomatal cavities are small (Table 24, Appendix 3).

HSS are present in the corners of the triangle of both species (Plate 56.3). In one of these corners there is a girder on a small bundle in *S. melanomphala* (Plate 56.4). The xylem of this small bundle faces the girder (Plate 56.4). The girders and HSS are small (Table 24, Appendix 3). The arrangement of girders in the culms of the *Sclerieae* is more complex than the leaves or bracts.

A girder is present on the phloem pole of the outer row of most of the vascular bundles and some second row large bundles in both species (Plate 56.5-10). The girders of the first row bundles may extend along the epidermis to join with the girders of the second row of large bundles. In the corners of the triangle in *S. melanomphala* there is a second row of large bundles. Some of the girders extend from the adjacent epidermal surface to these large bundles. These girders form bridges of sclerenchyma that extend from one side of the corner to the other (Plate 56.5). Present between these girders and the HSS, in the corner, is a single small bundle (Plate 56.3 and 56.5).
Plate 56. Shows structural details of the culms of *S. melanomphala* and *S. natalensis* in section, illustrating epidermal and stomatal complex structure; hypodermal sclerenchymatous strands, girders, sclerenchymatous strands arrangement and structure; cavity arrangement; ground tissue structure; vascular bundle arrangement; and vascular sheaths as well as tissues.

(56.1) Shows the epidermis in *S. melanomphala* with thick-walled outer periclinal wall. The stomata are slightly raised above the epidermal surface and have small sub-stomatal cavities. Subsidiary cells have relatively thin walls. The guard cells are thick-walled in the periclinal walls. (56.2) The epidermis in *S. natalensis* has a thick-walled outer periclinal wall. The stomata are flush with the epidermal surfaces and the sub-stomatal cavities are small. Subsidiary cells have relatively thin-walls. The guard cells are thick-walled in the periclinal walls. (56.3) Shows the triangle corner in *S. natalensis*. Hypodermal sclerenchymatous strands are present in the corner and a girder of inner large vascular bundle bridges the corner. Abutting the girder-bridge is an intermediate vascular bundle, which abuts the girder on the corner side of the girder. The ground tissues consist of chlorenchyma and translucent parenchyma. The chlorenchyma is present between the girder-bridge and the epidermis of the triangle corner. Additionally chlorenchyma extends from the epidermis to phloem sides of the first and second row vascular bundles. The chlorenchyma is thin-walled and contains numerous chloroplasts. Endarch to the chlorenchyma is thin-walled translucent parenchyma, which extends to the centre of the culm (not in picture). (56.4) A triangle corner in *S. melanomphala* showing the girder of a small vascular bundle. Note that the xylem side of the vascular bundle abuts the girder and not the phloem side (the vascular bundle is inverted). There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The parenchymatous sheath is thin-walled and chlorenchymatous. The mestome sheath is thick-walled in all walls, especially abutting the girder. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. Also note that, as with the leaves there is only one xylem vessel present in the vascular bundle. (56.5) Shows a corner bridge-girder in *S. melanomphala* where the girder of the second row large vascular bundle extends and bridges the corner of the triangular culm. Exarch to the bridge-girder is chlorenchyma and endarch to the girder is translucent parenchyma. The chlorenchyma extends from the epidermis on the sides of the girder to the phloem sides of the adjacent vascular bundles. Exarch to the girder is a single small vascular bundle with intact sheaths. (56.6) A corner girder in *S. natalensis* where the girder of the second row large vascular bundle extends and abuts the xylem pole of the first row intermediate vascular bundle. This girder of both vascular bundles does not bridge the corner. Chlorenchyma extends from the epidermis to the phloem sides of the first and second row vascular bundles. Endarch to the chlorenchyma is translucent parenchyma, which extends to the centre of the culm (not in picture). (56.7) Shows a first row large vascular bundle in *S. melanomphala* with abutting phloem side girder and xylem pole sclerenchymatous strands. Chlorenchyma extends from the epidermis to the phloem side of the vascular bundle. Endarch to the chlorenchyma is translucent parenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled, especially abutting the girder. The sheath of border parenchyma is interrupted by two large metaxylem vessels. There is a large protoxylem lacuna present near the xylem pole of the vascular bundle, inside the sheath of border parenchyma. (56.8) A first row large vascular bundle in *S. natalensis* with an abutting phloem side girder. Chlorenchyma extends from the epidermis to the phloem side of the vascular bundle. Endarch to the chlorenchyma is translucent parenchyma. There are also two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in all walls, especially abutting the girder. The sheath of border parenchyma is interrupted by two large metaxylem vessels and a large protoxylem lacuna. (56.9) Shows a first row intermediate vascular bundle in *S. melanomphala* with abutting phloem side girder. Chlorenchyma extends from the epidermis to the phloem side of the vascular bundle. Endarch to the chlorenchyma is translucent parenchyma. There are also two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled in inner tangential and radial walls, especially abutting the girder. The sheath of border parenchyma appears to be limited to the phloem side of the vascular bundle. (56.10) A first row intermediate vascular bundle in *S. natalensis* with abutting phloem pole girder and xylem pole sclerenchymatous strands. As with 56.9, chlorenchyma extends from the epidermis to the phloem side of the vascular bundle. Endarch to the chlorenchyma is translucent parenchyma. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is thin-walled and chlorenchymatous. The mestome sheath is thick-walled in all walls, especially abutting the girder. (56.11) Shows a second row large vascular bundle in *S. melanomphala* with both phloem side and xylem pole sclerenchymatous strands. Surrounding the vascular bundle is the translucent parenchyma of the central region of the culm. There are two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma. The mestome sheath is thick-walled, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels and a large protoxylem lacuna. (56.12) A second row large vascular bundle in *S. natalensis* with both phloem side and xylem pole sclerenchymatous strands. Surrounding the vascular bundle is thin-walled translucent parenchyma. There are two vascular sheaths, an outer lignified mestome sheath and an inner non-lignified sheath of border parenchyma.

(Legend continues on the next facing page)
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The mestome sheath is thick-walled, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is interrupted by two large metaxylem vessels and is indistinct on the phloem side of the vascular bundle. A large protoxylem lacuna is present inside the sheath of border parenchyma at the xylem pole.

Symbols are as follows: (Ca) cavity; (Ch) chlorenchyma; (BP) border parenchyma; (Ep) epidermal cell; (G) girder; (HSS) hypodermal sclerenchymatous strands; (I) intermediate vascular bundle; (L) large vascular bundle; (MS) mestome sheath; (MX) metaxylem vessel; (OT) outer periclinal wall (tangential) of epidermal cell; (PS) parenchymatous sheath; (Pxl) protoxylem lacuna; (S) small vascular bundle; (St) stoma; (Stc) sub-stomatal cavity; (SS) sclerenchymatous strands; (Su) subsidiary cell and (TP) translucent parenchyma. Bars = 10 μm.

Plate 57. Shows structural details of the culms of *S. melanomphala* and *S. natalensis* in section, including girders, sclerenchymatous strands, cavities, ground tissues, vascular bundle arrangement, and vascular sheaths as well as tissue structure.

(57.1) Shows a first row small vascular bundle in *S. melanomphala* where the sclerenchymatous strand on the xylem pole of the vascular bundle joins with the sclerenchymatous strands of second row large vascular bundle. Chlorenchyma is present up to the xylem pole and endarch to the chlorenchyma is translucent parenchyma. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath is thick-walled, especially parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. Mestome sheath cells are thick-walled in all walls. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (57.2) A first row small vascular bundle of the corner of the triangular culm of *S. natalensis*. An outer cavity abuts this vascular bundle and is present only in one corner. There are three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. Mestome sheath cells are also thick-walled in all walls. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (57.3) The ground tissues in *S. melanomphala* consist of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem side of the first row of vascular bundles. Endarch to the chlorenchyma is translucent parenchyma. Vascular bundles are present in two rows, where the first row is present at the transition of chlorenchyma and translucent parenchyma. The second row of vascular bundles is present in the central region of translucent parenchyma. (57.4) The ground tissues in *S. natalensis* consist of chlorenchyma and translucent parenchyma. The chlorenchyma extends from the epidermis to the phloem sides of the first two rows of vascular bundles. Endarch to the chlorenchyma is translucent parenchyma. There are three rows of vascular bundles. The first two rows of vascular bundles are present on the intersection (place where the two tissues meet) of chlorenchyma and translucent parenchyma. The third row of vascular bundles are present in the central region of translucent parenchyma. (57.5) Shows a first row small vascular bundle abutting a girder of second row large vascular bundles in *S. melanomphala* in the triangle corner. The small vascular bundle is surrounded by chlorenchymatous parenchyma; it has three vascular sheaths, an outer parenchymatous sheath, a middle lignified mestome sheath and an inner sheath of border parenchyma. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled, especially on the phloem side of the vascular bundle. The sheath of border parenchyma is limited to the phloem side of the vascular bundle. (57.6) A first row small vascular bundle in *S. natalensis* with an abutting xylem side sclerenchymatous strand. Chlorenchyma extends from the epidermis to the phloem side of the vascular bundle. The chlorenchyma is thin-walled and contains numerous chloroplasts. Endarch to the chlorenchyma is thin-walled translucent parenchyma. There are two vascular sheaths, an outer parenchymatous sheath and an inner lignified mestome sheath. The parenchymatous sheath is chlorenchymatous and thin-walled. The mestome sheath cells are thick-walled, especially on the phloem side of the vascular bundle.

Symbols are as follows: (1) first row of vascular bundles; (2) second row of vascular bundles; (3) third row of vascular bundles; (Ca) cavity; (Ch) chlorenchyma; (BP) border parenchyma; (Ep) epidermal cell; (G) girder; (MS) mestome sheath; (PS) parenchymatous sheath; (SS) sclerenchymatous strands and (TP) translucent parenchyma. Bars = 10 μm.
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The structure of the girders in *S. natalensis* is similar to *S. melanomphala*. The girder is a girder for both bundles (phloem side of the large bundle and xylem side of the small bundle). Not all the girders in the corners bridge the corner (Plate 56.6). The small bundles present beneath these large bundles with partial bridges of sclerenchyma in the corners, abut the girder.

The location and structure of the SS is similar for both species. SS are present on the xylem and phloem poles of the inner large bundles (Plates 56.11-12). SS are also present on the xylem side of most of the outer row bundles (Plates 56.7, 56.10 and 57.1). In one corner, where there is no girder bridge, the SS of the small bundle beneath the large bundle extends and joins the SS on the phloem pole of the bundle. Some of the outer row of small or intermediate bundles not in the corners, have SS present on the xylem pole that extends and joins the SS of the inner large bundles on the phloem pole of the bundle (Plate 57.1). The SS of the xylem pole of the second row of large bundles are large and similar in structure to the *Schoeneae* SS (a multiple MS in appearance [Plate 56.11]). The SS of the inner large bundles in *S. natalensis* (Plate 56.12) are not as distinctive as *S. melanomphala*.

![Image of plate 57](Plate 57. Legend on facing page.)

Cavities are present only in the corners of the triangle in *S. natalensis* (Plates 56.3 and 57.2), between the HSS and the small bundle of the corners. Cavities are small in size (Table 24, Appendix 3).

There are few tannin idioblasts present in the culms of the *Sclerieae*. The tannin idioblasts in *S. melanomphala* are present in the chlorenchymatous layer. The tannin idioblasts in *S. natalensis* are present abutting the epidermis.
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The ground tissues of the two species are similar in structure and composition (Plate 57.3-4). The chlorenchyma is present from the epidermis to the phloem side of the first and second row of large bundles, extending to the xylem pole of the first row of intermediate and small bundles. In the corners of the triangle the chlorenchyma extends to the phloem side of the second row of large bundle and surrounds the girder. Present from the chlorenchyma to the centre of the culm is TP. The cells of the TP abutting the bundles are small, increasing in size towards the centre of the culm. The cells of the chlorenchyma and TP are thin-walled.

*S. melanomphala* has two rows of bundles (Plate 57.3), whilst *S. natalensis* has three rows (Plate 57.4). The first row of bundles in the Sclerieae culms is composed of large, intermediate and small bundles. Small bundles are present in the corners of the triangle in both species. The inner row bundles in both species are composed of large bundles. There are generally more large and small bundles than intermediate bundles (Table 24, Appendix 3).

As in the leaves and bracts, the vascular bundles have three bundle sheaths (Plates 56.4, 56.10, 57.1-2 and 57.5-6), an outer PS, a middle lignified MS and an inner sheath of non-lignified BP. The rows of bundles in the TP do not have the outer sheath (Plate 56.8 and 56.11-12). The cells of the PS are larger than the abutting mestome sheath cells (Plates 56.4, 56.10, 57.1-2 and 57.5-6). The cells of the MS are thin-walled and chlorenchymatous. The MS cells are lignified in all the walls, especially on the phloem side of the vascular bundles (Plates 56.4, 56.10, 57.1-2 and 57.5-6). Lignification in the MS cells of most bundles in the Sclerieae is thin-walled. Thick-walls are present in the small bundles of *S. melanomphala* on the phloem side of the bundle (Plate 57.5). The BP of the large bundles in both species is bisected by the large metaxylem vessels and interrupted by the PxL (Plate 56.7-8 and 56.11). In the inner large bundles of *S. natalensis* the PxL is present inside the BP (Plate 56.12). The BP of the intermediate and small bundles in both species is limited to the phloem side of the bundle (Plates 56.9, 57.1-2 and 57.5-6).

Phloem and xylem outlines vary (Appendix 4). A PxL is only present in the large bundles of the Sclerieae culms (Plate 56.7-8 and 56.11-12). As in the leaves and bracts, most small bundles have one large xylem vessel present in the bundle (Plate 56.4).
11.1 Discussion

The scope of this project was to examine the anatomical structure of the leaves, bracts and culms, coupled with the apparent photosynthetic subtypes relative to habitat within the Cyperaceae which occurred in the Eastern Cape region of South Africa. Lubke (1988A & B) highlighted the under collection of Cyperaceae in the Eastern Cape. Little is known in South Africa about their anatomy other than the data for species examined by Gordon-Gray (1966, 1971), Vorster (1978), Mpikeleli (1982), Sonnenberg (1989, 1992) and Thame (1991). Prior to this investigation, only one meaningful collection existed that of the Mariscus genus by Vorster (1978).

The scope of the thesis was limited from the outset by the data which could physically be gathered from such a broad-based anatomical study. As a result there are inherent limitations and constraints (such as a lack of molecular or biochemical subtype data was not examined for example). However, I argue that this thesis forms an important basis for future research on the Cyperaceae, where specific interests to the nature of the photosynthetic activity (C$_3$, C$_4$ or C$_3$-C$_4$ intermediate) for example, being the recent studies such as those reported by Botha et al. (2004) which deal with the phloem loading pathway in the Cyperaceae. Botha et al. (2004) have for example, shown that the complex loading pathway within the C$_4$ Cyperaceae is related to the unique structure of the vascular bundles, the suberised layers within the mestome sheath cells and that this in turn, is reflected in the complex highly modified plasmodesmatal structure.

A number of questions were posed at the outset which were governed by, and in part limited the scope of the research to be carried out. Obviously these questions were modified as time went by. Broadly the questions focussed attention on structure (category A see introduction, page 9) and on climate related issues (category B see introduction, page 9), which are addressed by highlighting key aspects of the study below. The hypothesis upon which this thesis is based, for obvious reasons is one that argues for the influence of climate and habitat on the distribution of photosynthetic anatomical structure.

11.1.1 Unique anatomical structural characteristic of tribes, genera and species

There are many characters that are potentially influenced by hydromorphic, mesomorphic and xeromorphic environments that maybe specific to a particular tribe, genus or species. These anatomical structures include: the thickness of leaf (Esau 1977; Carpenter and Smith 1981; Araus et al. 1986; Ristic and Cass 1991; Strauss-Debenedetti and Berlyn 1994; Tipton and White 1995; Hlwatika et al. 1998; Raven et al. 1999), bract or culm; thickness of the adaxial and abaxial epidermal cells of leaves (Carpenter and Smith 1981; Körner et al. 1983; Halloy and Mark 1996; Hlwatika et al. 1998) and bracts; sunken, flush or raised stomata, as well as associated structures (Esau 1977; Raven et al. 1999); presence or absence of bulliform epidermal cells (Esau 1977; Blackmore and Tootill 1986; Raven et al. 1999); presence and distribution of lignification (Esau 1977; Garnier and Laurent 1994); presence or absence of lamina cavities (Veres and Williams 1985; Ueno and Koyama 1987), which may also be related to the presence or absence of parenchymatous bridges; presence or absence of a hypodermis (Esau 1977); mesophyll structure (Garnier and Laurent 1994; Iviezic et al. 1996) and the presence or absence of secretory substances (Fahn 1988).
A number of unique anatomical characteristics similar to those described in Metcalfe (1971), are present within only a few of the tribes of the Eastern Cape Cyperaceae, namely Abildgaardieae, Cariceae, Cypereae, Schoeneae, Scirpeae and Scherrieae. A few genera have distinctive or diagnostic anatomical characters that may separate them from the others found within the region. These are: Carpha; Cyperus; Ficinia; Fuirena; Kyllinga; Mariscus and Schoenoplectus. Within the Eastern Cape, 43 percent of the Cyperaceae species of have specific anatomical characteristics that may be of some use as taxonomic characters or keys that may be used to identify the species (Appendix 4). Many of the useful anatomical characteristics are unique, especially when used in conjunction with photosynthetic type (Appendix 4). Anatomical characters may thus be just as important as floral characters in the classification of the Cyperaceae. The most important are: pseudo-dorsiventral leaves and bracts; presence of papillate epidermal cells; absence of bulliform epidermal cells; absence of a hypodermis in a particular genus; mesophyll structure; lateral vascular bundles; vascular bundles of the midribs with additional bundles; rows of bundles in the leaves and/or bracts; presence of solenostele bundles and photosynthetic structure.

In the Eastern Cape, Cladium mariscus subsp. jamaicense has several unique anatomical characters. For example, pseudo-dorsiventral leaves and bracts are present only in this one genus and species. The presence of pseudo-dorsiventral leaves and bracts in Cladium is supported by both Fisher (1971) and Metcalfe (1971). Metcalfe (1971) noted that only two genera in the Cyperaceae have pseudo-dorsiventral leaves, namely Cladium and Mesomelaena, where only Cladium is present in the Eastern Cape. Most vascular bundles in this species face the central cavity, similar to a unifacial leaf or bract. In this instance the adaxial and abaxial epidermis may be called abaxial or just epidermis. In many of the species investigated, the interpretation of adaxial epidermis was taken as the epidermis that was above and closest to the xylem tissues of the lamina bundles. Of diagnostic significance are the girders of leaves and bracts of Cladium mariscus subsp. jamaicense (Plates 32.12, 34.6-8 and 36.11-12), which extend across the lamina cavities from the xylem pole of the adaxial row of the large or intermediate bundles to the xylem pole of the abaxial row of large bundles. These girders are surrounded by the parenchymatous bridges that extend across these large central cavities of the laminae.

The papillate abaxial epidermal cells are specific for the Cariceae, C. aethiopica (Plates 7.4, 7.8 and 10.6), C. glomerabilis, C. mossii and Schoenoxiphium rufum (Plate 7.3). Standley (1990) stated that papillate epidermal cells were absent in the Carex species that he investigated. Bruhl (1993) however, makes no mention of the occurrence and or absence of these cells. Metcalfe (1971) stated that papillate cells were of diagnostic importance to the genus Carex, but that their distribution needed to be checked. Shepard (1976) recorded the presence of papillate epidermal cells only in the epidermal cells abutting the stomata of the Vesicariae, which was also evident in the Eastern Cape Carex species (Plate 7.8). However, there were also additional papillate cells present at random in the epidermis between the stomata of these Eastern Cape species.

Metcalfe (1971) stated that the occurrence and distribution of bulliform cells is of taxonomic use, but added a cautionary note concerning the use of herbarium specimens, since it is well known how difficult it is to restore the cells. The present investigation made use of fresh tissue from the field, which was fixed, dehydrated and embed in wax. The absence of adaxial bulliform cells is diagnostic to a number of hydrophytic to xerophytic C. species in the Cypereae (C. immensis [leaves, hydrophytic and halophytic], C. laevigatus [bracts, halophytic], C. natalensis [leaves, halophytic], C. obtusiflorus [leaves, halophytic], C. rubicundus [bracts, mesophytic to xerophytic], C. rupestris var. rupestris [leaves and bracts, xerophytic], C. semitrigidus var. semitrigidus [bracts, xerophytic], C.
sexangularis [bracts, mesophytic to xerophytic], K. elatior [leaves and bracts, mesophytic], M. capensis [bracts, xerophytic], M. dubius [leaves and bracts, halophytic], M. macrocarpus [leaves, halophytic], M. sumatrensis [leaves, halophytic], M. tabularis subsp. major [leaves, halophytic], M. thunbergii [leaves, halophytic], M. uitenhagensis [leaves, xerophytic], P. cooperi [bracts, hydrophytic to mesophytic], P. maracanthus [bracts, hydrophytic to mesophytic], P. nitidus [bracts, hydrophytic] and P. polystachyos var. polystachyos [leaves, hydrophytic to mesophytic]). Most of these species occur in halophytic and xerophytic habitats, where not being able to roll the leaf or bracts is a disadvantage. The absence of bulliform cells in these species does not seem clear.

Vorster (1978) stated that the presence or absence of hypodermal layers and/or cavities was taxonomically significant in Mariscus. A hypodermis is absent in the lamina of M. congestus (leaves), M. dubius (leaves), M. macrocarpus (bracts) and M. sumatrensis (leaves and bracts). Metcalfe (1971), Vorster (1978) and Bruhl (1993) stated that all the Mariscus species they examined had a hypodermis, which is not evident for these four Mariscus species. Thus the absence of a hypodermis in the four Mariscus species reported in this thesis is anatomically significant.

Within the Eastern Cape species, the leaves and/or bracts of C3's can be divided into three structural classes using Koyama's (1967) scheme, which is based on mesophyll structure. Koyama's (1967) B and C structures are present only in the genus Scleria. Koyama's (1967) B mesophyll structure, occurs in the leaves and bracts of S. natalensis (Plate 53.1). The leaves and bracts of S. melanomphala have Koyama's (1967) mesophyll C structure (Plate 52.12).

The number of rows of vascular bundles within the laminas of the leaves is specific for P. cooperi, where four rows of bundles are present. Metcalfe (1971) noted only two rows of bundles to be present in Pycreus, whilst Bruhl (1993) noted only one row of bundles in Pycreus, which was not the case in the present study. In the leaf laminas, of P. cooperi the first three horizontal rows of bundles appear to be stacked (Plates 15.12 and 17.1). In the bracts (Plate 20.2) only the first two horizontal rows have this type of stacking. This type of vascular bundle stacking in P. cooperi is unique, in the Eastern Cape Cyperaceae. In addition, the number of rows of vascular bundles within the culms may also be of diagnostic value in the genus Mariscus, where seven rows are present in M. macrocarpus, eight in M. solidus and eleven in M. thunbergii.

Distinctive lateral vascular bundles are present in the genus Carpha, where these bundles are present in the culms, bracts and leaves of these species. The lateral vascular bundles abut the leaf, as well as bract midrib bundle and large bundles (Plates 32.1, 32.11, 33.11-12, 34.3, 34.10, 34.12, 35.2, 35.7, 37.2, 38.3-4 and 38.6), and are found adjacent the large bundles of the culms (Plate 40.9). Bruhl (1993) noted the presence of small bundles adjoining large bundles in the lamina of only C. capitellata. In the leaves and bracts of Carpha three lateral bundle conformations may be recognised. The first is present in C. bracteosa, where the lateral bundles are composed of one or two small or intermediate bundles abutting the larger bundle (Plate 37.2). Most of the laterals lack vascular bundle sheaths on the xylem side of the bundle. Additionally, these sheaths are also absent on the xylem side of the large bundle. The xylem tissue of the large bundle and lateral coalesce (Plates 35.7 and 38.6). In the second type, which is present in C. glomerata, the midrib vascular bundle is solitary. Lateral bundles abut the large bundles, where the lateral bundles, which are associated with the large bundles are small. The xylem at the adaxial pole of the bundles of the laterals and the large bundle may coalesce particularly when there is only one lateral bundle. Generally, the lateral vascular bundles are separated from the larger bundle by a few cells of translucent parenchyma (Plate 34.3). In the
third group, which is present in *C. schlechteri*, most of the vascular bundles are solitary (Plate 34.5). The midrib bundle (Plate 32.11) and a few of the large bundles (Plate 33.12) may have one or two laterals (mostly small bundles). The xylem at the adaxial pole of the vascular bundles of the midrib bundle and large bundles does not coalesce with the laterals (Plates 32.11 and 33.12).

One small bundle is usually present below the midrib bundle in a few of the leaves of the Eastern Cape Cyperaceae, namely *C. semitrifidus* var. *semitrifidus*, *K. alata*, *K. erecta* and *K. pauciflora* (*C* 4 species in the *Cypereae*), as well as *B. maritimus* (*C* 3 species in the *Scirpeae*). It is possible that both *C. semitrifidus* var. *semitrifidus* and *B. maritimus* are closely related to the genus *Kyllinga*. It is also possible that, anatomically, *C. semitrifidus* var. *semitrifidus* could be placed within the genus *Kyllinga*. Furthermore, *B. maritimus* may be ancestral to *C. semitrifidus* var. *semitrifidus*, *K. alata*, *K. erecta* and *K. pauciflora*. Molecular investigations would need to be undertaken to confirm these suppositions. The xylem in these small bundles encircles the phloem. The condition of xylem surrounding phloem is termed solenostelic and is unusual, since it is reported in the roots of the ferns *Marsilea* and *Adiantum* (Blackmore and Tootill 1986).

Solenostelic bundles are also present only in the culms of *Mariscus*, namely in *M. solidus*, *M. thunbergii* (Plate 23.10) and *M. uitenhagensis* (Plate 23.11). These solenostelic bundles are present in the inner vascular bundles of the culm within the region of translucent parenchyma (TP). Most of these bundles also have multi-layered mestome sheaths.

In *Mariscus*, *M. macrocarpus* (leaves), *M. sumatrensis* (leaves), *M. tabularis* subsp. *major* (bracts) and *M. thunbergii* (leaves, Plate 18.3), the vascular orientation of the abaxial row of small vascular bundles is specific. The long axis of these small bundles is parallel to the adaxial epidermal surface. Where the xylem in these small bundles faces the adaxial surface of the midrib.

### 11.1.2 Structural relationships in relation to photosynthetic forms

The leaves, bracts and culms may be divided into two structural groups based on the presence or absence of a radiating mesophyll (or radiate chlorenchyma as it is sometimes referred to in the literature). The radiating mesophyll is composed mostly of rectangular chlorenchymatous parenchyma, elongated radially with respect to the outer sheath of the vascular bundles. It often forms an encircling sheath around the bundle. Metcalfe's (1971) group A, or structural group with no radiating mesophyll, is present in the *Cariceae*, *Cypereae* (in part), *Hypolytraeae*, *Rynchosporae* (*R. brownii*), *Schoeneae*, *Scirpeae* and *Sclereae*. The *Cypereae* species with no radiating mesophyll are as follows: *Ascolepis capensis*, *Cyperus difformis*, *C. denudatus*, *C. pulcher*, *C. sphaerospermus*, *C. tennellus* var. *tennellus*, *C. textilis* and *P. mundii*. The presence of non-radiate chlorenchyma in these genera was supported by Metcalfe (1971) and by Bruhl (1993 & 1995), with the exception of *A. capensis*, which Bruhl (1993 & 1995) listed as C 4.

With the exception of *Cyathocoma hexandra* (bracts), *Cyperus tennellus* var. *tennellus* (leaves and bracts), *F. bulbosa* (leaves), *F. dura* (leaves and bracts), *F. lateralis* (leaves and bracts), *F. oligantha* (bracts), *F. pingiour* (bracts), *F. stolonifera* (leaves and bracts), *F. tribracteata* (leaves and bracts), *F. zeyheri* (leaves and bracts), *I. cernua* (leaves and bracts), *I. costata* var. *macra* (bracts), *Schoenus nigricans* (leaves), *Scirpus nodosus* (bracts) and
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*T. cuspidata* (leaves and bracts), the species with no radiating mesophyll all had a maximal cell distal count of greater than four. A maximal cell lateral count of greater than four cells suggests that these species may be C₃ (Hattersley and Watson 1975). Furthermore none of the bundles of these species has radiating mesophyll, also suggesting that these species are C₃ and fall within Goetghebeur's (1989) Eucyperoid group of species. Bruhl (1995) also lists these species as C₃. This may suggest that the species with no radiating mesophyll in the Eastern Cape Cyperaceae are C₃, which is supported by Evert (1980) who stated that very few C₃ grasses have radiating mesophyll. A number of the species with no radiating mesophyll also fall within the Hattersley and Watson (1975) category for C₄, namely have a minimal cell lateral count of one. These species are as follows: *F. arenicola* var. *arenicola* (leaves), *F. dura* (leaves), *F. lateralis* coastal (leaves and bracts), *F. pingiour* (bracts), *F. stolonifera* (bracts), *F. tribracteata* (leaves), *F. zeyheri* (leaves), *Schoenus nigricans* (leaves) and *T. cuspidata* (leaves and bracts). The Eucyperoid C₃ species with maximal distal cell counts of below four cells and minimal cell lateral count of one are small plants with small leaves (plants that are less than 100mm high) or species with scutiform to circular leaves and bracts. It is possible that criterion of Hattersley and Watson (1975) is specific for C₄ grasses and not C₄ Cyperaceae. This point has been highlighted by Soros and Dengler (2001) who have stated that the Hattersley and Watson (1975) criterion does not apply to the Cyperaceae. This conundrum can be solved using biochemical techniques. These Eastern Cape Cyperaceae should thus be tested biochemically to confirm that they either are C₃ or are intermediate to the C₃ or C₄'s.

Metcalfe's (1971) group B or structural group with radiating mesophyll occur in the *Abildgaardieae, Cypereae* (in part) and *Rhynchosporeae* (*R. barrosiana*). Similarly, Metcalfe (1971) also stated that these species had radiate chlorenchyma. All these species have a maximal cell distal count of four cells or fewer, which suggests that these species may be C₄ (Hattersley and Watson 1975, Soros and Dengler 1998). At the time of the publication of Metcalfe (1971), the description of the anatomy of C₄ photosynthetic plants was in its infancy. C₄ photosynthesis was discovered in sugarcane by Kortschack et al. in 1954 and later by Karpilov in 1960 in Hawaii. This early work served as the basis for the series of investigations carried out in Australia by Hatch and Slack (1966 and 1970) and Laetsch (1974). These investigations by Hatch and co-workers led to the further elucidation of C₄ photosynthesis. Of interest was that C₄ plants had different vascular sheath anatomy when compared to C₃ plants, and the term Kranz cells first noted by Haberlandt in 1882 was used for the enlarged cells of the primary carbon reducing sheath or PCR sheath (Laetsch 1974). All the Eastern Cape species with radiating mesophyll also have Kranz anatomy, which further suggests that these species are C₄ (Johnson and Brown 1973). The species with radiating mesophyll and the related Kranz sheath with large chloroplasts fall within Goetghebeur's (1989) Chlorocyperoid group. This may suggest that all the species in the Eastern Cape Cyperaceae with radiating mesophyll may be C₄. Only *Bulbostylis contexta* (bracts) and *Fimbristylis ferruginea* (leaves), have a minimal cell lateral count of greater than one. Thus these species with radiating mesophyll, Kranz and a maximal cell distal count of four or less, fail the Hattersley and Watson (1975) minimal cell lateral count. These C₄ species similar to the C₃ species that did not fall within the Hattersley and Watson (1975) maximal and minimal cell counts for C₃, may fall within the C₃-C₄ intermediate group. *B. contexta* and *F. ferruginea* will have to be tested biochemically to resolve whether they are C₄ or whether they are C₃-C₄ intermediates. It does seem however, that should the biochemical tests confirm the C₃ species are C₃ and the C₄ species are C₄, that Soros and Dengler (2001) would be correct, that the Hattersley and Watson (1975) delimitation of C₃ or C₄ for grasses, would not be applicable for the Cyperaceae.
Some species displayed varied anatomies. For example, leaves of *Cyperus albostriatus* are apparently C₄, whilst the bracts are apparently C₃. Brown (1975) stated that in grasses, a species without Kranz would not have subspecies with non-Kranz anatomy, although genera may have species with both forms present. However, this appears not to be the case within the Eastern Cape Cyperaceae, since *C. albostriatus* contains both anatomical types occurring within the same specimens. In addition the dimorphism represented by an alternation in apparent photosynthetic forms, is found in *Eleocharis vivipara*, where the terrestrial form is C₄ and NAD-Me, while the submerged form is structurally and biochemically C₃. The C₃ form of *E. vivipara* occurs under hydrophytic conditions, whilst the C₄ form occurs in dry land conditions (Ueno *et al.* 1988B; Bruhl and Perry 1995; Ueno 1996). Leaves and bracts are developed at different times in the life stages of the plant and also in different seasons as in *C. albostriatus*. The leaves are present for longer periods than the bracts and mature under xerophytic conditions, whilst the bracts mature under relatively mesophytic conditions. This dimorphism in *C. albostriatus*, similar to *E. vivipara* may afford this plant additional means of surviving the xeric and variable environment of the region.

Seventy four percent of the Cyperaceae genera in the Eastern Cape are C₃ and twenty six percent are C₄. Where the genera *Cyperus, Pycreus* and *Rhynchospora* have both C₃ and C₄ species. These percentages are somewhat different when comparing species percentages, with 60 percent C₃ and 40 percent are C₄. It is important to note that the Eastern Cape Cyperaceae have similar C₄ species composition to the C₄ grasses as present in the rest of the world, where 40 percent of the species are C₄ (Tieszen *et al.* 1979).

### 11.1.3 Structural observations of the C₃ and C₄ forms

Based on the results presented in this thesis, it appears that the species that are C₃ may be divided into two types when the number of vascular sheaths present is taken into account (Fig. 1E-F). In contrast, C₄ species may be divided into three types based on the number and distribution of these sheaths (Fig. 1B-C and Plate 2.9-10).

In the first C₃ type, or A type, vascular bundles are surrounded by two sheaths (Fig. 1E), and in the second, or B type, by three (Fig. 1F). The A type is present only in the *Cypereae* (*Cyperus denudatus* and *C. textilis*) and most of the *Scirpeae*. Two vascular bundle sheaths were reported to be present by Metcalfe (1971), Bruhl (1993) and Govindarajalu (1976) in *Scirpus*, which was evident in the Eastern Cape *Scirpeae*. Most of the Eastern Cape species with apparent C₃ structure fall within the B type in which the vascular bundles are surrounded by three sheaths. Within the *Scirpeae*, the species with B type anatomy are as follows: *Bolboschoenus maritimus, Ficinia cinnamomea, F. fascicularis, F. lateralis, F. pingouin, the genus Fuirena, I. diabolica, I. fluitans, I. prolifera* and *Schoenoplectus paludicola*. In contrast to the present findings, the earlier investigations carried out by Metcalfe (1971) and Govindarajalu (1968A) do not support the presence of three sheaths in these genera. Metcalfe (1971) reported only the A type as present in these genera. Govindarajalu (1975A) reported that within the genus *Scirpus* that there were only sheaths of the A type. Bruhl (1993) reported that *Bolboschoenus* had sheaths of the A type. With the exception of *Ascolepis*, most of the C₃ genera in the Eastern Cape with type B sheaths are in agreement with Bruhl's (1993) descriptions. *Ascolepis* was listed as C₄ by Bruhl (1993).

Within the C₄ Cyperaceae of the Eastern Cape, two of the four C₄ presently recognised anatomical types occur (Fig. 1B-C), with a new type discovered (this is an eleocharoid variant of the fimbristyloid type [Plate 2.9-10]). These two
types are the chlorocypeloid and fimbristyloid C₄ types. The new anatomical type, is present within the genus *Bulbostylis*. There are three C₄ anatomical types present within the genus *Bulbostylis* (chlorocypeloid, fimbristyloid and the new anatomical type), which is similar to the two C₄ types that are found in the genus *Rhynchospora* (chlorocypeloid and rynchosporoid).

The species with the C₄ chlorocypeloid anatomical type (Fig. 1C) were identified in the *Abildgaardieae* (*B. humilis* [bracts, Plates 4.1-5], *Cypereae* (Plate 17.8-12) and the *Rhynchosporae* (*R. barrosiana*, Plates 28.6, 28.12, 29.1-2 and 30.4-7). In the present context, *R. barrosiana* occurs within the C₄ chlorocypeloid anatomical types of the *Rhynchosporae* as described by Ueno and Koyama (1987), Bruhl (1995), as well as by Soros and Dengler (2001). The presence of an outer MS and inner Kranz sheath (KS) has been confirmed by others: namely, in *Cyperus* (Govindarajalu 1968B; Metcalfe 1971; Estelita-Teixeira and Handro 1987; Bruhl 1993); *Kyllinga* (Govindarajalu 1968B; Metcalfe 1971; Bruhl 1993); *Mariscus* (Metcalfe 1971); *Pycreus* (Metcalfe 1971; Bruhl 1993) and *Rhynchospora* (Bruhl 1993). Bruhl (1993) however, stated that the sheath structure of *Mariscus* was three-layered with an inner boundary layer bisected by MX, abutting MS and an outer PS, which is not evident in the vascular bundles of the Eastern Cape genus *Mariscus*. The differing C₄ anatomical types within the leaves and bracts of *B. humilis*, as well as the differing photosynthetic forms within *Cyperus albostriatus*, may be related to the differing seasons of development.

The fimbristyloid C₄ anatomical type (Fig. 1B, Plates 2.4-8 and 4.7-8) is present within the *Abildgaardieae* (*A. ovata*, *Bulbostylis contexta*, *B. hispidula*, *B. humilis* [leaves] and the genus *Fimbristylis*). Within the fimbristyloid type the presence of three sheaths in the genus *Abildgaardia* was supported by both Metcalfe (1971) and Bruhl (1995), who also described an outer and inner parenchymatous sheath (PS), with a central mestome sheath (MS). The presence of three sheaths in *Bulbostylis* was confirmed by Metcalfe (1971), Sharma and Meehra (1972) and Bruhl (1993). The presence of three sheaths in genus *Fimbristylis*, where the inner sheath is bisected by large metaxylem elements was also confirmed by Gordon-Gray (1971), Metcalfe (1971), Sharma and Meehra (1972), Estelita-Teixeira and Handro (1987) and Bruhl (1993).

The new C₄ anatomical type, occurs in *Bulbostylis schoenoides* of the *Abildgaardieae* (Plate 2.9-10). Here, the KS is not interrupted by large metaxylem vessels in the midrib bundle and marginal bundles (Fig. 30E). Only two other descriptions of this type of variation of the fimbristyloid C₄ anatomical type have been reported previously for *Bulbostylis atrosanguinea* by Hesla et al. (1982) and by Ueno et al. (1989). Both Hesla et al. (1982) and Ueno et al. (1989) however, did not mention in what anatomical type this species should be placed. The structure of this type is essentially similar to the eleocharoid variation of the chlorocypeloid type made by Bruhl et al. (1987), Ueno et al. (1989), Bruhl and Perry (1995) and Soros and Dengler (2001). Thus it is possible that this variant of the fimbristyloid type may be a fifth anatomical type of the Cyperaceae. For simplicity, this anatomical type is referred to as the bulboystyloid type. Thus three differing C₄ anatomical types may be recognised in the Eastern Cape Cyperaceae, namely bulboystyloid, chlorocypeloid and fimbristyloid. This additional, bulboystyloid, type may suggest that the C₄ species may have evolved a fifth time in the Cyperaceae and not four times as has been previously thought by Bruhl and Perry (1995), and by Soros and Dengler (2001).

Within the species with chlorocypeloid anatomy, a third partial sheath of parenchyma has been reported to be present situated exarch to the MS, and therefore similar to the fimbristyloid type. Bruhl and Perry (1995), and Soros...
and Dengler (1998, 2001) state that this is an additional parenchymatous sheath that occurs only laterally in the large vascular bundles. Esau (1965) states that a parenchymatous sheath is found exarch to the mestome sheath (where present) in all the monocotyledonae and, that the PS and mesophyll are derived from the ground meristem (Esau 1965, Fig. 16.6). Soros and Dengler (2001) have subsequently confirmed in their ontogenetic studies of the Cyperaceae that the mestome sheath and vascular tissues, including the inner PCR sheath (Kranz sheath) are derived from the procambium; furthermore that the tissues that are exarch to the mestome sheath are derived from the ground meristem (Soros and Dengler 2001). A few cells resembling a partial parenchymatous sheath of are present in the Eastern Cape chlorocyperoid Cyperaceae (Plate 17.8-9). These sheath cells are also present abutting a few of the intermediate and small bundles (Plate 17.10). Rounded cells resembling a partial “parenchymatous sheath” also abut a few of the large, intermediate and small bundles of the Eastern Cape fimbristyloid species. A similar finding was made by Ueno and Koyama (1987), who observed small parenchymatous cells that were different to the radiate mesophyll in a few of the Rhynchosporae. However, these authors did not refer to these cells as a distinctive or partial/incomplete parenchymatous sheath (Ueno and Koyama 1987). Previous investigations of the chlorocyperoid Cyperaceae do not support the presence of a third exarch parenchymatous sheath abutting the large bundles (Takeda et al. 1985 [Fig. 3]; Ueno et al. 1986 [Figs. 2-3], 1988A, Estelita-Teixeira and Handro 1987), described by Bruhl and Perry (1995), and Soros and Dengler (1998, 2001). In the leaves and bracts of the Eastern Cape chlorocyperoid Cyperaceae these “parenchymatous sheath” cells are not associated with all the large, intermediate and small bundles. Given that these rounded cells are laterally associated with all the vascular bundles, the “parenchymatous sheath”, defined by Bruhl and Perry (1995) and by Soros and Dengler (2001) may not be a truly useful diagnostic character. Unfortunately the diagrams in Soros and Dengler (2001) are misleading in that Figure 1E ignores the parenchymatous sheath cells on the phloem side and those abutting the metaxylem exarch to the mestome sheath in the eleocharoid type. In Figure 1C, the rounded parenchymatous cells opposite the large metaxylem vessels, as well as the radiate parenchyma cells clearly form part of what Esau (1965) defines as bundle sheath, common in all longitudinal veins of the monocotyledonae, which the chlorocyperoid Cyperaceae are part. Furthermore, Figure 1F of Soros and Dengler (2001, page 1000) shows that the rounded “parenchymatous sheath” cells in C₄ chlorocyperoid Pycreus polystachyos are all positive for PEPCase, as are the cells of the radiate above and below. The conclusions by Bruhl and Perry (1995) and Soros and Dengler (2001) are brought into question by Soros and Dengler’s findings presented in their paper of 2001. RuBPCase and PEPCase location data shown in Soros and Dengler (2001) confirms that all the radiate mesophyll, is PEPC positive and therefore conforms to Esau’s (1965) outer parenchymatous bundle sheath.

11.1.4 Distribution of C₃ and C₄ anatomical types related to habitat and climate

The C₃ and C₄ species may essentially be divided into two groups based on the number of vascular sheaths surrounding the vascular bundles. These two groups are the vascular bundles with two or three sheaths. For the C₃ species type A has two sheaths and type B has three sheaths. In the C₄ species three sheaths are found in the fimbristyloid and bulbostyloid types, within the tribe Abildgaardieae. Whilst two sheaths are found the chlorocyperoid type, present in the tribes Cyperae and Rhynchosporae. Microclimate was found to affect the distribution of species, so too did the elevation of the habitat and the habitat type. Where the geographical distribution of the C₃ or C₄ species with two or three sheaths within the region is complex.
Most of the species in the region are found on the slopes and valley floors of the rivers or streams. Almost half the genera occur in high elevation habitats, where only two are C₄. This is similar to the C₃ grasses, which are known to be more abundant in higher elevation habitats than the C₄ species (Pearcy and Ehleringer 1984; Cabido et al. 1997). Both these two genera are *Abildgaardia* (fimbriystloid) and *Bulbostylis* (bulbostyloid), which have three sheaths. Most of the C₃ genera that occur in high elevation habitats also have three sheaths namely, *Carpha*, *Isolepis*, *Pycreus* (*P. mundii*), *Rhynchospora* (*R. brownii*), *Schoenoplectus* and *Schoenoxiphium*. The genus *Isolepis* also contains species with two sheaths and these species are also found in high elevation habitats. Additionally all the two sheath species of the genus *Scirpus* also occur in high elevation habitats. The elevation of habitat is indicative of the Afromontane biome that the species *B. schoenoides*, *P. mundii*, *R. brownii* and the genus *Isolepis* are mostly found.

Unlike the findings of Ueno and Koyama (1987), as well as Ueno and Takeda (1992) both the C₃ and C₄ Cyperaceae species of the Eastern Cape are found in similar habitat ranges. It is important to note that the habitats of the C₄ species within the region tend to be more xeric in nature than the C₃ species, with the exception of the two sheathed C₃ species. Most of the two sheathed C₃ species are predominately found in the halophytic habitats of estuaries and sand dunes. It is these species that have unicellular and multicellular trichomes.

The two sheath C₄ genera of *Cyperus* and *Mariscus* occur in the most diverse range of habitats (namely 13). Many of these are considered to have a cosmopolitan distribution within the rest of the world (Bruhl 1993). The three sheath C₄ *Fimbristylistis* species also have the most diverse habitat distribution (eight). Whilst most three sheath C₃'s have the least diverse habitat distribution (average of five habitats) and are the most habitat specific. In the C₃ genera both the three sheath and two sheath species have similar habitat ranges (on average), eight and seven respectively. Where both *Carpha* and *Carex* with three sheaths have the largest habitat ranges (eleven). Whilst *Isolepis* and *Ficinia*, which have two sheaths have been collected from ten different habitats within the region.

C₄ species are most common in high light, hot, and arid climates (Ehleringer and Björkman 1977; De Jong 1978; Ehleringer 1978; Doliner and Jolliffe 1979; Boutton et al. 1980; Ellis et al. 1980; Pearcy et al. 1981; Pearcy and Ehleringer 1984; Edwards and Ku 1990; Ehleringer and Monson 1993; Li 1993A; Li 1993B; Lin et al. 1993; Cabido et al. 1997), were there would be low soil moisture conditions (Doliner and Jolliffe 1979; Ehleringer and Monson 1993). With the exception of *Bulbostylis schoenoides* and *R. barrosiana*, the C₄ Cyperaceae within the Eastern Cape region, similar to most C₄ species, occur in low rainfall habitats (less than 500mm), that are high in light intensity and temperature. Both *B. schoenoides* and *R. barrosiana* occur in habitats that receive more rainfall than regional average. The Eastern Cape region is essentially dry, where only the Afromontane areas (where *B. schoenoides* occurs), the south western forestry areas and the north eastern regions (where *R. barrosiana*) have rainfalls that are above average, greater than 1000mm (Kopke 1988). The distribution of *B. schoenoides* is found in high altitude habitats seems atypical. C₄ species tend to be more dominant in low altitude habitats in the rest of the world (Tieszen et al. 1979; Pearcy and Ehleringer 1984; Ehleringer and Monson 1993; Cabido et al. 1997). Although C₄'s are not uncommon in high altitude habitats in Central Argentina (Cabido et al. 1997) and in Australia have even been found to occur in sub-Alpine conditions (Hattersley 1983). The distribution of habitats of *R. barrosiana* is essentially similar to the C₃ Cyperaceae of Japan, which are positively correlated with increasing temperature and precipitation (Ueno and Takeda 1992). In this mostly dry region, most of the C₄'s occur in low rainfall habitats, as do most of the C₃ species. More of the C₃ genera however, occur in above average rainfall habitats, than the C₄.
species. All these genera have three sheaths, namely *Chrysithrix*, *Cyathocoma*, *Isolepis*, *Rhynchospora* and *Scleria*. In these genera the higher rainfall regime of the habitats may be linked directly with the biome that these habitats fall within, namely Afromontane. It is important to note that both the two and three sheath, C₄ species as well as the three sheath C₃ species, with the exception of *Isolepis* (C₃, which is found in the Karoo-Namib biome), are predominantly present in higher rainfall habitats than the C₃ species with two sheaths. In the C₃ and C₄ species with three sheaths that are predominantly present in the Afromontane biome, the C₄ species are mostly present on the drier slopes, in dry substratum, namely *Abildgaardia* and *Bulbostylis*. It is important to note that only three genera, two C₄'s and one C₃ have been found to occur in the xeric Karoo-Namib biome namely, *Cyperus* (two C₄ specimens with two sheaths, namely *C. laevigatus* and *C. rupestris* var. *rupestris*), *Isolepis* (one C₃ specimen with three sheaths, namely *I. cernua*) and *Mariscus* (two C₄ specimens with two sheaths, namely, *M. capensis* and *M. uitenhagensis*). The existence of *Mariscus* in the dry Karoo-Namib region is unique since Vorster (1983) has stated that *Mariscus* is essentially hygrophilous in nature and absent in this biome, and rainfall areas with less than 250mm. So too is the presence of *Isolepis*, which is a water loving species that is predominantly found in marshes, river banks and damp depressions (Gordon-Gray 1995). The *Cyperus* genus is the only genus with species that are know to occur in mesic to xeric habitats (Gordon-Gray 1995).

All the C₄ genera with the notable exception of the two sheathed genera *Pycreus* and *Rhynchospora*, are predominantly found in grassland habitats. In *Pycreus* most species are found in marshy habitats at the edges of rivers in thickets. *Rhynchospora* has only been collected from coastal thickets. Many of the C₄ species have been collected from hydrophytic to mesophytic habitats of marshes, river banks and in rivers, similar to the C₄ species of Japan as investigated by Ueno and Takeda (1992) and America (Teeri et al. 1980). Where Ueno and Takeda (1992), as well as Teeri et al. (1980) found a strong positive correlation with increased temperature and rainfall. However, in the Eastern Cape this does not seem to be the case, where only two species are positively correlated with increased rainfall, namely *B. schoenoides* and *R. barrosiana*. However, the increased rainfall of the habitats is related to the biome that *B. schoenoides'* habitat fall within, which is Afromontane and thus cool, but not with increased temperature. Only the habitat of *R. barrosiana* may be correlated with increased temperature and rainfall, similar to Ueno and Takeda's (1992), as well as Teeri et al. (1980) findings. Since, the habitats of this species are in the far north eastern corner of the Eastern Cape, which is located near the warmer waters of the Agulhas current, which can account for as much as a 10°C difference in temperature between the coastal temperature and the inland temperature (Stone 1988). Atypical of the C₄ species is the higher frequency of collections from low light habitats of indigenous forest floors in the three sheaths species, than the two sheaths species and the C₃'s. Although Hattersley (1983), as well as Pearcy and Ehleringer (1984) have stated that C₃'s grasses of Australia have been know to occur within forest habitats. Pearcy and Ehleringer (1984) have further stated that C₄ evolved in response to arid, hot environments, although they are not uncommon in cool shaded ones. It may be likely that C₄'s would have to invade established forests in order to evolve adaptive responses. Since the C₄'s are rapid growers it is not unlikely for these species, to eventually dominate these environments. Within the C₄'s only *Fimbristylis* (three sheaths) and *Mariscus* (two sheaths) have been more frequently collected from halophytic habitats. In *Fimbristylis* habitats are predominantly found in estuaries and for *Mariscus* sand dunes. *Mariscus* in Natal is said to thrive in disturbed habitats (Gordon-Gray 1995). The coastal sand dune habitats within the Eastern Cape are in a continual flux, with moving sands due to the high wind speeds in this environment (Lubke et al. 1988B), but atypical of the *Mariscus* species as investigated by Vorster (1978), which were predominantly hygrophilous in nature. In Natal only *F. ferruginea* is said to be found in estuarine environments, whilst *F. complanata* and *F. dichotoma* are mostly found in
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The C₃ species are mostly found in hydrophytic to mesophytic habitats (Takeda et al. 1985, Ueno and Koyama 1987). Where the three sheaths species are mostly frequently found in the hydrophytic habitats bordering water masses including dams, rivers and streams, as well as in marshy areas, with a few notable exceptions, namely the genera Carpha, Chrysithrix, Schoenus and Tetraria. Carpha, Schoenus and Tetraria are mostly found in low rainfall, low nutrient fynbos habitats, on well drained substratum. The genus Tetraria is common in the South African Ericaceous fynbos biome, which is mostly found on the moist seaward facing slopes of the of the coast up to Humansdorp and in the dry fynbos biome found on mountains tops near the Suurberg and Grahamstown (Cowling and Richardson 2000). Carpha however, is uncommon in dry habitats and is mostly present in hydrophytic habitats (Gordon-Gray 1995). Schoenus is also uncommon in dry xeric habitats, where these species are more commonly found in hydrophytic to mesophytic environments (Bruhl 1993). C₄ species should be more common in the fynbos environment that the C₃ species. Since C₄ species show higher nitrogen use efficiency in areas that are nutrient poor (Ueno et al. 1989), which is not the case in the Eastern Cape. Chrysithrix capensis is only found in the high rainfall habitats of the coastal forests of Wite Els Bosch SAFCOL forests in the extreme south western parts of the Eastern Cape on stony substratum. Whilst the two sheathed species, with the exception of Ficinia, are mostly hydrophytic. Most of the two sheathed species are found on river banks and in rivers or in marshes. Ficinia has the most atypical habitats of the C₃ species, where most of the species have been collected from grassland habitats. More especially the two sheathed Ficinia species are more dominant in mesic grasslands than the three sheathed C₃ and two sheathed C₄ species. This is similar to the distribution of habitats for the Ficinia genus in Natal, which are more frequently found to be present in mesic grasslands (Gordon-Gray 1995), as well as present in mesic habitats within Africa (Bruhl 1993). Similarly, a few of the Schoenoxiphium and Tetraria species are present within inland mesic grasslands. Whilst a large number of specimens from the Bolboschoenus and the Ficinia genera have been collected from xeric, halophytic habitats of estuaries and sand dunes.

The C₄ species tend to be more frequently collected from dry soils than the C₃ species, similar to the grass species (Doliner and Jolliffe 1979, Ehleringer and Monson 1993). Only the C₄ genus Fimbristylis has been more frequently collected from habitats with wet soils. Even though the C₃ species mostly have been found on wet soils, three genera have mostly been collected from dry substratum, namely Ascolepis, Chrysithrix and Ficinia. In both Chrysithrix and Ficinia, the moisture status of the substratum may be linked directly to the type of substratum that these genera are predominantly rooted on namely, rock and sand respectively. In Natal Ascolepis is uncommon on dry soils and is predominantly found on waterlogged soils in marshes and in rivers (Gordon-Gray 1995). Most of the soils that both the C₃ and C₄ species are rooted in the Eastern Cape have a low water retention status, with the exception of the three sheathed Cariceae and Cypereae. Only three genera have been collected from soils with good water retention, namely clay. Cyperus (C₃, with two and three sheaths), Pycreus (C₄, with two sheaths) and Schoenoxiphium (three sheaths) have been collected from mostly clay based soils. Where the Cyperus and Pycreus species habitats are predominantly hydrophytic in nature, namely river bank and marsh habitats. These Schoenoxiphium species habitats are mostly hydrophytic to mesophytic in nature namely, river bank, to forest and grasslands.
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Only three species are habitat specific within the Eastern Cape, namely *Ascolepis capensis*, *Chrysithrix capensis* and *Rhynchospora barrosiana*. *Ascolepis capensis* has only been collected inland, from marsh habitats, in the Alice and Hogsback districts by five different collectors and may thus be endemic to this part of the Eastern Cape, similar to the distribution of *C. capensis*. *C. capensis* has only been collected from the Wite Els Bosch SAFCOL forestry area, by four different collectors and thus may also be endemic to that part of the Eastern Cape. The collection of *R. barrosiana* at the Cape Morgan Reserve, at Kei Mouth was the first within the Eastern Cape and thus the habitat data may only appear to be habitat specific. However, in Natal this species seems to be most frequently present in coastal areas, in marshes or riverbanks with moving water or from very damp soils (Gordon-Gray 1995), which was similar to the habitat that this species originated.

11.1.5 Possible evolutionary pathways of C₄ anatomical types from a C₃ ancestor

The development of C₄ photosynthesis from C₃ is thought to be a derived condition, confined to the more advanced families, having evolving 31 times within the Angiospermae (Soros and Dengler 2001). Within the monocotyledoneae, C₄ photosynthesis is found only in the Poaceae and the Cyperaceae (Raghavendra and Das 1976; Tieszen et al. 1979; Ehleringer and Monson 1993; Soros and Dengler 1998), and facilitated diversification, as well as expansion into warmer areas. Phylogenetic evidence seems to suggest that the presence of C₄ photosynthesis in the Poaceae and the Cyperaceae is due to independent events (Ehleringer and Monson 1993). The Poaceae are not closely related to the Cyperaceae (Ehleringer and Monson 1993; Plunkett et al. 1995; Kellogg 2000). The Poaceae are however, closely related to the Restionaceae (Ehleringer and Monson 1993; Kellogg 2000), Centrolepidaceae, Joinvilleaceae, Ecdiocolaceae, Anthriaceae and Flagellariaceae (Kellogg 2000). Molecular data seems to suggest that the Cyperaceae are closely related to the Juncaceae (Plunkett et al. 1995; Doyle 1998; Muasya et al. 1998) and Thurniaceae (Muasya et al. 1998).

C₄ photosynthesis has evolved independently at least four times within the Poaceae (Ellis 1974; Brown 1975; Ehleringer and Monson 1993; Kellogg 2000; Soros and Dengler 2001). Two anatomical forms may be recognised, XyMS- and XyMS+. In the XyMS-, the primary carbon reducing (PCR) sheath is not separated from the metaxylem vessels by the mestome sheath. In the XyMS+, the PCR tissue is separated from the metaxylem vessels by a mestome sheath which abuts these vessels and the PCR tissue. The XyMS- are reported to be malate formers or are NADP-Me. The XyMS+ are reported to be aspartate formers or NAD-Me and PCK (Hattersley and Watson 1976; Dengler et al. 1985; Nelson and Langdale 1989; Nelson and Dengler 1992). Within the PCR sheath, three anatomical forms, corresponding to the biochemical sub-type are present (Hatch et al. 1975; Prendergast et al. 1987; Kellogg 2000).

Dengler et al. (1985), Nelson and Langdale (1989), Nelson and Dengler (1992) state that the PCR sheaths of "double sheath" XyMS+ C₄ grasses are homologous to the parenchymatous sheath in XyMS- species ("single sheath"). In the XyMS- grasses, where the PCR sheath abuts the metaxylem, the PCR tissue is derived from the procambium. In the XyMS+, the mestome sheath abuts the metaxylem and the PCR tissue is exarch to the mestome sheath. Thus, in the XyMS+, the PCR tissue is derived from the ground meristem and the mestome sheath from the procambium. In this case, the PCR tissue is referred to as the bundle sheath (Dengler et al. 1985; Nelson and Langdale 1989; Nelson and Dengler 1992).
Unlike the Poaceae, the Cyperaceae have developed four unique anatomical C<sub>4</sub> forms, namely the chlorocyperoid, eleocharoid, fimbristyloid and rhynchosporoid types (Bruhl and Perry 1995; Soros and Dengler 1998 & 2001). The fimbristyloid type is surrounded by three sheaths (Johnson and Brown 1973; Carolin et al. 1977; Gilliland and Gordon-Gray 1978; Takeda et al. 1980 & 1985; Ueno et al. 1986 & 1988A; Bruhl and Perry 1995; Soros and Dengler 1998 & 2001), whilst two sheath are present in the chlorocyperoid (Johnson and Brown 1973; Laetsch 1974; Brown 1975; Takeda et al. 1985; Ueno and Koyama 1987; Ueno et al. 1988A), eleocharoid (Bruhl et al. 1987; Ueno and Samejima 1989; Ueno et al. 1989; Bruhl and Perry 1995; Soros and Dengler 2001) and rhynchosporoid types (Takeda et al. 1980, 1985; Ueno and Koyama 1987; Bruhl and Perry 1995; Soros and Dengler 1998 & 2001). In the Cyperaceae, however, the PCR tissues occur within the inner border parenchyma in the fimbristyloid, chlorocyperoid and eleocharoid types. In the rhynchosporoid type, the PCR tissue is present in the mestome sheath region. Thus, in the Cyperaceae, the PCR tissues are always formed from the procambium and therefore may not be termed the bundle sheath (Soros and Dengler 2001).

Ueno et al. (1989), believe that the C<sub>4</sub> anatomical types within the Cyperaceae developed sequentially, from a primitive ancestral form (C<sub>3</sub>, with small border parenchymatous cells or C<sub>3</sub>-B type) to an advanced form (C<sub>4</sub>, with eleocharoid anatomy). Soros and Dengler (2001) however, contend that each of the evolutionary assemblages of the C<sub>4</sub> types occurred in different tribes, where they did state that the genus Rhynchospora was said to be an exception. The three C<sub>4</sub> anatomical types, which are present within the Eastern Cape genus Bulbostylis (bulbostyloid, chlorocyperoid and fimbristyloid), similar to the two C<sub>4</sub> types that are found in the genus Rhynchospora (chlorocyperoid and rhynchosporoid), supports the hypothesis of Ueno et al. (1989). This sequential approach is supported by the multiple development of C<sub>4</sub> anatomical types within Rhynchospora and Bulbostylis. The results reported in this thesis calls into question the hypothesis of Soros and Dengler (2001), that each of the evolutionary assemblages of the C<sub>4</sub> types occurred in different tribes. Detailed histochemical, molecular and ontogenetic investigations will be needed to resolve the problem of the evolution of the C<sub>4</sub> anatomical types within the Cyperaceae.

### 11.1.6 Distribution of anatomical forms relative to habitat

Within the C<sub>3</sub> and C<sub>4</sub> photosynthetic forms in the Eastern Cape there are two C<sub>3</sub> types and three C<sub>4</sub> types. In the C<sub>3</sub> species the type A and B. In the C<sub>4</sub>'s there are the fimbristyloid and bulbostyloid types with three sheaths and the chlorocyperoid type with two sheaths. The bulbostyloid type is an eleocharoid variation of the fimbristyloid type, where the metaxylem vessels do not interrupt the Kranz sheath.

The C<sub>3</sub> species are similar to those in the C<sub>3</sub> grasses. The C<sub>4</sub> species are different from the C<sub>4</sub> grasses, in that a mestome sheath is always present. The grasses have both XyMS- and XyMS+ forms. With the exception of the rhynchosporoid type, the most important and unique anatomical characteristic particular to the Cyperaceae is that the primary carbon assimilating tissues are separated from the primary carbon reducing tissues by the mestome sheath (Fig. 1B-D). In the rhynchosporoid type, the mestome sheath contains the primary carbon reducing chloroplasts (the rhynchosporoid type [Fig. 1A] is not present within the Eastern Cape).
This separation of primary carbon assimilating tissues from the primary carbon reducing tissues by a sheath of lignified cells that have suberin lamellae within their walls, raises a few interesting but pertinent questions, that may be answered in subsequent investigations of this family. The most important of these relates to the transportation of photoassimilates between the primary carbon assimilating tissues and the primary carbon reducing tissues. Firstly, is the mestome sheath with its suberised walls involved in the regulation of photoassimilate transport. Secondly, is the suberised layer within the mestome sheath involved in forcing the transport of the substances within the Cyperaceae into entirely symplastic pathways. Thirdly, if the suberised lamellae is involved in forcing transportation of all substances and fluids through the symplast. If so then one would be able to surmise that the mestome sheath would then also be involved in regulation and transportation of water. The mestome sheath would then act as a regulatory gateway between the mesophyll and the vascular tissues of the bundles of the Cyperaceae. This would then enable the Cyperaceae to control their water conservation.

But does the control of water conservation within the Cyperaceae really matter? If it is an important growth limiting factor, then the C4 Cyperaceae should occur in drier habitats including mesic, xerophytic and even halophytic habitats, arguably the C4 anatomical types would (possibly) occur in specific habitats within which the regulation of the water and photoassimilate by the mestome sheath in these species would become an important ecophysiological factor. It is well documented that the C4 photosynthetic form arose as a direct result of elevated temperatures, high light environments, with alternating periods of water stress. However, Pearcy and Ehleringer (1984) reported that the C4 grasses of Australia were invading habitats that they would uncommonly be found in, such as such as forests floors, where low light conditions and a more temperate environment prevails. C4 species grow rapidly due to increased carboxylation efficiency. With time, it is not unlikely therefore that C4 species would, and will continue to invade and evolve within habitats that are far removed from their origins. Arguably, regulation of assimilate transport to the conducting phloem, coupled with efficient, managed water use (possibly in the mestome sheath) could be an important factor favouring the occupation of a wide range of habitats, in a region where the alternation of winter and summer rainfall, with habitats that range from a hydrophytic or even mesophytic habitat into a more xeric one in which the plants have to cope.

Within the Eastern Cape only two species were found to be habitat specific, namely R. barrosiana (C4, chlorocyperoid) and Chrysithrix capensis (C3, type B). C3 and C4 anatomical types were recorded from a wide range of habitats, and the C4 species tended to be found in more xeric habitats than the C3 species. However, C3 and C4 Cyperaceae are not specifically found in a particular rainfall regime or habitat type. Thus it may be that the development and evolution of the different C4 anatomical forms (or phylogenetic forms) within the Cyperaceae may have enabled these species to establish themselves in habitats somewhat removed from their origin. Clearly, the ability to regulate water loss may well be one of the deciding factors that governs their distribution.

### 11.2 Conclusions

This thesis demonstrates that the Cyperaceae are complex in anatomical structure and, that they are in many instances dissimilar to the Poaceae. A few of the differences have been highlighted in this thesis. Detailed histochemical, molecular and ontogenetic investigations are, however, needed to resolve the interesting problems highlighted in this thesis. Problems in need of special attention are as follows; clear definition of C3, C3-C4...
intermediates and C₄ species; the position and development of the primary carbon assimilating, the parenchymatous sheaths and the primary carbon reducing tissues, as well as their phylogeny or evolution of photosynthetic form.

The Eastern Cape Cyperaceae may be divided into distinct C₃, C₄ as well as a potential C₃-C₄ intermediate group. The C₃ species all have non-radiate mesophyll and an inner parenchymatous sheath which contain small chloroplasts. The C₄ group all have radiate mesophyll, with an inner parenchymatous sheath containing enlarged chloroplasts (Kranz or PCR sheath). A few C₃ species have anatomical characteristics that are similar to the species with C₄ anatomy. The vascular bundles within this intermediate group, fall within what Hattersley and Watson (1975) described as the "minimal cell lateral count" and "maximal cell distal count" criteria for C₄ grass species. However, no biochemical data exists to see whether they are C₃-C₄ intermediates or whether the Hattersley and Watson's (1975) C₄ criteria for grasses can be applied to the smaller, or scutiform Cyperaceae.

There are two anatomical types/forms within the C₃ species (A and B type) and three C₄ types/forms (bulbostyloid, chlorocyperoid and fimbristyloid). No rhynchosporoid nor eleocharoid anatomical types were evident within the Eastern Cape Cyperaceae. The PCA cell layer always occupies the outer sheath position (structurally akin to the Poaceae) and the PCR layer is endarch to the mestome sheath, thereby posing many unique questions relating to the transport pathway followed by assimilated carbon from PCA to PCR cells. Additionally, a few of the C₃ species lack the inner PCR layer, which in a few species (B type) becomes replaced by a chloroplast-containing border parenchyma. In many C₃ species (A type) however, the inner sheath of border parenchyma is absent, and the PCR tissues are present exarch to the mestome sheath. Within the Cyperaceae the photosynthetic pathway is located in five structurally different formats, with some obvious physiological implications.

A new C₄ anatomical form/type, namely the bulbostyloid type was discovered by the author of this thesis in the Eastern Cape Cyperaceae, which represents a possible fifth C₄ anatomical type within the Cyperaceae world-wide. Thus whereas previously only the genus Rhynchospora was reported to have more than one anatomical type. The genus Bulbostylis appears to have three C₄ anatomical types. As a result, the C₄ syndrome (based upon anatomical data above) may have arisen five times and not four as previously suggested by Bruhl and Perry (1995) and by Soros and Dengler (2001).

Bruhl and Perry (1995), Soros and Dengler (2001) as well as one of the examiners of this thesis, have highlighted that there is some difficulty with the interpretation of a "parenchymatous sheath" abutting the mestome sheath in the chlorocyperoid Cyperaceae. In many of the vascular bundles of the chlorocyperoid Cyperaceae, these rounded cells referred to by Bruhl and Perry (1995) are absent laterally and thus may not be a truly useful diagnostic character. Furthermore data presented in Soros and Dengler (2001), relating to RuBPCase and PEPCase location within the mesophyll and vascular tissues, confirm that the all outer radiate parenchyma, including rounded cells abutting the mestome sheath, which is more correctly referred to as the outer parenchymatous bundle sheath following Esau's (1965) suggestions.

The C₃ Cyperaceae species within the Eastern Cape are more dominant in higher elevation habitats than the C₄ species, similar to the C₃ grasses. The only C₄ species that occur at high elevations are those with three sheaths. The C₃ and C₄ species within the region occur in similar low rainfall habitat ranges, where the C₄'s are more dominant in xeric habitats on drier soils than the C₃ species. More C₃ species occur in higher rainfall habitats than the C₄ species.
With the exception of the Afromontane Bulbostylis schoenoides and R. barrosiana, the Eastern Cape C₄ Cyperaceae species similar to the C₄ grasses, are dominant in high light and temperature habitats with low rainfall, unlike the C₄ Cyperaceae of Japan and America. Only five species occur in the desert like conditions of the Karoo-Namib biome (Cyperus laevigatus, C. rupestris var. rupestris, I. cernua, M. capensis and M. uitenhagensis), which have less than 250mm of rainfall per annum.

It would appear that only three species (A. capensis, Chrysithrix capensis and R. barrosiana) are habitat-specific or may be endemic to a specific area within the Eastern Cape. A. capensis occurs in marshes on the Amatole mountains near Alice and Hogsback. C. capensis occurs in the Tstsikamma mountains of the Wite Els Bosch forests and R. barrosiana in the marshlands of the Cape Morgan Coastal Nature Reserve at Kei Mouth.

All the anatomical types of the C₃ but more especially C₄ Cyperaceae of the Eastern Cape are not specifically found in a particular rainfall regime or habitat type, which is contrary to the thesis hypothesis. However, the C₃ species are mostly correlated with hydrophytic to mesic habitats, with the exception of Ficinia and the two sheathed species. Ficinia is dominant in mesic grasslands and halophytic habitats. The two sheathed C₃ species are mostly present in halophytic habitats. The C₄ species are also more dominant in mesic to xerophytic grasslands, as expected in the hypothesis. Where only a few species occur in habitats correlated with increasing rainfall and temperature similar to the C₄ Cyperaceae of Japan and America. It may be that the development and evolution of the different C₄ anatomical forms (or phylogenetic forms) within the Cyperaceae may have enabled these species to establish themselves in habitats that were alien to their origins. It may be that the ability to regulate photoassimilate and water transport within the Cyperaceae enables their success in a dynamic and unpredictable climate, such as the Eastern Cape.

The work embodied in this thesis represents an examination of the majority of the Cyperaceae of the eastern Cape. There are many anatomical characteristics reported in this thesis and its appendices that are unique at the level of tribe, genus and/or species. Whilst this work is not considered definitive by the author, it nonetheless provides a working platform for future, more detailed research on this often forgotten component of the vegetation. The research presented in this thesis will hopefully aid future revisions and studies on this unique group of plants.
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Foreword to Volume 2

Volume two consists of Appendices one through five, which initially were included in the thesis. This volume was requested by all three first examiners to make it easier to read. This volume contains information relating to the Eastern Cape Cyperaceae: gathered during my collections; from the data from 1PRE; the 2GRA herbarium sheets and the slides made. This volume summarises the thesis outline and common, as well as unique anatomical characteristics of these species.

Appendix 1 lists the genera, species and specimens collected during the course of this investigation. Not only does the list reflect where each specimen was collected, but it also lists where the duplicates of the six specimens collected are housed. The list of each specimen’s reference details, includes the following the collection number, specific location of specimen, habitat type, including edaphic, microclimatic data, elevation in metres, grid square reference and district where specimen occurs.

Appendix 2 lists in table form the anatomical characters that were examined, so that the descriptions within the tribe chapters could be made.

Appendix 3 contains the tabulated data obtained from Appendix 2. The data in Appendix 3 is referred to in the text of the result chapters (three to ten).

Appendix 4 contains the shape/outline descriptions that were removed from the body of the thesis at the request of the examiners. Appendix 4 is also a summary of the common and unique anatomical characteristics for the Eastern Cape Cyperaceae.

Appendix 5 lists all the Cyperaceae species that are listed as being present within the boundaries of the Eastern Cape in the Precis data base (PRE) prior to 1992. Also listed in Appendix 5 are the Cyperaceae obtained from the herbarium sheets housed in the Schönland herbarium (GRA) for the Eastern Cape. This list (MS-Word) is on CD. Appendix 5 has also been lodged in the Schönland herbarium library in text format.

1PRE = National Herbarium in Pretoria, South Africa
2GRA = Schönland Herbarium in Grahamstown
List of abbreviations

?- scattered arrangement of vascular bundles;
#- number(s);
BP- border parenchyma;
GRA- Schönland Herbarium, Grahamstown, South Africa;
HSS- hypodermal sclerenchymatous strands;
I- intermediate bundles;
L- large bundles;
KS- kranz sheath;
MG- Missouri Botanical Gardens Herbarium, St. Louis, United States of America;
MS- mestome sheath;
MX- large metaxylem vessels;
NE- University of New England Herbarium, Armindale, Australia;
NU- Natal University Herbarium, Pietermaritzburg, South Africa;
PRE- National Herbarium in Pretoria, South Africa;
PS- parenchymatous sheath;
PxL- protoxylem vessel;
RM- radiate mesophyll;
S- solenostele;
SS- sclerenchymatous sheath;
TM- Transvaal Museum Herbarium;
VB- vascular bundles.
APPENDIX 1: LIST OF SPECIMENS COLLECTED IN THE EASTERN CAPE ............................................ 9

ABILDGAARDIA VAHL ....................................................................................................................... 10

A. ovata (Kunth) Kred. ....................................................................................................................... 10

ACSOLPIIS NEES ex STUED ........................................................................................................... 10

A. capensis (Kunth) Ridley .................................................................................................................. 10

BOLBOSCHOENUS (ASCHERSON) PALLA ..................................................................................... 10

B. martimbus (Linnaeus) Palla ....................................................................................................... 10

BOLBOSTYLIS KUNTH ..................................................................................................................... 10

B. contorta (Nees) Bedard .............................................................................................................. 10

B. humilis Kunth .............................................................................................................................. 10

B. schoenoides (Kunth) C.B.Clarke ............................................................................................... 10

CAREX LINNAEUS ....................................................................................................................... 11

C. albostriatus (Schrad) .................................................................................................................... 11

C. clomerabilis V.L.Kreuz .................................................................................................................. 11

C. mossii Neimes .............................................................................................................................. 11

C. salembro C.B.Clarke ................................................................................................................... 11

C. BRETTVANKS & SOLAND ex R.BROWN .................................................................................. 12

C. brevica C.B.Clarke ...................................................................................................................... 12

C. clemmata (Thunb.) Nees ............................................................................................................. 12

C. diomera C.B.Clarke .................................................................................................................... 12

CHRYSITRIX LINNAEUS ................................................................................................................... 12

C. capensis Linnaeus ....................................................................................................................... 12

C. ADHUMP-BROWNE ................................................................................................................... 12

C. albastralis Schrader ..................................................................................................................... 12

C. denudatus L.f. ............................................................................................................................. 12

C. differito Linnaeus ....................................................................................................................... 12

C. distans L.f. ..................................................................................................................................... 12

C. esculentus Linnaeus ..................................................................................................................... 12

C. fastidiatus Rottboel ...................................................................................................................... 12

C. immensis C.B.Clarke ................................................................................................................... 12

C. hevigular Linnaeus ...................................................................................................................... 12

C. torquus Linnaeus var. tenhimorus (Rottboel) Boeck .................................................................. 12

C. martindus Thumb .......................................................................................................................... 12

C. naldensis Hochst. .......................................................................................................................... 12

C. jamaicense (Crantz) Kükenthal .................................................................................................. 12

C. utriculatus (Linnaeus) Palla subsp. jamaicense (Crantz) Kükenthal ......................................... 12

CATHOCOMA NEES ....................................................................................................................... 12

C. byzantina (Nees) J.Browning ..................................................................................................... 12

CYPHERS LINNAEUS ....................................................................................................................... 13

C. affinis Schrader ............................................................................................................................ 13

C. benignus L.f. .................................................................................................................................. 13

C. differito Linnaeus ....................................................................................................................... 13

C. byzantina (Nees) J.Browning ..................................................................................................... 13

C. tenuiflorus (Rottboel) Boeck ....................................................................................................... 13

C. martindus Thumb .......................................................................................................................... 13

C. naldensis Hochst. .......................................................................................................................... 13

C. jamaicense (Crantz) Kükenthal .................................................................................................. 13

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**POTTIBULARIS R.BROWN**

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Appendix 1: List of Specimens collected in the Eastern Cape

Appendix one is a list of all the specimens collected during in this investigation, within the Eastern Cape. Not only does the list reflect where each specimen was collected, but it also lists where the six duplicates for the specimens I collected are housed. Herbaria where the specimens are housed are as follows: (GRA) Schönland Herbarium, Grahamstown, South Africa; (MG) Missouri Botanical Gardens Herbarium, St. Louis, United States of America; (NE) University of New England Herbarium, Armindale, Australia; (NU) Natal University Herbarium, Pietermaritzburg, South Africa. Species author names are according to Gordon-Gray (1995) as well as Arnold and De Wet (1993). Specimens are grouped alphabetically under genera, species and specimen number.

The list of each specimen’s reference details, includes the following, where possible: specimen number (which is the collection number for BJ.Sonnenberg), specific location of specimen, description of location of specimen, habitat type, soil condition or hydration, relevant microclimatic data (immediate environment surrounding specimen, within a 50m radius), elevation in metres, grid square reference (e.g. 3326BC) and district where specimen occurs.
ABILDGAARDIA VAHL

A. ovata (Burm.f.) Král

Specimen 277 (GRA, MG & NU): Round Hill (Oribi Reserve), 50m from the Conservation House, near the path leading to the trig beacon, in a grassy area, 375m above sea level, 3326BD, Bathurst District.

Specimen 403 (GRA, MG & NU): Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth District.

Specimen 444 (GRA, MG, NE & NU): Road to Hagga Hagga, 4 kilometres from the Hagga Hagga turnoff, on a slope above a large dam, opposite large Eucalyptus and Eleocharis species, sandy soil, 3328CD, Hagga Hagga District.

ASCOLEPIS NEES ex STUED.

A. capensis (Kunth) Ridley

Specimen 314 (GRA, MG & NU): Central Hog, on the Gaika's Kop side of the Hog, half way up the Hog, in a marsh, 3226DB, Hogsback District.

BOLBOSCHOENUS (ASCHERSON) PALLA

B. maritimus (Linnaeus) Palla

Specimen 212 (GRA & MG): Fish River Mouth, 250m from the sea, in a small marsh surrounded by clumps of Juncus sp. and Imperata sp., 3327CA, Bathurst District.

Specimen 427 (GRA, MG & NU): Ntshala River Mouth, on the side opposite Morgan’s Bay, close to the Nature Conservation offices, in the sand dunes, 3228CB, Morgan’s Bay District.

BULBOSTYLIS KUNTH

B. contexta (Nees) Bodard

Specimen 226 (GRA & MG): Bathurst commonage, 200m from the Waters Meeting Reserve-Bathurst road, 2 kilometres from Bathurst, in the between grass and the bush clumps, 3326BD, Bathurst District.

Specimen 272 (GRA, MG & NU): Round Hill (Oribi Reserve), 50m from the Conservation House, near the path leading to the trig beacon, in bush-clump grassland, 3326BD, Bathurst District.

Specimen 399 (GRA & MG): Kei Mouth golf course, grassland, sandy soil, 3228CB, Kei Mouth District.

Specimen 404 (GRA & MG): Kei Mouth golf course, grassland, sandy soil, 3228CB, Kei Mouth District.

Specimen 498 (GRA, MG & NU): Mountains near Humansdorp, in the grassy fynbos, sandy soil, 3324DD, Humansdorp District.

B. hispidula (Vahl) R.W.Haines

Specimen 408 (GRA & MG): Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth District.
**B. humilis** Kunth

Specimen 210 (GRA & MG): Tharfield Private Nature Reserve, 700m from the Port Alfred-Fish River Mouth road, on the fourth dune ridge from the sea, in the grassland, 3327CA, Bathurst District.

Specimen 230 (GRA & MG): Bathurst Common, 3 kilometres from Bathurst, on the Southwell road, 150m from the road, in the grassland, between the bush-clumps, 33326DB, Bathurst District.

Specimen 239 (GRA & MG): Waterloo Farm, 100m from the Grahamstown-Port Alfred road, 200m from the Grahamstown-King William’s Town bypass, 1.5 kilometres from Grahamstown, in Acacia sp. invaded grassland, on dry ground, 650m above sea level, 3326BC, Grahamstown District.

Specimen 247 (GRA, MG & NU): 1.5 kilometres west of Cintsa West, on a farm road verge, 500m from the sea, in coastal thicket, 3227CC, East London District.

Specimen 268 (GRA, MG & NU): Grahamstown Golf Course, next to the second tee, in sandy soil of a grassy thicket, 3326BC, Grahamstown District.

**B. schoenoides** (Kunth) C.B.Clarke

Specimen 315 (GRA, MG & NU): Third Hog, on the Gaika’s Kop side of the Hog, in a marsh 3226DB, Hogsback District.

Specimen 344 & 378 (GRA, MG & NU): Siberia Marsh, halfway to Gaika’s Kop, looking down from Tor Doone, in a marsh, 3226DB, Hogsback District.

Specimen 393 (GRA, MG & NU): Halfway between Gaika’s Kop, Tor Doone and the Hog, in a marsh, 3226DB, Hogsback District.

**CAREX LINNAEUS**

**C. aethiopica** Schukr

Specimen 423 (GRA, MG & NU): Cape Morgan Nature Reserve, on the margin of coastal thicket, in high grass, in wet soil, 3228CB, Morgan’s Bay District.

**C. glomerabilis** V.I.Krecz.

Specimen 265 (GRA, MG & NU): Blaauwkrantz Nature Reserve, 10m from the main pool, under a large rock, near the river's edge, 3326BC, Albany District.

Specimen 449 (GRA, MG & NU): Marsh Sands, at the entrance to the village, in a small marsh, in grassland, 3228CD, Hagga Hagga District.

**C. mossii** Nelmes

Specimen 297 (GRA, MG & NU): Kettle Spout Falls, 500m from the falls, on the banks of the small stream that feeds the falls, 3226DB, Hogsback District.

Specimen 308 (GRA & MG): Central Hog, near a small waterfall, in the grassland 20m to the left of the fall, 3226DB, Hogsback District.

Specimen 310 (GRA, MG & NU): Central Hog, near a small waterfall, in the grassland 200m to the left of the fall, 3226DB, Hogsback District.

Specimen 331 (GRA, MG & NU): Kettle Spout Falls, in the marsh at the source of the stream that feeds the falls, wet sandy soil, 3226DB, Hogsback District.
**C. zuluensis** C.B.Clarke
Specimen 99 (GRA & MG): Woest Hill, on a grassy slope that has been invaded by exotics, sandy soil, 3326BC, Grahamstown District.

**CARPHA BANKS & SOLAND ex R.BROWN**

**C. bracteosa** C.B.Clarke
Specimen 301 (GRA, MG, NE & NU): 5 Kilometres from the Central Hog, near the forestry road, in a marsh, 3226DB, Hogsback District.

Specimen 336 (GRA, MG, NE & NU): Robertson Falls, overlooking the Tyumie Basin, on the river banks of the river above the falls, in rocky soil, 3226DB, Hogsback.

**C. glomerata** (Thunb.) Nees
Specimen 295 (GRA, MG & NU): Kettle Spout Falls, in the stream that feeds the falls, at the pine forest margin, 3226DB, Hogsback.

Specimen 387 (GRA, MG & NU): 700m up the hill from the Robertson Falls Dam, on the slope of the First Hog, in a small stream within the pine forest, 3226DB, Hogsback District.

**C. schlechteri** C.B.Clarke
Specimen 458 (GRA, MG, NE & NU): Witelsbos SAFCOL forest, 1 kilometre from the SAFCOL offices, 500m from the N2, in wet soil, in an area cleared of *Eucalyptus* sp. trees, 3424AA, Humansdorp District.

**CHRYSITRIX LINNAEUS**

**C. capensis** Linnaeus
Specimen 478 (GRA, MG & NU): Witelsbos SAFCOL forest, on the slopes of the Tsitsikammaberg, on the grassy road verge, in pine forest, 3424AA, Humansdorp District.

**CLADIUM P.BROWNE**

**Cladium mariscus** (Linnaeus) Pohl subsp. *jamaicense* (Crantz) Kükenthal
Specimen 493 (GRA, MG & NU): Cape St. Francis, on the side of the road to Humansdorp 2 kilometres from the entrance to the town, in a rocky, marsh, on dry ground, 3324DD, Humansdorp District.

**CYATHOCOMA NEES**

**C. hexandra** (Nees) J.Browning
Specimen 483 & 484 (GRA, MG &NU): Witelsbos SAFCOL forest, indigenous forest, on rocky stream banks, in an area just cleared of forest, 3424AA, Humansdorp District.
Specimen 477 (GRA, MG & NU): Witelsbos SAFCOL forest, on the slopes of the Tsitsikammaberg, on the grassy road verge, in pine forest, 3424AA, Humansdorp District.

**CYPERUS LINNAEUS**

*C. albostriatus Schrader*

Specimen 187 (GRA & MG): Woest Hill, on the rocky slopes of the grassy fynbos, in damp places, 560m above sea level, 3326BC, Grahamstown District.

*C. denudatus L.f.*

Specimen 261 (GRA & MG): 40 kilometres from Grahamstown on the Port Alfred road, 100m from the road, at the edge of a small marsh, 3326BC, Albany District.

Specimen 263 (GRA, MG & NU): At the top of Blaauwkrantz, on the left hand side of the road to Grahamstown, 35 kilometres from Grahamstown, in a shallow pan, 3326BC, Albany District.

Specimen 433 (GRA, MG & NU): Kei Mouth Air Field, in the marsh opposite the field, in grassland, wet soil, 3228CB, Kei Mouth District.

*C. difformis Linnaeus*

Specimen 223 (GRA & MG): Bathurst Commonage, on the road side, 5 kilometres from Bathurst, on the Southwell road, in a water furrow, at the edge of grassland, on clay soil, 3326DB, Bathurst District.

Specimen 260 (GRA & MG): 40 Kilometres from Grahamstown on the road to Port Alfred, on the banks of a small marsh, in clay soil, 3326BC, Albany District.

Specimen 431 (GRA, MG & NU): Double Mouth Reserve, 2 kilometres from the camp site, on the Morgan’s Bay side of the reserve, at the edge of a small pool of water, in the grasslands, 3228CB, Morgan’s Bay District.

*C. distans L.f.*

Specimen 200 (GRA & MG): 7 kilometres from the turn-off to Committees Drift, on the road that turns near Fort Brown, bordering the Andries Vosloo Nature Reserve, 150m from a shale outcrop and 100m from the road, in a rocky stream bed, under the rocks, in the middle of the stream bed, 500m above sea level, 3326BA, Albany District.

Specimen 204 (GRA & MG): Trompetter's Drift Fort, in the shale river bed of the Ble River, in *Acacia karoo* riverine thicket, 400m above sea level, 3326BB, Albany District.

Specimen 441 (GRA, MG & NU): One kilometre from the turnoff to Hagga Hagga, on the road to Hagga Hagga, 100m from the road, on the left hand side of the road, on the clay banks of a small dam, 3228CB, Hagga Hagga District.

*C. esculentus Linnaeus*

Specimen 439 (GRA, MG & NU): Morgan's Bay in front of the Mitford Holiday Flats, 50m from the beach, in the gravel at the side of the road, 3228CB, Morgan’s Bay District.

Specimen 451 (GRA, MG & NU): Marsh Sands, in the marsh alongside a small river, 3228CB, Hagga Hagga District.

Specimen 452 (GRA, MG & NU): Marsh Sands, 700m from a small river, in the building site, in sandy soil, 3228CB, Hagga Hagga District.
**C. fastigiatus** Rottboel
Specimen 20 (GRA & MG): Lushington river, 5 kilometres from town near the commonage, on a river bank, dry soil, 3326DB, Bathurst District.

**C. immensis** C.B.Clarke
Specimen 222 (GRA & MG): Bathurst Commonage, along the banks of the Lushington River, 11 kilometres from Bathurst, 3326BD, Bathurst District.

**C. laevigatus** Linnaeus
Specimen 240 (GRA, MG & NU): Cintsa River mouth, 250m from the sea, on the sandy river bank, next to a steep sand dune, 3228CC, Cintsa District.
Specimen 241 (GRA & MG): Cintsa River mouth, near a bridge below Buccaneers Retreat, in the rock crevices of a small tributary stream to the Cintsa river, 3228CC, Cintsa District.

**C. longus** Linnaeus var. *tenuiflorus* (Rottboel) Boeck.
Specimen 435 (GRA, MG & NU): Centenary Dam, on the dam banks, 3228CB, Kei Mouth District.

**C. marginatus** Thunb.
Specimen 1 (collected by Tasmer & Sonnenberg, GRA): Grahamstown, Victoria Girl's High School, next to the wall of the lower hockey field, 3326BC, Grahamstown District.

**C. natalensis** Hochst.
Specimen 270 (GRA, MG & NU): Rufane's River mouth, 2 kilometres to the north of the mouth, in a dune slack, 3326DB, Port Alfred District.
Specimen 271 (GRA, MG & NU): Round Hill (Oribi Reserve), grassland, 3326DB, Bathurst District.
Specimen 406 (GRA, MG & NU): Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth District.

**C. obtusiflorus** Vahl
Specimen 401 (GRA, MG & NU): Kei Moth golf course, sandy soil, 3228CB, Kei Mouth.

**C. pulcher** Thunb.
Specimen 437 (GRA, MG & NU): Centenary Dam, on the Dam banks, at the waters edge, wet soil, in full sunlight, 3228CB, Kei Moth District.

**C. rubicundus** Vahl
Specimen 188 (GRA & MG): Near the bridge at Committees Drift, near the turn-off to Trumpeter’s Drift Fort, on a shale substratum, on the river bed, 3326BB, Albany District.
Specimen 202 (GRA, MG & UN): Mooi River, 2.5 kilometres from Committees Drift on the Fort Brown road, on the river banks, 3326BA, Albany District.


*C. rupestris* Kunth var. *rupestris*

Specimen 227 (GRA & MG): Bathurst Commonage, 3 kilometres from Bathurst on the Bathurst-Southwell road, approximately 400m from the road, on the right hand side, in grassy spots, between the bush-clumps, 370m above sea-level, 3326BD, Bathurst District.

Specimen 383 (GRA, MG & NU): Rockford, 40 kilometres from Cathcart, on both banks of the Tay river above and below a small bridge, 3226DA, Cathcart District.

*C. semitrifidus* Schrader var. *semitrifidus*

Specimen 280 (GRA, MG & NU): Round Hill (Oribi Reserve), 200m from a thickly wooded area and 50m from a small reservoir, in open grassland, 375m above sea-level, 3326BD, Bathurst District.

*C. sexangularis* Nees

Specimen 203 (GRA & MG): Mooi River, 2.5 kilometres from Committees Drift, next to the bridge, on the road between Committees Drift and Trompetter's Drift Fort, in the dry river bed, in shale fragments, 400m above sea-level, 3326BB, Albany District.

*C. sphaerospermus* Schrader

Specimen 278 (GRA, MG & NU): Round Hill (Oribi Reserve), 200m up the hill from the Conservation House, near a thickly wooded area, 50m from a small reservoir, grassland, 375m above sea-level, 3326BD, Bathurst District.

Specimen 424 (GRA, MG & NU): Double Mouth, on a slope overlooking the mouth, grassland, 3228CB, Morgan’s Bay District.

Specimen 448 (GRA & MG): Cochin Farm, near Marsh Sands, on both the banks of a small river, in riverine thicket, on sandy soil, 3228CB, Hagga Hagga District.

*C. tenellus* L.f. var. *tenellus*

Specimen 341 (GRA, MG & NU): Madonna and Child Falls, on the rocky slope at the foot of the falls and in the river leading away from the falls, wet soil, in shade, 3226DB, Hogsback District.

Specimen 385 (GRA, MG & NU): 700m up the hill from the Robertson Falls Dam, on both the banks of a small stream, 3226DB, Hogsback District.

Specimen 388 (GRA, MG & NU): 1.1 Kilometres up the hill from the Robertson Falls Dam, on the banks of a small stream, 3226DB, Hogsback District.

Specimen 489 (GRA, MG & NU): Witelsbos SAFCOL forest, on the sea-ward facing slopes of the Tsitsikammaberg, below the radio tower, in a newly cleared area, rocky soil, 3424AA, Humansdorp District.

*C. textilis* Thunb.

Specimen 100 (GRA, MG & NU): Jamieson’s Dam, on both the banks of a small unnamed river leading to dam, 3326BC, Albany District.
ELEOCHARIS R. BROWN

_E. dregeana_ Steud.

Specimen 262 (GRA, MG & NU): Waldon Farm turnoff, 40 kilometres from Grahamstown on the Port Alfred road, at the edge of a small marsh, clay soil, 3326BC, Albany District.

Specimen 384 (GRA, MG & NU): Robertson Falls, overlooking the Tyumie Basin, on both the rocky river banks of the river that feeds the falls, 3226DB, Hogsback District.

Specimen 394 (GRA, MG & NU): Siberia Marsh, on the way to Gaika’s Kop, in the marsh, on clay soil, 3226DB, Hogsback District.

Specimen 434 (GRA, MG & NU): Kei Mouth dump site, in the grassland surrounding the site, sandy soil, Kei Mouth District.

_E. limosa_ (Schrader) Schultes

Specimen 218 (GRA & MG): Eight kilometres from Riebeek-East, 100m from the Riebeek-East road to Hells Poort, in a dry dam, 3326AA, Albany District.

Specimen 413 (GRA, MG & NU): Cape Morgan Nature Reserve, in the grassland near the gate to the reserve, in an old marsh, on sandy soil, 3228CB, Kei Mouth District.

_E. pauciflora_ R. Brown

Specimen 215 (GRA & MG): Kasouga River Mouth, 750m from the sea, directly across from the holiday shacks, in the salt marsh flood plain, 3326DA, Bathurst District.

FICINIA SCHRADER

_F. arenicola_ Arnold & Gordon-Gray var. _arenicola_

Specimen 209 (GRA & MG): Tharfield Private Nature Reserve (West-Kleinemonde), on the third dune ridge from the sea, in the sand at the verge of a coastal thicket, in the grassy areas surrounding the thicket, 3326DB, Bathurst District.

_F. bulbosa_ (Linnaeus) Nees

Specimen 208 (GRA & MG): Tharfield Private Nature Reserve (West-Kleinemonde), near the FM tower, three dune ridges from the sea, in the dune thicket, 3326CA, Bathurst District.

_F. cinnamomea_ C. B. Clarke

Specimen 339 (GRA, MG & NU): Robertson Falls, on the rocky river banks of the river that feeds the falls, 3226DB, Hogsback District.

_F. dura_ Turrill

Specimen 395 (GRA, MG & NU): Near Gaika’s Kop, where two river marshes converge, at the base of a small hillock, marsh, 3226DB, Hogsback District.

Specimen 397 (GRA, MG & NU): Gaika’s Kop, below the old forestry tower, at the margin of the pine forest, in the marsh, on sandy soil, 3226DB, Hogsback District.
**F. fascicularis Nees**

Specimen 298 (GRA, MG & NU): Kettle Spout Falls, at the margin of the pine forest and fynbos, in the small stream, 3226DB, Hogsback District.

Specimens 463, 464, 466 (GRA, MG & NU): Witelsbos SAFCOL forest, 700m from the N2 to Storms River, one kilometre from the SAFCOL offices, in an area cleared of *Eucalyptus* trees, in wet clay soil, 3424AA, Humansdorp District.

Specimen 476 (GRA, MG & NU): Witelsbos SAFCOL forest, 1.1 kilometres up the Tsitsikammbaerg, on a rocky slope, in a pine forest, 3424AA, Humansdorp District.

**F. filiculmea B.L.Burtt**

Specimens 474 & 475 (GRA, MG & NU): Witelsbos SAFCOL forest, 700m up the Tsitsikammbaerg, on a rocky slope, in pine forest, 3424AA, Humansdorp District.

Specimen 481 (GRA, MG & NU): Witelsbos SAFCOL forest, on the Tsitsikammbaerg side of the N2 to Storms River, in the understorey of indigenous forest, 3424AA, Humansdorp District.

**F. filiformis (Lam.) Schrader**

Specimen 216 (GRA & MG): Kasouga River Mouth, edge of *Juncus* species dominated area, on both the river banks, 3326DA, Bathurst District.

Specimen 221 (GRA & MG): Bathurst Commonage, 6 kilometres from Bathurst, one kilometre from the Bathurst-Southwell road, on both the banks of the Lushington river, amongst the grasses and *Cyperus textilis*, 3326BD, Bathurst District.

**F. indica (Lam.) Pfeiffer var. indica**

Specimen 213 (GRA & MG): East-Kleinemonde, 100m from the closed river mouth, the marsh area at the river's edge, next to *Stenotaphrum* spp., 3326CA, Bathurst District.

**F. lateralis (Vahl) Kunth**

**Inland:**

Specimen 205 (GRA & MG): Tharfield Private Nature Reserve, 250m from West-Kleinemonde, under a large *Rhus crenata*, in dune thicket, 3326CA, Bathurst District.

Specimen 225 (GRA & MG): Bathurst Commonage, 5 kilometres from Bathurst, 250m from the right hand side of the Bathurst-Southwell road, in the grassland between the bush-clumps, on sandy soil, 3326DB, Bathurst District.

**Coastal:**

Specimens 420 & 421 (GRA, MG & NU): Cape Morgan Nature Reserve, near the ruins of a large old house, in the dune thicket, sandy soil, 3228CB, Kei Mouth District.

**F. oligantha (Steud.) J.Raynal**

Specimen 266 (GRA, MG & NU): Grahamstown Golf Course, next to the second tee, in grassy thicket, on sandy soil, 3326BC, Grahamstown District.
**F. pinguior C.B.Clarke**

Specimen 319 (GRA & MG): The Third Hog, near a small rock pool with rapids leading to it, grassland, 3226DB, Hogsback District.

**F. repens Kunth**

Specimen 211 (GRA & MG): Tharfield Private Nature Reserve, in between the Riet and West-Kleinemonde River Mouths, 300m from the National road between the two mouths, in grassland, 3327CA, Bathurst District.

Specimen 330 (GRA & MG): Gaika’s Kop, on both the stream banks of a small stream, 3226DB, Hogsback District.

**F. stolonifera Boeck.**

Specimen 309 (GRA, MG & NU): Central Hog, near a stream, 50m from the summit, grassland, 3226DB, Hogsback District.

Specimen 333 (GRA, MG & NU): Tor Doone, on the Kettle Spout Falls side, near a small waterfall, 3226DB, Hogsback District.

**F. tenuifolia Kunth**

Specimen 273 (GRA, MG & NU): Round Hill (Oribi Reserve), 50m up the hill from the Nature Conservation hut, bush-clump grassland, 3326DB, Bathurst District.

**F. tribracteata Boeck.**

Specimen 347 (GRA, MG & NU): Near Siberia Marsh, on the way to Gaika’s Kop, in a marsh, 3226DB, Hogsback District.

Specimen 365 (GRA, MG & NU): Gaika’s Kop, on the north side, at the edge of the pine forest, in both the fynbos and in a marsh, 3226DB, Hogsback District.

**F. zeyheri Boeck.**

Specimen 453 (GRA & MG): Cochin Farm, on a hill opposite the main house, 4 kilometres away, on a hill facing the sea, grassland, stony ground, 3228CB, Hagga Hagga District.

**FIMBRISTYLIS VAHL**

**F. complanata (Retz.) Link**

Specimen 279 (GRA & MG): Round Hill (Oribi Reserve), above and below the Conservation House, 50-100m, from the house, in grassy areas, 3326BD, Bathurst District.

Specimen 412 (GRA, MG & NU): Cape Morgan Nature Reserve, near the gate of the reserve, in an old marsh, on sandy soil, 3228CB, Kei Mouth District.

Specimen 447 (GRA, MG & NU): Cochin Farm, near Marsh Sands, on both the banks of a small river, in riverine thicket, on sandy soil, 3228CB, Hagga Hagga District.

Specimen 495 (GRA, MG & NU): Mountains near Humansdorp, in grassy fynbos, on sandy soil, 3324DD, Humansdorp District.
**F. dichotoma** (Linnaeus) Vahl

Specimen 440 (GRA, MG & NU): One kilometre from the Hagga Hagga turnoff from the Kei Mouth road, on the way to Hagga Hagga, to the left of the road, on the banks of the marsh and in the marsh, 3228CB, Hagga Hagga District.

**F. ferruginea** (Linnaeus) Vahl

Specimen 428 (GRA, MG & NU): Ntshala River Mouth, near the Nature Conservation Huts, opposite Morgan’s Bay, 700m from the sea on the banks of the estuary, sandy soil, 3228CB, Morgan’s Bay District.

**Fuirena** Rottboel

**F. coerulescens** Steud.

Specimen 320 (GRA & MG): Third Hog, near a small stream, grasslands, 3226DB, Hogsback District.

Specimen 363 (GRA, MG & NU): Gaika’s Kop, just off the Siberia Marsh, in a small marsh, 3226DB, Hogsback District.

**F. hirsuta** (P.J.Bergius) P.L.Forbes

Specimen 231 (GRA & MG): Howieson's Poort, Palmiet River, 3326AD, Grahamstown District.

Specimen 249 (GRA & MG), 256 (GRA, MG & NU), 257 (GRA & MG): Hamilton Reservoir, marshy areas on the edge of the dam, 3326BC, Grahamstown District.

Specimen 414 (GRA & MG): Cape Morgan Nature Reserve, in the grassland near the gate to the reserve, in an old marsh, on sandy soil, 3228CB, Kei Mouth District.

Specimen 488 (GRA, MG & NU): Witelsbos SAFCOL forest, on the slopes of the Tsitsikammbaerg, in an area cleared of indigenous forest, in the marshy areas near a damaged dam, 3424AA, Humansdorp District.

**F. pachyrhiza** Ridley

Specimen 416 (GRA, MG & NU): Cape Morgan Nature Reserve, in the grassland near the gate to the reserve, in an old marsh, on sandy soil, 3228CB, Kei Mouth District.

**Isolepis** R.Brown

**I. cernua** (Vahl) Roem. & Schultes

Specimens 252 & 254 (GRA & MG): Hamilton Reservoir, above the waterline at the edge of the dam, on sandy soil, 620m above sea-level, 3326BC, Grahamstown District.

Specimen 327 (GRA, MG & NU): Gaika’s Kop, 200m further up Gaika’s from the old forestry tower, on both the banks of a small stream, wet soil, 3226DB, Hogsback District.

**I. costata** (Boeck.) A.Rich var. *macra* (Boeck.) B.L.Burtt.

Specimen 290 (GRA, MG & NU): Kettle Spout Falls, 700m from the falls, on the forest/fynbos margin, on both the banks of the river that feeds the falls, 3226DB, Hogsback.
Specimen 305 (GRA, MG & NU): Central Hog, on the Gaika’s Kop side, 5 kilometres from the Hog, in the grassland, in a marsh, 3226DB, Hogsback District.

Specimen 316 (GRA, MG & NU): Third Hog, on the Gaika’s Kop side, in the grassland, in a marsh, 3226DB, Hogsback District.

Specimen 326 (GRA & MG): Gaika’s Kop, 100m from the old forestry tower, on the wet river banks of a small stream, 3226DB, Hogsback District.

Specimen 332 (GRA, MG & NU): Kettle Spout Falls, on the banks of the marsh that is the source of the river that feeds the falls, on sandy soil, 3226DB, Hogsback District.

Specimen 362, 371 & 374 (GRA, MG & NU): Gaika’s Kop, in the marsh on the way to the hiking hut, 3226DB, Hogsback District.

**I. diabolica (Steud.) Schrader**

Specimen 238 (GRA & MG): 5 kilometres from Grahamstown on the Grahamstown-Port Alfred road, on the Farm Waterloo, in *Eucalyptus* invaded savannah grassland, on sandy soil, 3326BC, Grahamstown District.

Specimen 302 (GRA, MG & NU): Central Hog, 5 kilometres away from the Hog, on the Gaika’s Kop side, in the grassland, in a marsh, 3226DB, Hogsback.

Specimen 321 (GRA, MG & NU): Third Hog, near a small stream, on the Gaika’s Kop side, grassland, 3226DB, Hogsback District.

Specimen 323 (GRA, MG & NU): Gaika’s Kop, below a cliff, 400m from the summit, on both the banks of a small marsh, 3226DB, Hogsback District.

Specimen 345 (GRA, MG & NU): Siberia Marsh, grassland, 3226DB, Hogsback District.

**I. fluitans (Linnaeus) R.Brown**

Specimen 299 (GRA, MG & NU): Kettle Spout Falls, on both the banks and in the stream that feeds the falls, 3226DB, Hogsback District.

**I. natans (Thunb.) D.Dietr.**

Specimen 291 (GRA & MG): Kettle Spout Falls, on both the banks of the stream that feeds the falls, at the margin of the forest/fynbos, 3226DB, Hogsback District.

Specimen 304 (GRA, MG & NU): First Hog, on the Gaika’s Kop side, 5 kilometres from the Hog, in a marsh, 3226DB, Hogsback District.

Specimen 364 (GRA, MG & NU): Gaika’s Kop, in the marsh on the way to the hiking hut, 3226DB, Hogsback District.

**I. pellocolea B.L.Burtt**

Specimen 329 (GRA, MG & NU): Gaika’s Kop, 200m uphill from the old forestry tower, on both the banks of a small stream, wet soil, 3226DB, Hogsback District.

**I. prolifera (Rottboel) R.Brown**

Specimen 201 (GRA & MG): In the alluvium of an un-named tributary of the Mooi river, 1.5 kilometres from the Ecca Pass near the Committees Drift turn-off on the Plutovale road, on the dry river bed, in shale soils, 3326BB, Albany District.
Appendix 1

Specimen 250 (GRA & MG): Hamilton Reservoir, near the water's edge, 3326BC, Grahamstown District.

Specimen 482 (GRA, MG & NU): Witelsbos SAFCOL forest, on the Tsitsikammaberg side of the N2 to Storms River, in the understorey of indigenous forest, on sandy soil, 3424AA, Humansdorp District.

**KYLLINGA ROTTBOEL**

*K. alata* Nees

Specimen 274 (GRA, MG & NU): Round Hill (Oribi Reserve), 50m up the hill from the Conservation House, near the path to the trig beacon, in a grassy area, 375m above sea-level, 3326BD, Bathurst District.

Specimen 400 (GRA, MG & NU): Kei Mouth golf course, on sandy soil, 3228CB, Kei Mouth District.

*K. brevifolia* Rottboel

Specimen 443 (GRA, MG & NU): 1 Kilometre from the Hagga Hagga turnoff from the Kei Mouth road, on the road to Hagga Hagga, in a marsh on the left hand side of the road, 3228CB, Hagga Hagga District.

*K. elatior* Kunth

Specimen 438 (GRA, MG & NU): Centenary Dam, at the water's edge, 3228CB, Kei Mouth District.

Specimen 490 (GRA, MG & NU): Witelsbos SAFCOL forest, 400m from the N2, at the edge of the Witelsbos forests, in a marsh near the foresters cottages, 3424AA, Humansdorp District.

*K. erecta* Schumach.

Specimen 228 (GRA, MG & NU): Bathurst Commonage, 500m from the Bathurst-Southwell road, 5 kilometres from Bathurst, in the grasslands between the bush-clumps, on sandy soil, 3326DB Bathurst District.

Specimen 410 (GRA, MG & NU): Kei Mouth golf course, in grassland, on sandy soil, 3228CB, Kei Mouth District.

*K. pauciflora* Ridley

Specimen 348 (GRA, MG & NU): Siberia Marsh, grassland, 3226DB, Hogsback District.

Specimen 356 (GRA, MG & NU): Gaika’s Kop, on the way to the hiking hut, at the edge of the pine forest, on the margin of the marsh below the mountain, 3226DB, Hogsback District.

**MARISCUS VAHL**

*M. albomarginatus* C.B.Clarke

Specimen 409 (GRA, MG & NU): Kei Mouth golf course, grassland, on sandy soil, 3228CB, Kei Mouth District.

*M. capensis* (Steud.) Schrader

Specimen 224 (GRA & MG): Bathurst Commonage, approximately 5 kilometres from Bathurst, near the ruins of the old Pineapple Research Station, near some old large *Eucalyptus* species, in close integrating disturbed savannah, 3326DB, Bathurst District.
Specimen 267 (GRA, MG & NU): Grahamstown Golf Course, next to the second tee, in grassy thicket, on sandy soil, 3326BC, Grahamstown District.

Specimen 276 (GRA & MG): Round Hill (Oribi Reserve), grassland, 3326DB, Bathurst District.

*M. congestus* (Vahl) C.B.Clarke

Specimen 353 (GRA, MG & NU): SAFCOL camping site (Hogsback), marsh, 3226DB, Hogsback District.

Specimen 402 (GRA, MG & NU): Kei Mouth golf course, grassland, on sandy soil, 3228CB, Kei Mouth.

Specimen 419 (GRA, MG & NU): Cape Morgan Nature Reserve, grassland, in an old marsh near the gate, on sandy soil, 3228CB, Kei Mouth District.

*M. dubius* (Rottboel) Kükenthal ex C.E.C.Fischer

Specimen 246 (GRA, MG & NU): On a road verges, 500m from the sea and 1.5 kilometres west of Cintsa West, in coastal thicket, 3227CC, East London District.

Specimen 405 (GRA, MG & NU): Kei Mouth golf course, grassland, on sandy soil, 3228CB, Kei Mouth District.

*M. macrocarpus* Kunth

Specimen 244 (GRA, MG & NU): Cintsa River mouth, 100m from the Cintsa West river mouth, in a gully with sharp sides, on sand dunes, 3228CC, East London District.

Specimen 245 (GRA, MG & NU): Cintsa River mouth, 300m from the sea, 1 kilometre west of Cintsa West, in a gully, on the margin of coastal dune forest, in loose white sand, 3228CC, East London District.

Specimen 248 (GRA, MG & NU): Near Buccaneer’s Retreat, 150m from Cintsa West river mouth, on a steep first dune, in the coastal thicket and on exposed dunes on the verge of the thicket, 3227CC, East London District.

*M. solidus* (Kunth) P.J.Vorster

Specimen 88 (GRA, MG & NU): West-Kleinemonde, on both the banks of the river, 3326CA, Bathurst District.

*M. sumatrensis* (Retz.) J.Raynal

Specimen 198 (GRA, MG & NU): Tharfield Private Nature Reserve, near West-Kleinemonde, 3326CA, Bathurst District.

Specimen 206 (GRA, MG & NU): 600m west of West-Kleinemonde, on a north-facing sand dune slope, in dune forest, under a large *Mimusops caffra*, 3326CA, Bathurst District.

Specimen 242 (GRA, MG & NU): Cintsa West, in thicket, on a river bank, on sandy soil, 3228CB, East London District.

Specimen 436 (GRA, MG & NU): Centenary Dam, on the banks, 3228CB, Kei Mouth District.

*M. tabularis* (Schrader) C.B.Clarke subsp. *major*

Specimen 281 (GRA, MG & UN): Round Hill (Oribi Reserve), 250m from the Conservation House, below the house, near the Bathurst road, in a grassy area, 3326BD, Bathurst District.
**M. thunbergii (Vahl) Schrader**

Specimen 214 (GRA, MG & NU): Riet River Mouth, 500m from the sea, at the edge of a salt marsh on a river bank, 3326CA, Bathurst District.

Specimen 292 (GRA, MG & NU): Kettle Spout Falls, 700m from the falls, on both the banks of the river that feeds the falls, on the forest/fynbos margin, 3226DB, Hogsback District.

**M. uitenhagensis Steud.**

Specimen 501 (Sonnenberg & Hobson, GRA, MG & NU): Roodeberg Farm, on dolerite crests, northern slopes, rocky slopes, 3224AD, Kendrew District.

**PYCREUS P.BEAUVOIS**

**P. cooperi C.B.Clarke**

Specimen 311 (GRA, MG & NU): Third Hog, on the Gaika’s Kop side, on a stream bank, 3226DB, Hogsback District.

Specimen 392 (GRA, MG & NU): Gaika’s Kop, in a marsh near the start of a small stream, 3226DB, Hogsback District.

**P. intactus (Vahl) J.Raynal**

Specimen 407 (GRA, MG & NU): Kei Mouth golf course, grassland, on sandy soil, 3228CB, Kei Mouth District.

Specimen 422 (GRA, MG & NU): On a slope overlooking Morgan’s Bay, on the margin of grass/thicket, wet soil, 3228CB, Morgan’s Bay District.

**P. macranthus (Boeck.) C.B.Clarke**

Specimen 300 (GRA, MG & NU): Kettle Spout Falls, 700m away, in a marsh, 3226DB, Hogsback District.

Specimen 303 (GRA, MG & NU): First Hog, 5 kilometres from the Hog, on the Gaika’s Kop side, in grassland, in a marsh, 3226DB, Hogsback District.

Specimen 367 (GRA, MG & NU): Gaika’s Kop, on the way to the hiking hut, on the pine forest/marsh margin, in the marsh, 3226DB, Hogsback District.

**P. mundii Nees**

Specimen 229 (GRA & MG): Bathurst Commonage, 500m from the Southwell-Bathurst road, 5 kilometres from Bathurst, in the grassland between the bush-clumps, on sandy soil, 3326DB, Bathurst District.

Specimen 491 (GRA, MG & NU): Witelsbos SAFCOL forest, near the foresters cottage, 400m from the N2 to Storms River, at the edge of the Witelsbos forests, in a marsh, 3424AB, Humansdorp District.

**P. nitidus (Lam.) J.Raynal**

Specimen 455 (GRA, MG & NU): Cochin Farm, near Marsh Sands, grassland, in a gully, 3228CB, Hagga Hagga District.
**P. polystachyos** (Rottboel) P.Beauvois subsp. **polystachyos**

Specimen 264 (GRA & MG): Blaauwkrantz Reserve, along the river, near the water, in rock cracks, 3326BC, Albany District.

Specimen 465 (GRA, MG & NU): Witelsbos SAFCOL forest, 2 kilometres from the SAFCOL offices, 700m from the N2 to Storms River, in an area cleared of *Eucalyptus* trees, wet soil, 3424AA, Humansdorp District.

**RHYNCHOSPORA VAHL**

**R. barrosiana** Guaglianone

Specimen 417 (GRA, MG, NE & NU): Cape Morgan Nature Reserve, in the grassland near the gate to the reserve, in an old marsh, on sandy soil, 3228CB, Kei Mouth District.

**R. brownii** Roem. & Schultes

Specimen 313 (GRA, MG & NU): Third Hog, on the Gaika’s Kop side, grassland, in a marsh, 3226DB, Hogsback District.

Specimen 334 (GRA, MG & NU): Tor Doone, in pine forest, on a rocky slope, 3226DB, Hogsback District.

Specimens 337 (GRA & MG) & 338 (GRA, MG & NU): Robertson Falls, on the rocky river-banks above the falls, 3226DB, Hogsback District.

Specimen 426 (GRA & MG): Double Mouth, on the hill above, 3228CB, Morgan’s Bay District.

Specimen 472 (GRA, MG & NU): Witelsbos SAFCOL forest, 600m from the Kromdraai turnoff on the N2 to Storms River, on the margin of pine forest, wet sandy soil, 3424AA, Humansdorp District.

**SCHOENOPLECTUS** (REICHENBACH) PALLA

**S. decipiens** (Nees) J.Raynal

Specimen 219 (GRA & MG): Eight kilometres from Riebeek-East, near the Gxetu river, in a dry farm dam, 3326AA, Riebeek-East District.

Specimen 236 (GRA & MG): Firdene Farm, in a shallow water resting area with rocky sides, 3326AD, Grahamstown District.

**S. paludicola** (Kunth) Palla ex J.Raynal

Specimen 199 (GRA & MG): Firdene Farm, near the farm road, 150m from the summit of Stones Hill, in a shallow pan of seasonal water, 3326BC, Grahamstown District.

Specimen 354 (GRA, MG & NU): SAFCOL camping site (Hogsback), in a marsh, 3226DB, Hogsback District.

Specimen 382 (GRA, MG & NU): 40 kilometres from Cathcart, near Rockford, on both the Tay river banks, 3226BD, Cathcart District.

Specimen 432 (GRA, MG & NU): Double Mouth Nature Reserve, 4 kilometres from the camp site, grassland, on the banks of a small pool, 3228CB, Morgan’s Bay District.
SCHENOXIPHIUM NEES

S. bracteosum Kukkonen
Specimen 294 (GRA, MG & NU): Kettle Spout Falls, 700m from the falls on the pine forest/fynbos margin, on the banks of the river that feeds the falls, 3226DB, Hogsback District.

Specimen 386 (GRA, NU): Robertson Falls Dam, on the slopes of the First Hog, on the banks of a small stream, on stony soil, 3226DB, Hogsback District.

S. lehmannii (Nees) Steud.
Specimen 217 (GRA, MG & NU): Lushington River, on the river's edge, on the rocky slopes of riverine thicket, 3326DB, Bathurst District.

Specimen 340 (GRA, MG & NU): Madonna and Child Falls, at the foot of the falls, on the rocky slopes, 3226DB, Hogsback District.

Specimen 361 (GRA, MG & NU): Gaika’s Kop, in the marsh on the way to the hiking hut, on the marsh/pine forest margin, 3226DB, Hogsback District.

Specimen 429 (GRA, MG & NU): Near the Morgan’s Bay turnoff, from the Kei Mouth road, on river banks, 3228CB, Morgan’s Bay District.

S. rufum Nees
Specimen 296 (GRA, MG & NU): Kettle Spout Falls, in fynbos, in the marsh near the falls and on both the banks of the river that feeds the falls, 3226DB, Hogsback.

S. schweikerdtii Merxmuller & Podlech
Specimen 328 (GRA, MG & NU): Gaika’s Kop, 100m up the hill from the old forestry tower, on the banks of a small stream, 3226DB, Hogsback District.

Specimen 480 (GRA, MG & NU): Witelsbos SAFCOL forest, on the Tsitsikammaberg side of the N2 to Storms River, in the understorey of indigenous forest, on sandy soil, 3424AA, Humansdorp District.

S. sparteum (Wahlenb.) C.B.Clarke
Specimen 317 (GRA, MG & NU): Third Hog, on the Gaika’s Kop side, grassland, in a small stream, 3226DB, Hogsback District.

Specimen 366 (GRA, MG & NU): Gaika’s Kop, in the marsh on the way to the hiking hut, on the pine forest/marsh margin, 3226DB, Hogsback District.

SCHENOUS LINNAEUS

S. nigricans Linnaeus
Specimen 445 (GRA, MG & NU): Cochin Farm, near Marsh Sands, on both the banks of a small river, in indigenous thicket, on sandy soil, 3228CB, Hagga Hagga District.
SCIRPUS LINNAEUS 0468000

*S. falsus* C.B.Clarke

Specimen 335 (GRA, MG & NU): Robertson Falls, on both the rocky river banks of the river that feeds the falls, 3226DB, Hogsback District.

Specimen 342 (GRA, MG & NU): Madonna and Child Falls, at the foot of the falls, on a rocky slope, 3226DB, Hogsback District.

*S. ficinioideae* Kunth

Specimen 312 (GRA, MG & NU): Third Hog, on the Gaika’s Kop side, in a marshy area, 3226DB, Hogsback District.

Specimen 322 (GRA, MG & NU): Gaika’s Kop, 400m from the summit, in a marsh, 3226DB, Hogsback District.

Specimen 324 (GRA, MG & NU): Gaika’s Kop, 100m from the old forestry tower, grassland, near a large pine tree, 3226DB, Hogsback District.

*S. nodosus* Rottboel

Specimen 269 (GRA, MG & NU): Rufane's River mouth, 2 kilometres north of the mouth, in a dune slack, 2m above sea level, 3326DB, Port Alfred District.

SCLERIA P.J.BERGIUS

*S. melanomphala* Kunth

Specimen 425 (GRA, MG & NU): Double Mouth, overlooking the mouth, grassland, 3228CB, Morgan’s Bay District.

*S. natalensis* C.B.Clarke

Specimen 473 (GRA, NU): One kilometre from the Kromdraai turnoff on the N2 to Storms River, at the edge of the forest, on both the banks of a small river, 3424AA, Humansdorp District.

TETRARIA P.BEAUVOIS

*T. cuspidata* (Rottboel) C.B.Clarke

Specimen 325 (GRA, MG & NU): Gaika’s Kop, 100m uphill from the old forestry tower, on both the banks of a small stream, wet soil, 3226DB, Hogsback District.

Specimen 346 (GRA, MG & NU): Siberia Marsh, grassland, 3226DB, Hogsback District.

Specimen 454 (GRA, MG & NU): Cochin Farm, on a hill overlooking the sea, opposite the main farm house, grassland, on stony soil, 3228CB, Hagga Hagga District.

Specimen 499 (GRA, MG & NU): Mountains near Loerie, near the cable way, on stony soil, 3324CD, Loerie District.
## Appendix 2: List of Anatomical Characteristics investigated.

This appendix lists the anatomical characteristics that were noted for each specimen examined in this investigation.

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<td>Where is MS lignified</td>
<td>Phloem shape in large</td>
</tr>
<tr>
<td>PS shape</td>
<td>Phloem shape in intermediate</td>
</tr>
<tr>
<td>PS chloroplasts</td>
<td>Phloem shape in small</td>
</tr>
<tr>
<td>PCR chloroplasts</td>
<td># phloem in large</td>
</tr>
<tr>
<td>PCR chloroplasts arrangement</td>
<td># phloem in intermediate</td>
</tr>
<tr>
<td># rows vascular bundles</td>
<td># phloem in small</td>
</tr>
<tr>
<td>Adaxial row consists</td>
<td>Stomata raised or sunk</td>
</tr>
<tr>
<td>Abaxial row consists</td>
<td>Stomata lignified, where</td>
</tr>
<tr>
<td>Central row consists</td>
<td>Stomatal cavity size (µm)</td>
</tr>
<tr>
<td>Tannin cell arrangement</td>
<td>Trichomes present, where</td>
</tr>
<tr>
<td>Hypodermis size adaxially (cells)</td>
<td>Trichome shape</td>
</tr>
<tr>
<td>Hypodermis size abaxially (cells)</td>
<td>Trichome uni- or multicellular</td>
</tr>
<tr>
<td>Are there parenchyma bridges and where?</td>
<td>Trichome height (µm)</td>
</tr>
<tr>
<td>Other parenchyma presence</td>
<td>Unusual features ?</td>
</tr>
<tr>
<td>Protoxylem lacunae, and where ?</td>
<td></td>
</tr>
<tr>
<td>Characteristics of</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>--</td>
</tr>
<tr>
<td>Leaf and Bract continued</td>
<td></td>
</tr>
<tr>
<td>Xylem shape in midrib</td>
<td></td>
</tr>
<tr>
<td>Xylem shape in large</td>
<td></td>
</tr>
<tr>
<td>Xylem shape in intermediate</td>
<td></td>
</tr>
<tr>
<td>Xylem shape in small</td>
<td></td>
</tr>
<tr>
<td>Xylem shape in marginal</td>
<td></td>
</tr>
<tr>
<td># xylem in midrib</td>
<td></td>
</tr>
<tr>
<td># xylem in large</td>
<td></td>
</tr>
<tr>
<td># xylem in intermediate</td>
<td></td>
</tr>
<tr>
<td># xylem in small</td>
<td></td>
</tr>
<tr>
<td># xylem in marginal</td>
<td></td>
</tr>
<tr>
<td>Phloem shape in midrib</td>
<td></td>
</tr>
<tr>
<td>Phloem shape in large</td>
<td></td>
</tr>
<tr>
<td>Phloem shape in intermediate</td>
<td></td>
</tr>
<tr>
<td>Phloem shape in small</td>
<td></td>
</tr>
<tr>
<td>Phloem shape in marginal</td>
<td></td>
</tr>
<tr>
<td># phloem in midrib</td>
<td></td>
</tr>
<tr>
<td># phloem in large</td>
<td></td>
</tr>
<tr>
<td># phloem in intermediate</td>
<td></td>
</tr>
<tr>
<td># phloem in small</td>
<td></td>
</tr>
<tr>
<td># phloem in marginal</td>
<td></td>
</tr>
<tr>
<td>Thickness of lamina (µm)</td>
<td></td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td></td>
</tr>
<tr>
<td>Stomata raised or sunk</td>
<td></td>
</tr>
<tr>
<td>Stomata lignified, where</td>
<td></td>
</tr>
<tr>
<td>Stomatal cavity height (µm)</td>
<td></td>
</tr>
<tr>
<td>Trichomes present, where ?</td>
<td></td>
</tr>
<tr>
<td>Trichome shape</td>
<td></td>
</tr>
<tr>
<td>Trichomes uni- or multicellular</td>
<td></td>
</tr>
<tr>
<td>Trichome height (µm)</td>
<td></td>
</tr>
<tr>
<td>Silica cells, where ?</td>
<td></td>
</tr>
<tr>
<td>Unusual features?</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (MS) mestome sheath; (PS) parenchymatous sheath and (SS) Sclerenchymatous strands.
Appendix 3: Tables of anatomical characteristics

This appendix records the specific characteristics of the leaves, bracts and culms of the specimens investigated (defined in the materials and methods section). The measurements reflected are the means and standard error of the mean (Student T-test means and standard errors). The tables reflected here are referred to in the text of the chapter result sections.
Table 1: Anatomical characteristics of the leaves of *Abildgaardia*.

<table>
<thead>
<tr>
<th>Genus</th>
<th><em>Abildgaardia</em></th>
<th><em>Balbostylis</em></th>
<th><em>Fimbrystylis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. ovata</td>
<td>B. contexta</td>
<td>B. hispidula</td>
</tr>
<tr>
<td>Mean thickness of leaf (µm)</td>
<td>146±21</td>
<td>124±31</td>
<td>157±8</td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>151</td>
<td>151</td>
<td>151</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>38±4</td>
<td>36±4</td>
<td>19±5</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>16±3</td>
<td>18±10</td>
<td>15±2</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>31±1</td>
<td>9±1</td>
<td>-</td>
</tr>
<tr>
<td># HSS at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td># HSS at midrib (abaxial)</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>HSS # adaxially</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>HSS # abaxially</td>
<td>11</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Mean HSS height adaxially (µm)</td>
<td>17±3</td>
<td>11±1</td>
<td>14±1</td>
</tr>
<tr>
<td>Mean HSS height abaxially (µm)</td>
<td>22±2</td>
<td>18±4</td>
<td>19±2</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>1-3</td>
<td>0-2</td>
<td>1-3</td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VB spacing</td>
<td>1-2</td>
<td>1-</td>
<td>1-2</td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
</tr>
<tr>
<td># large VB</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># intermediate VB</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td># small VB</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number(s); (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (VB) vascular bundles.
Table 2: Anatomical characteristics of the bracts of the *Abildgaardieae*.

<table>
<thead>
<tr>
<th>Genera</th>
<th><em>Abildgaardia</em></th>
<th><em>Bulbostylis</em></th>
<th><em>Fimbristylis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. ovata</td>
<td>B. contexta</td>
<td>B. humilis</td>
</tr>
<tr>
<td>Characters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean thickness of bract (µm)</td>
<td>87±1</td>
<td>84±18</td>
<td>322±91</td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>97</td>
<td>87</td>
<td>330</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>16±2</td>
<td>17±2</td>
<td>7±2</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>9±2</td>
<td>8±3</td>
<td>10±3</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>11±3</td>
<td>34±11</td>
<td>23±1</td>
</tr>
<tr>
<td># HSS at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># HSS at midrib (abaxial)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HSS # adaxially</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>HSS # abaxially</td>
<td>4</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>Mean HSS height adaxially (µm)</td>
<td>13±3</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Mean HSS height abaxially (µm)</td>
<td>11±1</td>
<td>9±2</td>
<td>12±3</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>-</td>
<td>34±11</td>
<td>-</td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>1</td>
<td>1</td>
<td>3-7</td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>VB spacing</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
</tr>
<tr>
<td># large VB</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># Intermediate VB</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td># small VB</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number(s); (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (VB) vascular bundles.
### Table 3: Anatomical characteristics of the culms of the Abildgaardieae.

<table>
<thead>
<tr>
<th>Genera</th>
<th>Abildgaardia</th>
<th>Bulboystis</th>
<th>Fimbrystylis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. ovata</td>
<td>B. contexta</td>
<td>B. hispiduala</td>
</tr>
<tr>
<td>Mean culm height (µm)</td>
<td>601±10</td>
<td>687±10</td>
<td>400±164</td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>11±2</td>
<td>9±1</td>
<td>14±4</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>-</td>
<td>20±7</td>
<td>45±1</td>
</tr>
<tr>
<td># HSS</td>
<td>22</td>
<td>23</td>
<td>12</td>
</tr>
<tr>
<td>Mean HSS height (µm)</td>
<td>22±2</td>
<td>37±13</td>
<td>20±9</td>
</tr>
<tr>
<td>Mean height outer cavities (µm)</td>
<td>-</td>
<td>43</td>
<td>-</td>
</tr>
<tr>
<td>Mean height inner cavities (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rows or arrangement of VB’s</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td># large VB’s</td>
<td>5</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td># intermediate VB’s</td>
<td>17</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td># small VB’s</td>
<td>0</td>
<td>53</td>
<td>5</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number(s); (HSS) hypodermal sclerenchymatous strands; (VB) vascular bundle.
### Table 4: Anatomical characteristics of the leaves of the *Cariceae*

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th>C. aethiopica</th>
<th>C. glomerabilis</th>
<th>C. mossii</th>
<th>C. zuluensis</th>
<th>S. bracteosum</th>
<th>S. lehmannii</th>
<th>S. rufum</th>
<th>S. schweikerdtii</th>
<th>S. sparteum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean thickness of leaf (µm)</td>
<td>207±73</td>
<td>97±25</td>
<td>123±31</td>
<td>133±31</td>
<td>98±16</td>
<td>85±22</td>
<td>97±83</td>
<td>148±44</td>
<td>75±13</td>
</tr>
<tr>
<td></td>
<td>Midrib thickness (µm)</td>
<td>284</td>
<td>130</td>
<td>387</td>
<td>284</td>
<td>97</td>
<td>130</td>
<td>162</td>
<td>195</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>Mean adaxial epidermis height (µm)</td>
<td>47±10</td>
<td>20±11</td>
<td>15±7</td>
<td>33±16</td>
<td>23±8</td>
<td>29±14</td>
<td>21±3</td>
<td>17±5</td>
<td>18±5</td>
</tr>
<tr>
<td></td>
<td>Mean abaxial epidermis height (µm)</td>
<td>13±3</td>
<td>7±2</td>
<td>13±4</td>
<td>11±4</td>
<td>11±2</td>
<td>11±3</td>
<td>11±1</td>
<td>12±3</td>
<td>9±2</td>
</tr>
<tr>
<td></td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>11±2</td>
<td>9±5</td>
<td>4±2</td>
<td>12±5</td>
<td>10±4</td>
<td>20±5</td>
<td>11±2</td>
<td>4±1</td>
<td>6±1</td>
</tr>
<tr>
<td></td>
<td># HSS/girder at midrib (adaxial)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td># HSS/girder at midrib (abaxial)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>HSS/girder # adaxially</td>
<td>28</td>
<td>11</td>
<td>32</td>
<td>20</td>
<td>9</td>
<td>6</td>
<td>25</td>
<td>44</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>HSS/girder # abaxially</td>
<td>37</td>
<td>10</td>
<td>26</td>
<td>17</td>
<td>8</td>
<td>8</td>
<td>21</td>
<td>41</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>44±18</td>
<td>18±10</td>
<td>45±15</td>
<td>38±16</td>
<td>25±9</td>
<td>20±15</td>
<td>44±21</td>
<td>46±9</td>
<td>13±3</td>
</tr>
<tr>
<td></td>
<td>Mean HSS/girder height abaxially (µm)</td>
<td>44±28</td>
<td>14±5</td>
<td>17±7</td>
<td>23±14</td>
<td>20±4</td>
<td>13±2</td>
<td>31±3</td>
<td>53±13</td>
<td>9±4</td>
</tr>
<tr>
<td></td>
<td>Mean lamina cavities height (µm)</td>
<td>88±29</td>
<td>35±14</td>
<td>75±32</td>
<td>48±14</td>
<td>66±34</td>
<td>20±5</td>
<td>99±34</td>
<td>81±31</td>
<td>37±16</td>
</tr>
<tr>
<td></td>
<td>Hypodermis adaxially</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1 in midrib</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td># rows VB</td>
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<td>1</td>
<td>1</td>
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<td></td>
<td>VB spacing</td>
<td>6-10</td>
<td>7-11</td>
<td>6-10</td>
<td>5-11</td>
<td>8-10</td>
<td>5-13</td>
<td>7-11</td>
<td>12</td>
<td>6-10</td>
</tr>
<tr>
<td></td>
<td># small between L &amp; I</td>
<td>1</td>
<td>no pattern</td>
<td>1</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
</tr>
<tr>
<td></td>
<td># large VB</td>
<td>19</td>
<td>4</td>
<td>12</td>
<td>12</td>
<td>6</td>
<td>4</td>
<td>18</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td># Intermediate VB</td>
<td>12</td>
<td>6</td>
<td>22</td>
<td>9</td>
<td>7</td>
<td>6</td>
<td>12</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td># small VB</td>
<td>16</td>
<td>7</td>
<td>7</td>
<td>9</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number(s); (HSS) hypodermal sclerenchymatous strands or girders; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
Table 5: Anatomical characteristics of the bracts of the *Cariceae*.

<table>
<thead>
<tr>
<th>Genera</th>
<th>Carex</th>
<th>Schoenoxiphium</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mean thickness of bract (µm)</strong></td>
<td>C. aethiopica</td>
<td>156±42</td>
</tr>
<tr>
<td></td>
<td>C. glomerabilis</td>
<td>60±14</td>
</tr>
<tr>
<td></td>
<td>C. mossii</td>
<td>136±36</td>
</tr>
<tr>
<td></td>
<td>C. zuluensis</td>
<td>55±6</td>
</tr>
<tr>
<td><strong>Midrib thickness (µm)</strong></td>
<td>344</td>
<td>141</td>
</tr>
<tr>
<td><strong>Mean adaxial epidermis height (µm)</strong></td>
<td>14±3</td>
<td>12±4</td>
</tr>
<tr>
<td><strong>Mean abaxial epidermis height (µm)</strong></td>
<td>14±2</td>
<td>10±3</td>
</tr>
<tr>
<td><strong>Mean sub-stomatal cavity height (µm)</strong></td>
<td>9±2</td>
<td>26±10</td>
</tr>
<tr>
<td><strong># HSS/girders at midrib (adaxial)</strong></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong># HSS/girders at midrib (abaxial)</strong></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>HSS/girder # adaxially</strong></td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td><strong>HSS/girder # abaxially</strong></td>
<td>25</td>
<td>5</td>
</tr>
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<td><strong>Mean HSS/girder height adaxially (µm)</strong></td>
<td>43±9</td>
<td>15</td>
</tr>
<tr>
<td><strong>Mean HSS/girder height abaxially (µm)</strong></td>
<td>29±23</td>
<td>10±3</td>
</tr>
<tr>
<td><strong>Mean lamina cavities height (µm)</strong></td>
<td>65±19</td>
<td>26±10</td>
</tr>
<tr>
<td><strong>Hypodermis adaxially</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Hypodermis abaxially</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong># rows VB</strong></td>
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</tr>
<tr>
<td><strong>VB spacing</strong></td>
<td>4-8</td>
<td>6-14</td>
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<tr>
<td><strong># small between L &amp; I</strong></td>
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<td>no pattern</td>
</tr>
<tr>
<td><strong># large VB</strong></td>
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<td>2</td>
</tr>
<tr>
<td><strong># intermediate VB</strong></td>
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<td>1</td>
</tr>
<tr>
<td><strong># small VB</strong></td>
<td>13</td>
<td>1</td>
</tr>
</tbody>
</table>

Symbols: (#) number; (HSS) hypodermal sclerenchymatous strand; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle.
### Table 6: Anatomical characteristics of the culms of the *Cariceae*.

<table>
<thead>
<tr>
<th>Characters</th>
<th><em>Carex</em></th>
<th><em>Schoenoxiphium</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>C. aethiopica</em></td>
<td><em>S. bracteosum</em></td>
</tr>
<tr>
<td>Mean culm height (µm)</td>
<td>2019±282</td>
<td>168±8</td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>12±5</td>
<td>7±1</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>9±2</td>
<td>10±2</td>
</tr>
<tr>
<td># HSS/girders</td>
<td>35</td>
<td>10</td>
</tr>
<tr>
<td>Mean HSS/girders height (µm)</td>
<td>122±28</td>
<td>10±4</td>
</tr>
<tr>
<td>Mean outer cavity height (µm)</td>
<td>73±17</td>
<td>-</td>
</tr>
<tr>
<td>Mean inner cavity height (µm)</td>
<td>856±133</td>
<td>-</td>
</tr>
<tr>
<td>Rows of VB</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td># large VB</td>
<td>61</td>
<td>19</td>
</tr>
<tr>
<td># Intermediate VB</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td># small VB</td>
<td>16</td>
<td>3</td>
</tr>
</tbody>
</table>

|                                  | *C. glomerabilis*            | *S. lehmannii*                 |
|                                  | 487±52                       | 819±150                       |
|                                  | 1720±112                     | 1248±80                       |
|                                  | 555±530                      | 2367±259                      |
| Mean epidermis height (µm)       | 9±1                          | 10±1                          |
| Mean sub-stomatal cavity height (µm) | 10±2                        | 7±1                           |
| # HSS/girders                    | 12                           | 26                            |
| Mean HSS/girders height (µm)     | 28±16                        | 30±9                          |
| Mean outer cavity height (µm)    | 29±12                        | 55±13                         |
| Mean inner cavity height (µm)    | 108±53                       | 76±19                         |
| Rows of VB                       | 1                            | 55                            |
| # large VB                       | 6                            | 21                            |
| # Intermediate VB                | 6                            | 24                            |
| # small VB                       | 18                           | 57                            |

|                                  | *C. mossii*                  | *S. rufum*                     |
|                                  | 10±1                         | 7±1                           |
| Mean epidermis height (µm)       | 10±1                         | 7±1                           |
| Mean sub-stomatal cavity height (µm) | 5±2                          | 8±5                           |
| # HSS/girders                    | 22                           | 38                            |
| Mean HSS/girders height (µm)     | 34±16                        | 39                            |
| Mean outer cavity height (µm)    | 108±53                       | 127±15                        |
| Mean inner cavity height (µm)    | 114±114                      | 124±14                        |
| Rows of VB                       | 2                            | 215±10                        |
| # large VB                       | 4                            | -                             |
| # Intermediate VB                | 4                            | -                             |
| # small VB                       | 7                            | -                             |

|                                  | *C. zuluensis*               | *S. schweikerdtii*             |
|                                  | 555±530                      | 8±5                           |
| Mean epidermis height (µm)       | 9±2                          | 10±2                          |
| Mean sub-stomatal cavity height (µm) | 5±2                          | 7±1                           |
| # HSS/girders                    | 43                           | 38                            |
| Mean HSS/girders height (µm)     | 34±16                        | 39                            |
| Mean outer cavity height (µm)    | 108±53                       | 127±15                        |
| Mean inner cavity height (µm)    | 114±114                      | 124±14                        |
| Rows of VB                       | 3                            | 215±10                        |
| # large VB                       | 2                            | -                             |
| # Intermediate VB                | 2                            | -                             |
| # small VB                       | 7                            | -                             |

|                                  | *S. sparteum*                |                                |
|                                  | 544±25                       |                                |
| Mean epidermis height (µm)       | 8±2                          |                                |
| Mean sub-stomatal cavity height (µm) | 7±1                          |                                |
| # HSS/girders                    | 11                           |                                |
| Mean HSS/girders height (µm)     | 11                           |                                |
| Mean outer cavity height (µm)    | -                            |                                |
| Mean inner cavity height (µm)    | -                            |                                |
| Rows of VB                       | -                            |                                |
| # large VB                       | -                            |                                |
| # Intermediate VB                | -                            |                                |
| # small VB                       | -                            |                                |

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (VB) vascular bundle(s).
## Table 7: Anatomical characteristics for the leaves of the C₃ Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Ascolepis</th>
<th>C. denudatus</th>
<th>C. difformis</th>
<th>C. pulcher</th>
<th>C. sphaerospermus</th>
<th>C. tennellus var. tennellus</th>
<th>C. textilis</th>
<th>Pycreus P. mundii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characters</td>
<td>A. capensis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Mean thickness of leaf (µm)</td>
<td>118±19</td>
<td>99±26</td>
<td>224±56</td>
<td>143±30</td>
<td>204±48</td>
<td>79±11</td>
<td>107±33</td>
<td>160±22</td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>130</td>
<td>151</td>
<td>284</td>
<td>389</td>
<td>284</td>
<td>87</td>
<td>144</td>
<td>284</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>42±3</td>
<td>26±21</td>
<td>20±8</td>
<td>38±1</td>
<td>74±24</td>
<td>10±6</td>
<td>17±2</td>
<td>40±12</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>8±1</td>
<td>9±2</td>
<td>11±2</td>
<td>20±2</td>
<td>13±4</td>
<td>7±2</td>
<td>9±3</td>
<td>11±4</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>9±3</td>
<td>8±4</td>
<td>16±4</td>
<td>15±5</td>
<td>9±2</td>
<td>13±3</td>
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<td>11±3</td>
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<tr>
<td># HSS/girder at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># HSS/girder at midrib (abaxial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
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<td>HSS/girder # adaxially</td>
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<td>8</td>
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<td>HSS/girder # abaxially</td>
<td>9</td>
<td>10</td>
<td>17</td>
<td>18</td>
<td>12</td>
<td>4</td>
<td>32</td>
<td>16</td>
</tr>
<tr>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>23±1</td>
<td>18±4</td>
<td>15±5</td>
<td>36±1</td>
<td>21±3</td>
<td>8±2</td>
<td>39±10</td>
<td>18±1</td>
</tr>
<tr>
<td>Mean HSS/girder height abaxially (µm)</td>
<td>11±2</td>
<td>18±4</td>
<td>14±3</td>
<td>20±2</td>
<td>17±2</td>
<td>13±3</td>
<td>38±11</td>
<td>14±4</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>45±14</td>
<td>36±14</td>
<td>188±57</td>
<td>86±20</td>
<td>86±40</td>
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<td>-</td>
<td>54±22</td>
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<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>1</td>
</tr>
<tr>
<td>VB spacing</td>
<td>3-10</td>
<td>6-10</td>
<td>15-21</td>
<td>5-7</td>
<td>12-18</td>
<td>2</td>
<td>3-5</td>
<td>6-14</td>
</tr>
<tr>
<td># small VB between L &amp; I</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>1</td>
<td>no pattern</td>
</tr>
<tr>
<td># large VB</td>
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<td>11</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td># Intermediate VB</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>11</td>
<td>2</td>
<td>0</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td># small VB</td>
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<td>8</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>30</td>
<td>2</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (VB) vascular bundle(s).
Table 8A: Anatomical characteristics for the leaves of the C₄ species of *Cyperus* genus of the *Cypereae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th>C. albostratius</th>
<th>C. distans</th>
<th>C. esculentus</th>
<th>C. fastigiatus</th>
<th>Cyperus</th>
<th>C. immensis</th>
<th>C. laevigatus</th>
<th>C. natalensis</th>
<th>C. obtusiflorus</th>
<th>C. rubicundus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean thickness of lamina (µm)</td>
<td>154±55</td>
<td>133±25</td>
<td>167±21</td>
<td>143±54</td>
<td>366±182</td>
<td>172±10</td>
<td>190±25</td>
<td>158±30</td>
<td>170±10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Midrib thickness (µm)</td>
<td>216</td>
<td>227</td>
<td>269</td>
<td>276±8</td>
<td>515</td>
<td>515</td>
<td>184</td>
<td>173</td>
<td>281</td>
<td></td>
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<tr>
<td></td>
<td>Mean adaxial epidermis height (µm)</td>
<td>8±4</td>
<td>11±4</td>
<td>40±14</td>
<td>23±19</td>
<td>46±44</td>
<td>20±6</td>
<td>20±5</td>
<td>14±9</td>
<td>53±18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean abaxial epidermis height (µm)</td>
<td>9±3</td>
<td>7±5</td>
<td>11±2</td>
<td>8±3</td>
<td>11±1</td>
<td>15±2</td>
<td>11±1</td>
<td>9±2</td>
<td>18±3</td>
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</tr>
<tr>
<td></td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>72±19</td>
<td>8±2</td>
<td>63±20</td>
<td>4±2</td>
<td>3±3</td>
<td>7±6</td>
<td>9±5</td>
<td>21±2</td>
<td>18±7</td>
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<td># HSS/girder at midrib (adaxial)</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td># HSS/girder at midrib (abaxial)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td></td>
<td>HSS/girder # adaxially</td>
<td>16</td>
<td>13</td>
<td>8</td>
<td>19</td>
<td>53</td>
<td>0</td>
<td>6</td>
<td>24</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HSS/girder # abaxially</td>
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<td>31</td>
<td>42</td>
<td>45</td>
<td>70</td>
<td>21</td>
<td>31</td>
<td>61</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>8±4</td>
<td>13±3</td>
<td>32±6</td>
<td>15±9</td>
<td>20±7</td>
<td>-</td>
<td>41±9</td>
<td>18±10</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean HSS/girder height abaxially (µm)</td>
<td>11±2</td>
<td>14±6</td>
<td>16±4</td>
<td>17±9</td>
<td>19±3</td>
<td>15±1</td>
<td>17±4</td>
<td>21±4</td>
<td>20±6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean lamina cavities height (µm)</td>
<td>72±19</td>
<td>42±21</td>
<td>63±20</td>
<td>61±44</td>
<td>197±127</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
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<td>2-4</td>
<td>-</td>
<td>1</td>
<td>1-3</td>
<td>-</td>
<td>1-3</td>
<td>2-4</td>
<td>1-3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td># rows VB</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>VB spacing</td>
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<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td># small VB between L &amp; I</td>
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<td>1-3</td>
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<td>2-4</td>
<td>1</td>
<td></td>
</tr>
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<td></td>
<td># large VB</td>
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<td>8</td>
<td>10</td>
<td>14</td>
<td>21</td>
<td>2</td>
<td>4</td>
<td>9</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td># intermediate VB</td>
<td>10</td>
<td>24</td>
<td>8</td>
<td>30</td>
<td>28</td>
<td>0</td>
<td>6</td>
<td>7</td>
<td>10</td>
<td></td>
</tr>
<tr>
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<td># small VB</td>
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<td>22</td>
<td>99</td>
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<td>243</td>
<td>38</td>
<td>64</td>
<td>54</td>
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</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (VB) vascular bundle(s).
### Table 8B: Anatomical characteristics for the leaves of the C₄ species of the genera *Cyperus* (continued) and *Kyllinga* of the Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th><em>C. rupestris</em> var. <em>rupestris</em></th>
<th><em>C. semitrifidus</em> var. <em>semitrifidus</em></th>
<th><em>C. sexangularis</em></th>
<th><em>K. alta</em></th>
<th><em>K. brevifolia</em></th>
<th><em>K. elatior</em></th>
<th><em>K. erecta</em></th>
<th><em>K. pauciflora</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean thickness of leaf (µm)</td>
<td>397±81</td>
<td>249±49</td>
<td>154±36</td>
<td>123±29</td>
<td>93±10</td>
<td>140±39</td>
<td>84±24</td>
<td>86±9</td>
</tr>
<tr>
<td></td>
<td>Midrib thickness (µm)</td>
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<td>385</td>
<td>288±51</td>
<td>216</td>
<td>108</td>
<td>173</td>
<td>130</td>
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</tr>
<tr>
<td></td>
<td>Mean adaxial epidermis height (µm)</td>
<td>10±3</td>
<td>10±1</td>
<td>67±32</td>
<td>28±26</td>
<td>35±15</td>
<td>50±17</td>
<td>34±17</td>
<td>22±11</td>
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<tr>
<td></td>
<td>Mean abaxial epidermis height (µm)</td>
<td>10±2</td>
<td>10±2</td>
<td>19±3</td>
<td>12±6</td>
<td>11±2</td>
<td>9±2</td>
<td>7±2</td>
<td>6±2</td>
</tr>
<tr>
<td></td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>11±5</td>
<td>11±3</td>
<td>19±6</td>
<td>12±3</td>
<td>12±3</td>
<td>16±3</td>
<td>12±4</td>
<td>6±2</td>
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<td># HSS/girder at midrib (adaxial)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td># HSS/girder at midrib (abaxial)</td>
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<td>1</td>
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</tr>
<tr>
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<td>HSS/girder # adaxially</td>
<td>4</td>
<td>2</td>
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<td>HSS/girder # abaxially</td>
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<td>23</td>
<td>20</td>
<td>28</td>
<td>19</td>
<td>29</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>13±2</td>
<td>18±1</td>
<td>-</td>
<td>11±2</td>
<td>10±2</td>
<td>14±2</td>
<td>23±1</td>
<td>18±1</td>
</tr>
<tr>
<td></td>
<td>Mean HSS/girder height abaxially (µm)</td>
<td>13±2</td>
<td>10±2</td>
<td>19±5</td>
<td>8±1</td>
<td>9±3</td>
<td>12±6</td>
<td>8±4</td>
<td>8±4</td>
</tr>
<tr>
<td></td>
<td>Mean lamina cavities height (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Hypodermis adaxially</td>
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<td>3-9</td>
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<td>1</td>
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</tr>
<tr>
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<td>1-2</td>
<td>1</td>
<td>1-2</td>
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<td>no pattern</td>
<td>no pattern</td>
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<td>6</td>
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<td># small VB</td>
<td>32</td>
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<td>61</td>
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</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (VB) vascular bundle(s).
Table 8C: Anatomical characteristics for the leaves of the C₄ species of the genus *Mariscus* of the Cypereae.

<table>
<thead>
<tr>
<th>Genus Characters</th>
<th><em>M. albomarginatus</em></th>
<th><em>M. capensis</em></th>
<th><em>M. congestus</em></th>
<th><em>M. dubius</em></th>
<th><em>M. macrocarpus</em></th>
<th><em>M. solidus</em></th>
<th><em>M. sumatrensis</em></th>
<th><em>M. tabularis</em> subsp. major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean thickness of leaf (µm)</td>
<td>147±6</td>
<td>95±5</td>
<td>131±18</td>
<td>136±48</td>
<td>175±24</td>
<td>146±36</td>
<td>140±39</td>
<td>198±61</td>
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<td>Midrib thickness (µm)</td>
<td>284</td>
<td>119</td>
<td>173</td>
<td>173</td>
<td>173</td>
<td>184</td>
<td>141</td>
<td>162</td>
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<td>Mean adaxial epidermis height (µm)</td>
<td>55±21</td>
<td>29±10</td>
<td>33±14</td>
<td>53±24</td>
<td>64±25</td>
<td>20±10</td>
<td>55±29</td>
<td>19±17</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>14±3</td>
<td>8±3</td>
<td>10±3</td>
<td>9±1</td>
<td>11±3</td>
<td>5±2</td>
<td>11±4</td>
<td>10±2</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>26±15</td>
<td>5±2</td>
<td>10±2</td>
<td>10±4</td>
<td>15±5</td>
<td>6±2</td>
<td>34±12</td>
<td>2±2</td>
</tr>
<tr>
<td>Number of HSS/girder at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>2</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>69</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>HSS/girder # adaxially</td>
<td>19</td>
<td>17</td>
<td>28</td>
<td>36</td>
<td>31</td>
<td>114</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>15±1</td>
<td>11±1</td>
<td>22±6</td>
<td>26±4</td>
<td>33±4</td>
<td>10±3</td>
<td>21±3</td>
<td>23±11</td>
</tr>
<tr>
<td>MEan HSS/girder height abaxially (µm)</td>
<td>10±2</td>
<td>6±1</td>
<td>10±7</td>
<td>14±3</td>
<td>10±2</td>
<td>6±2</td>
<td>11±2</td>
<td>48±28</td>
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<td>Mean lamina cavities height (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>24±10</td>
<td>29±10</td>
<td>38±16</td>
<td>70±36</td>
<td>34±12</td>
</tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>Hypodermis abaxially</td>
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<td>-</td>
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</tr>
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<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>VB spacing (adaxially)</td>
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<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
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<td>1-2</td>
</tr>
<tr>
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<td>no pattern</td>
<td>0-6</td>
<td>no pattern</td>
<td>3</td>
<td>2-4</td>
<td>no pattern</td>
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</tr>
<tr>
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<td>2</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>16</td>
<td>8</td>
<td>7</td>
</tr>
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<td># Intermediate VB</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>12</td>
<td>20</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td># small VB</td>
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<td>27</td>
<td>62</td>
<td>38</td>
<td>91</td>
<td>244</td>
<td>68</td>
<td>24</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (VB) vascular bundle(s).
Table 8D: Anatomical characteristics for the leaves of the C4 genera *Mariscus* (continued) and *Pycreus* of the Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th><em>Mariscus</em></th>
<th><em>Pycreus</em></th>
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</thead>
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<td></td>
<td></td>
<td>M. thunbergii</td>
<td>M. uitenhagensis</td>
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<td>Mean thickness of leaf (µm)</td>
<td>348±42</td>
<td>193±107</td>
</tr>
<tr>
<td></td>
<td>Midrib thickness (µm)</td>
<td>374</td>
<td>284</td>
</tr>
<tr>
<td></td>
<td>Mean adaxial epidermis height (µm)</td>
<td>8±2</td>
<td>72±29</td>
</tr>
<tr>
<td></td>
<td>Mean abaxial epidermis height (µm)</td>
<td>8±2</td>
<td>10±3</td>
</tr>
<tr>
<td></td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>7±1</td>
<td>18±9</td>
</tr>
<tr>
<td></td>
<td># HSS/girder at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td># HSS/girder at midrib (abaxial)</td>
<td>2</td>
<td>1</td>
</tr>
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<td></td>
<td>HSS/girder # adaxially</td>
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<td>1</td>
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<td></td>
<td>HSS/girder # abaxially</td>
<td>51</td>
<td>23</td>
</tr>
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<td>Mean HSS/girder height adaxially (µm)</td>
<td>27±5</td>
<td>10±1</td>
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<td>Mean HSS/girder height abaxially (µm)</td>
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<td>Mean lamina cavities height (µm)</td>
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<td>1 in Midrib</td>
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<td>Hypodermis abaxially</td>
<td>0-2</td>
<td>-</td>
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<td>VB spacing (adaxial)</td>
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<td>1-2</td>
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<td>no pattern</td>
</tr>
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<td>37</td>
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</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (VB) vascular bundle(s).
Table 9: Anatomical characteristics of the bracts of the C₃ Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Ascolepis</th>
<th>C. albostriatus</th>
<th>C. denudatus</th>
<th>C. differmis</th>
<th>Cyperus</th>
<th>C. pulcher</th>
<th>C. sphaerospermus</th>
<th>C. tennellus var. tennellus</th>
<th>C. textilis</th>
<th>P. mundii</th>
</tr>
</thead>
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<td></td>
<td></td>
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<td></td>
</tr>
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<td>Mean thickness of bract (µm)</td>
<td>99±37</td>
<td>73±15</td>
<td>687±10</td>
<td>194±28</td>
<td>153±19</td>
<td>155±39</td>
<td>156±6</td>
<td>130</td>
<td>156±49</td>
<td>169±16</td>
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<td>Midrib thickness (µm)</td>
<td>130</td>
<td>171</td>
<td>749</td>
<td>472</td>
<td>184</td>
<td>390</td>
<td>344</td>
<td>151</td>
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<td>284</td>
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<td>Mean adaxial epidermis height (µm)</td>
<td>34±4</td>
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<td>31±16</td>
<td>25±15</td>
<td>36±13</td>
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<td>14±3</td>
<td>12±2</td>
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<td>13±3</td>
<td>7±2</td>
<td>13±3</td>
<td>14±4</td>
</tr>
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<td>Mean sub-stomatal cavity height (µm)</td>
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<td>16±3</td>
<td>17±2</td>
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<td>4±3</td>
<td>93±40</td>
<td>9±2</td>
<td>-</td>
<td>-</td>
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<td>0</td>
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<td>0</td>
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<td>1</td>
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<td>2</td>
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<td>11</td>
<td>7</td>
<td>13</td>
<td>13</td>
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<tr>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>10±2</td>
<td>14±6</td>
<td>18±1</td>
<td>23±5</td>
<td>25±7</td>
<td>21±3</td>
<td>11±1</td>
<td>7±1</td>
<td>32±10</td>
<td>18±1</td>
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<td>14±3</td>
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<td>25±8</td>
<td>19±9</td>
<td>12±3</td>
<td>7±2</td>
<td>23±14</td>
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<td>Mean lamina cavities height (µm)</td>
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<td>259±195</td>
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<td>93±40</td>
<td>42±4</td>
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<td>2</td>
<td>8</td>
<td>3</td>
<td>20</td>
<td>2</td>
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<td>0</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
### Table 10A: Anatomical characteristics of the bracts of the C₄ species of the genus *Cyperus* of the *Cypereae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th>C. distans</th>
<th>C. esculentus</th>
<th>C. immensis</th>
<th>C. laevigatus</th>
<th>C. longus var. tenuiflorus</th>
<th>C. natalensis</th>
<th>C. obtusiflorus</th>
<th>C. rubicundus var. rupestris</th>
<th>C. rupestris var. rupestris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean thickness of bract (µm)</td>
<td></td>
<td>151±45</td>
<td>64±11</td>
<td>206±109</td>
<td>344±10</td>
<td>172±20</td>
<td>137±38</td>
<td>154±26</td>
<td>82±33</td>
<td>201±36</td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td></td>
<td>216</td>
<td>195</td>
<td>387</td>
<td>515</td>
<td>162</td>
<td>173</td>
<td>195</td>
<td>216</td>
<td>344</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td></td>
<td>18±10</td>
<td>25±21</td>
<td>28±25</td>
<td>19±2</td>
<td>11±5</td>
<td>17±6</td>
<td>17±12</td>
<td>27±14</td>
<td>9±2</td>
</tr>
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<td>9±2</td>
<td>7±1</td>
<td>9±5</td>
<td>15±1</td>
<td>6±2</td>
<td>7±1</td>
<td>9±1</td>
<td>15±2</td>
<td>11±4</td>
</tr>
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<td>Stomatal cavity height (µm)</td>
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<td>8±1</td>
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<td>12±12</td>
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<td>12±11</td>
<td>10±8</td>
<td>10±2</td>
<td>13±4</td>
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<td>0</td>
<td>0</td>
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<td># HSS at midrib (abaxial)</td>
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<td>2</td>
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<td>18</td>
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<td>48</td>
<td>0</td>
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<td>13</td>
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<td>70</td>
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<td>7</td>
<td>29</td>
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<td>12</td>
<td>16</td>
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<td>Mean HSS height adaxially (µm)</td>
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<td>15±4</td>
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<td>37±30</td>
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<td>22±4</td>
<td>-</td>
<td>9±1</td>
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<td>Mean HSS height abaxially (µm)</td>
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<td>15±3</td>
<td>17±3</td>
<td>12±3</td>
<td>24±9</td>
<td>10±1</td>
<td>12±4</td>
<td>25±2</td>
<td>10±3</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
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<td>72±23</td>
<td>-</td>
<td>126±71</td>
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<td>62±19</td>
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<td>-</td>
<td>-</td>
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<td>1 in Midrib</td>
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<td>0</td>
<td>2-4</td>
<td>1-3</td>
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<td>2-6</td>
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<td>Hypodermis abaxially</td>
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<td>1-2</td>
<td>1-2</td>
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<td>1-2</td>
<td>1-2</td>
<td>1</td>
<td>1-2</td>
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<td>no pattern</td>
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<td>8</td>
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<td>57</td>
<td>42</td>
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<td>18</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
Table 10B: Anatomical characteristics of the bracts of the C4 species of the genera *Cyperus* (continued) and *Kyllinga* of the Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th><em>C. semitrichus</em> var. <em>semitrichus</em></th>
<th><em>C. sexangularis</em></th>
<th><em>K. alata</em></th>
<th><em>K. brevifolia</em></th>
<th><em>K. elatior</em></th>
<th><em>K. erecta</em></th>
<th><em>K. pauciflora</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean thickness of bract (µm)</td>
<td>174±96</td>
<td>90±20</td>
<td>97±18</td>
<td>85±11</td>
<td>93±20</td>
<td>67±25</td>
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<td>Midrib thickness (µm)</td>
<td>216</td>
<td>176</td>
<td>205</td>
<td>97</td>
<td>195</td>
<td>87</td>
<td>130</td>
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<td>Mean adaxial epidermis height (µm)</td>
<td>8±6</td>
<td>28±17</td>
<td>26±17</td>
<td>29±9</td>
<td>36±18</td>
<td>22±12</td>
<td>24±13</td>
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<td>Mean abaxial epidermis height (µm)</td>
<td>10±3</td>
<td>13±2</td>
<td>9±2</td>
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<td>12±4</td>
<td>6±2</td>
<td>6±2</td>
</tr>
<tr>
<td></td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>15±5</td>
<td>11±5</td>
<td>9±1</td>
<td>9±5</td>
<td>23±11</td>
<td>4±1</td>
<td>5±1</td>
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<td>2</td>
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<td>2</td>
</tr>
<tr>
<td></td>
<td># HSS at midrib (abaxial)</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
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<td>1</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
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<td>HSS abaxially</td>
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<td>1</td>
<td>21</td>
<td>20</td>
<td>28</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Mean HSS height adaxially (µm)</td>
<td>18±1</td>
<td>-</td>
<td>14±3</td>
<td>11±1</td>
<td>11±2</td>
<td>10±2</td>
<td>21±3</td>
</tr>
<tr>
<td></td>
<td>Mean HSS height abaxially (µm)</td>
<td>14±3</td>
<td>14±3</td>
<td>7±3</td>
<td>11±2</td>
<td>8±1</td>
<td>7±2</td>
<td>7±2</td>
</tr>
<tr>
<td></td>
<td>Mean lamina cavities height (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>Hypodermis adaxially</td>
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<td>0-2</td>
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<td>0</td>
<td>0</td>
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<td>1</td>
<td>1</td>
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<td>VB spacing</td>
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<td>1-2</td>
<td>1</td>
<td>1</td>
<td>1-2</td>
<td>1-2</td>
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<td># small VB between L &amp; I</td>
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<td>-</td>
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<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>3</td>
</tr>
<tr>
<td></td>
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<td>3</td>
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<td>4</td>
<td>1</td>
<td>2</td>
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<tr>
<td></td>
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<td>3</td>
<td>5</td>
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<td>4</td>
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<td># small VB</td>
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<td>18</td>
<td>28</td>
<td>32</td>
<td>56</td>
<td>15</td>
<td>26</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
Table 10C: Anatomical characteristics of the bracts of the C4 species of the genus *Mariscus* of the Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th>M. albomarginatus</th>
<th>M. capensis</th>
<th>M. congestus</th>
<th>M. dubius</th>
<th>M. macrocarpus</th>
<th>M. solidus</th>
<th>M. sumatrensis</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Mean thickness of bract (µm)</td>
<td>105±17</td>
<td>88±11</td>
<td>131±17</td>
<td>113±21</td>
<td>115±20</td>
<td>184±32</td>
<td>108±36</td>
</tr>
<tr>
<td></td>
<td>Midrib thickness (µm)</td>
<td>195</td>
<td>130</td>
<td>173</td>
<td>195</td>
<td>129</td>
<td>270</td>
<td>162</td>
</tr>
<tr>
<td></td>
<td>Mean adaxial epidermis height (µm)</td>
<td>29±17</td>
<td>25±12</td>
<td>40±10</td>
<td>49±22</td>
<td>36±14</td>
<td>15±10</td>
<td>51±22</td>
</tr>
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<td>Mean abaxial epidermis height (µm)</td>
<td>10±1</td>
<td>9±2</td>
<td>11±2</td>
<td>10±3</td>
<td>9±3</td>
<td>6±2</td>
<td>10±3</td>
</tr>
<tr>
<td></td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>7±2</td>
<td>3±2</td>
<td>29±10</td>
<td>15±5</td>
<td>31±13</td>
<td>9±5</td>
<td>34±11</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td># HSS at midrib (abaxial)</td>
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<td>2</td>
<td>2</td>
<td>2</td>
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<td>2</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>66</td>
<td>3</td>
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<tr>
<td></td>
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<td>11</td>
<td>35</td>
<td>30</td>
<td>28</td>
<td>104</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Mean HSS height adaxially (µm)</td>
<td>13±3</td>
<td>8±2</td>
<td>22±6</td>
<td>13±3</td>
<td>21±3</td>
<td>14±2</td>
<td>15±1</td>
</tr>
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<td></td>
<td>Mean HSS height abaxially (µm)</td>
<td>8±1</td>
<td>6±3</td>
<td>11±6</td>
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</tr>
<tr>
<td></td>
<td>Mean lamina cavities height (µm)</td>
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<td>-</td>
<td>31±13</td>
<td>69±23</td>
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<td>VB spacing</td>
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<td>1-2</td>
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<td>no pattern</td>
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<td>2-4</td>
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<td></td>
<td># large VB</td>
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<td>8</td>
<td>4</td>
<td>6</td>
<td>11</td>
<td>4</td>
</tr>
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<td># intermediate VB</td>
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<td>12</td>
<td>4</td>
<td>2</td>
<td>25</td>
<td>6</td>
</tr>
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<td># small VB</td>
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<td>16</td>
<td>68</td>
<td>48</td>
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<td>228</td>
<td>66</td>
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</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
Table 10D: Anatomical characteristics of the bracts of the C₄ species of the genera *Mariscus* (continued) and *Pycreus* of the Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th><em>M. tabularis</em> subsp. major</th>
<th><em>M. thunbergii</em></th>
<th><em>M. uitenhagensis</em></th>
<th><em>P. cooperi</em></th>
<th><em>P. intactus</em></th>
<th><em>P. maracanthus</em></th>
<th><em>P. nitidus</em></th>
<th><em>P. polystachyos</em> var. polystachyos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean thickness of bract (µm)</td>
<td>153±23</td>
<td>398±112</td>
<td>222±74</td>
<td>165±50</td>
<td>115±19</td>
<td>201±123</td>
<td>159±25</td>
<td>122±22</td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>173</td>
<td>387</td>
<td>344</td>
<td>344</td>
<td>195</td>
<td>344</td>
<td>238</td>
<td>141</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>22±8</td>
<td>12±4</td>
<td>82±36</td>
<td>8±2</td>
<td>53±12</td>
<td>10±5</td>
<td>12±8</td>
<td>37±16</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>6±2</td>
<td>9±2</td>
<td>9±3</td>
<td>9±2</td>
<td>8±2</td>
<td>5±2</td>
<td>8±4</td>
<td>9±3</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>2±1</td>
<td>6±1</td>
<td>22±12</td>
<td>12±6</td>
<td>9±1</td>
<td>10±4</td>
<td>17±7</td>
<td>12±5</td>
</tr>
<tr>
<td># HSS at midrib (adxial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># HSS at midrib (abaxial)</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>HSS # adaxially</td>
<td>28</td>
<td>40</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td>34</td>
<td>2</td>
</tr>
<tr>
<td>HSS # abaxially</td>
<td>28</td>
<td>66</td>
<td>20</td>
<td>42</td>
<td>29</td>
<td>19</td>
<td>56</td>
<td>32</td>
</tr>
<tr>
<td>Mean HSS height adaxially (µm)</td>
<td>30±11</td>
<td>30±7</td>
<td>10±1</td>
<td>11±4</td>
<td>22±6</td>
<td>15±7</td>
<td>13±6</td>
<td>33±4</td>
</tr>
<tr>
<td>Mean HSS height abaxially (µm)</td>
<td>37±15</td>
<td>18±6</td>
<td>10±2</td>
<td>11±4</td>
<td>10±5</td>
<td>8±4</td>
<td>8±6</td>
<td>12±4</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>59±17</td>
<td>178±62</td>
<td>-</td>
<td>50±18</td>
<td>-</td>
<td>76±30</td>
<td>54±23</td>
<td>-</td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>1-3</td>
<td>3-5</td>
<td>1 in Midrib</td>
<td>3-5</td>
<td>0</td>
<td>2-4</td>
<td>2-4</td>
<td>1</td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># rows VB</td>
<td>41</td>
<td>271</td>
<td>38</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>VB spacing</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
<td>1-2</td>
</tr>
<tr>
<td># small VB between L &amp; I</td>
<td>14</td>
<td>105</td>
<td>8</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>2-4</td>
</tr>
<tr>
<td># large VB</td>
<td>1-3</td>
<td>1-3</td>
<td>2-4</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td># Intermediate VB</td>
<td>1-3</td>
<td>no pattern</td>
<td>no pattern</td>
<td>18</td>
<td>6</td>
<td>8</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td># small VB</td>
<td>5</td>
<td>25</td>
<td>4</td>
<td>30</td>
<td>43</td>
<td>12</td>
<td>47</td>
<td>51</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
Table 11: Anatomical characteristics of the culms of the C₃ Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th>Ascolepis A. capensis</th>
<th>C. albostratus</th>
<th>C. denudatus</th>
<th>C. difformis</th>
<th>C. marginatus</th>
<th>C. pulcher</th>
<th>C. sphaerospermus</th>
<th>C. tennellus var. tennellus</th>
<th>C. textilis</th>
<th>Pycreus P. mundii</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean culm height (µm)</td>
<td>718±135</td>
<td>578±10</td>
<td>646±80</td>
<td>1'054±179</td>
<td>4'309±80</td>
<td>694±10</td>
<td>151±10</td>
<td>151±11</td>
<td>2'311±100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean epidermis height (µm)</td>
<td>13±4</td>
<td>13±6</td>
<td>8±1</td>
<td>13±3</td>
<td>10±1</td>
<td>12±3</td>
<td>7±1</td>
<td>5±2</td>
<td>6±1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>20±8</td>
<td>15±1</td>
<td>-</td>
<td>10±2</td>
<td>-</td>
<td>23±5</td>
<td>13±2</td>
<td>11±1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td># HSS/girders</td>
<td>17</td>
<td>45</td>
<td>89</td>
<td>29</td>
<td>390</td>
<td>34</td>
<td>31</td>
<td>9</td>
<td>213</td>
</tr>
<tr>
<td>Mean HSS/girder height (µm)</td>
<td>38±10</td>
<td>38±8</td>
<td>15±6</td>
<td>17±4</td>
<td>26±8</td>
<td>18±6</td>
<td>16±1</td>
<td>8±1</td>
<td>35±16</td>
<td>28±3</td>
<td></td>
</tr>
<tr>
<td>Mean height of cavities (µm) outer</td>
<td>123±25</td>
<td>73±44</td>
<td>-</td>
<td>-</td>
<td>106±43</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>?</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td># large VB's</td>
<td>12</td>
<td>26</td>
<td>20</td>
<td>20</td>
<td>206</td>
<td>36</td>
<td>6</td>
<td>2</td>
<td>49</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td># intermediate VB's</td>
<td>16</td>
<td>16</td>
<td>15</td>
<td>3</td>
<td>119</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>102</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td># small VB's</td>
<td>20</td>
<td>0</td>
<td>19</td>
<td>8</td>
<td>86</td>
<td>5</td>
<td>37</td>
<td>0</td>
<td>10</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Symbols are as follows: (?) scattered arrangement of vascular bundles; (#) number; (HSS) hypodermal sclerenchymatous strands; (VB) vascular bundle.
Table 12A: Anatomical characteristics of the culms of the C₄ species of the genus *Cyperus* of the *Cypereae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>C. distans</th>
<th>C. esculentus</th>
<th>C. immensis</th>
<th>C. laevigatus</th>
<th>C. longus var. tenuiflorus</th>
<th>C. natalensis</th>
<th>C. obtusiflorus</th>
<th>C. rubicundus</th>
<th>C. rupestris var. rupestris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean culm height (µm)</td>
<td>953±101</td>
<td>1'663±93</td>
<td>4'905±429</td>
<td>1'040±100</td>
<td>1'550±66</td>
<td>920±22</td>
<td>1'285±65</td>
<td>856±10</td>
<td>807±97</td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>7±2</td>
<td>6±3</td>
<td>11±4</td>
<td>12±3</td>
<td>8±2</td>
<td>7±1</td>
<td>7±1</td>
<td>12±3</td>
<td>10±1</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>10±3</td>
<td>8±4</td>
<td>18±5</td>
<td>10±3</td>
<td>-</td>
<td>4±3</td>
<td>12±6</td>
<td>13±2</td>
<td>13±1</td>
</tr>
<tr>
<td># HSS</td>
<td>58</td>
<td>74</td>
<td>312</td>
<td>46</td>
<td>130</td>
<td>41</td>
<td>62</td>
<td>18</td>
<td>41</td>
</tr>
<tr>
<td>Mean HSS height (µm)</td>
<td>17±1</td>
<td>17±2</td>
<td>25±4</td>
<td>13±2</td>
<td>13±3</td>
<td>31±15</td>
<td>55±20</td>
<td>29±6</td>
<td>17±3</td>
</tr>
<tr>
<td>Mean height of cavities (µm) outer</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean height of cavities (µm) centre</td>
<td>-</td>
<td>230±171</td>
<td>41±11</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># rows VB</td>
<td>4</td>
<td>4</td>
<td>?</td>
<td>?</td>
<td>4</td>
<td>?</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td># large VB’s</td>
<td>16</td>
<td>40</td>
<td>71</td>
<td>12</td>
<td>20</td>
<td>19</td>
<td>37</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td># intermediate VB’s</td>
<td>7</td>
<td>50</td>
<td>129</td>
<td>5</td>
<td>32</td>
<td>11</td>
<td>12</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td># small VB’s</td>
<td>71</td>
<td>93</td>
<td>229</td>
<td>53</td>
<td>125</td>
<td>77</td>
<td>77</td>
<td>31</td>
<td>55</td>
</tr>
</tbody>
</table>

Symbols are as follows: (?) scattered arrangement of vascular bundles; (#) number; (HSS) hypodermal sclerenchymatous strands; (VB) vascular bundle.
### Table 12B: Anatomical characteristics of the culms of the C₄ species of the genera *Cyperus* (continued) and *Kyllinga* of the Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th><em>C. semitridifus</em> var. semitridifus</th>
<th><em>C. sexangularis</em></th>
<th><em>K. alata</em></th>
<th><em>K. brevifolia</em></th>
<th><em>K. elatior</em></th>
<th><em>K. erecta</em></th>
<th><em>K. pauciflora</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>_</td>
<td>Mean culm height (µm)</td>
<td>610±19</td>
<td>1'792±540</td>
<td>74±95</td>
<td>623±159</td>
<td>1'399±155</td>
<td>351±18</td>
<td>623±71</td>
</tr>
<tr>
<td>_</td>
<td>Mean epidermis height (µm)</td>
<td>8±2</td>
<td>9±2</td>
<td>12±4</td>
<td>9±2</td>
<td>11±4</td>
<td>6±1</td>
<td>6±2</td>
</tr>
<tr>
<td>_</td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>14±3</td>
<td>11±2</td>
<td>7±2</td>
<td>-</td>
<td>11±3</td>
<td>5±2</td>
<td>9±2</td>
</tr>
<tr>
<td>_</td>
<td># HSS</td>
<td>25</td>
<td>82</td>
<td>27</td>
<td>27</td>
<td>67</td>
<td>21</td>
<td>27</td>
</tr>
<tr>
<td>_</td>
<td>Mean HSS height (µm)</td>
<td>18±3</td>
<td>37±20</td>
<td>23±5</td>
<td>15±3</td>
<td>27±1</td>
<td>10±4</td>
<td>17±12</td>
</tr>
<tr>
<td>_</td>
<td>Mean height of cavities (µm) outer</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>_</td>
<td>Mean height of cavities (µm) centre</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>249±27</td>
<td>117±37</td>
<td>139±19</td>
<td>339±39</td>
</tr>
<tr>
<td>_</td>
<td># rows VB</td>
<td>2</td>
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<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>_</td>
<td># large VB's</td>
<td>8</td>
<td>38</td>
<td>15</td>
<td>11</td>
<td>13</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>_</td>
<td># intermediate VB's</td>
<td>1</td>
<td>42</td>
<td>6</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>_</td>
<td># small VB's</td>
<td>29</td>
<td>11</td>
<td>54</td>
<td>48</td>
<td>104</td>
<td>29</td>
<td>25</td>
</tr>
</tbody>
</table>

Symbols are as follows: (?) scattered arrangement of vascular bundles; (#) number; (HSS) hypodermal sclerenchymatous strands; (VB) vascular bundle.
Table 12C: Anatomical characteristics of the culms of the C4 species of the genus *Mariscus* of the *Cypereae*.

<table>
<thead>
<tr>
<th>Genus Characters</th>
<th><em>M. albomarginatus</em></th>
<th><em>M. capensis</em></th>
<th><em>M. congestus</em></th>
<th><em>Mariscus</em></th>
<th><em>M. dubius</em></th>
<th><em>M. macrocarpus</em></th>
<th><em>M. solidus</em></th>
<th><em>M. sumatrensis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean culm height (µm)</td>
<td>581±22</td>
<td>764±110</td>
<td>1'267±85</td>
<td>1'323±171</td>
<td>1'633±129</td>
<td>3'204±163</td>
<td>1'153±85</td>
<td></td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>9±1</td>
<td>8±2</td>
<td>8±2</td>
<td>7±3</td>
<td>10±2</td>
<td>8±2</td>
<td>11±2</td>
<td></td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>9±1</td>
<td>9±3</td>
<td>7±2</td>
<td>13±4</td>
<td>-</td>
<td>8±3</td>
<td>11±2</td>
<td></td>
</tr>
<tr>
<td># HSS</td>
<td>25</td>
<td>31</td>
<td>60</td>
<td>53</td>
<td>77</td>
<td>148</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Mean HSS height (µm)</td>
<td>33±11</td>
<td>13±4</td>
<td>19±5</td>
<td>31±4</td>
<td>38±8</td>
<td>42±14</td>
<td>28±9</td>
<td></td>
</tr>
<tr>
<td># rows VB</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td># large VB’s</td>
<td>9</td>
<td>12</td>
<td>29</td>
<td>20</td>
<td>64</td>
<td>178</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td># intermediate VB’s</td>
<td>3</td>
<td>7</td>
<td>27</td>
<td>6</td>
<td>13</td>
<td>151</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td># small VB’s</td>
<td>37</td>
<td>46</td>
<td>71</td>
<td>97</td>
<td>145</td>
<td>228</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td># S 1’s</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>16</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td># S 2’s</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (S) solenostele; (VB) vascular bundle.
### Table 12D: Anatomical characteristics of the culms of the C₄ species of the genera *Mariscus* (continued) and *Pycreus* of the Cypereae.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th><em>M. tabularis</em> subsp. major</th>
<th><em>Mariscus</em> M. thunbergii</th>
<th><em>M.uitenhagensis</em></th>
<th><em>P. cooperi</em></th>
<th><em>P. intactus</em></th>
<th><em>Pycreus</em> P. maracanthus</th>
<th><em>P. nitidus</em></th>
<th><em>P. polystachyos</em> var. polystachyos</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean culm height (µm)</td>
<td>1'096±185</td>
<td>3’168±112</td>
<td>1’059±59</td>
<td>881±65</td>
<td>1’173±132</td>
<td>659±22</td>
<td>1’361±72</td>
<td>1’021±72</td>
</tr>
<tr>
<td></td>
<td>Mean epidermis height (µm)</td>
<td>8±1</td>
<td>7±2</td>
<td>7±2</td>
<td>16±5</td>
<td>9±1</td>
<td>6±2</td>
<td>8±3</td>
<td>8±1</td>
</tr>
<tr>
<td></td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>9±4</td>
<td>3±2</td>
<td>24±2</td>
<td>26±9</td>
<td>7±2</td>
<td>6±3</td>
<td>15±14</td>
<td>11±3</td>
</tr>
<tr>
<td></td>
<td># HSS</td>
<td>67</td>
<td>126</td>
<td>49</td>
<td>41</td>
<td>48</td>
<td>32</td>
<td>45</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Mean HSS height (µm)</td>
<td>29±13</td>
<td>33±9</td>
<td>28±7</td>
<td>55±18</td>
<td>42±12</td>
<td>11±4</td>
<td>45±22</td>
<td>29±4</td>
</tr>
<tr>
<td></td>
<td>Mean height of cavities (µm) outer</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mean height of cavities (µm) centre</td>
<td>62±21</td>
<td>103±48</td>
<td>-</td>
<td>88±36</td>
<td>126±76</td>
<td>384±22</td>
<td>68±23</td>
<td>115±68</td>
</tr>
<tr>
<td></td>
<td># rows VB</td>
<td>4</td>
<td>11</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td># large VB’s</td>
<td>26</td>
<td>133</td>
<td>24</td>
<td>17</td>
<td>25</td>
<td>8</td>
<td>36</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td># intermediate VB’s</td>
<td>38</td>
<td>211</td>
<td>10</td>
<td>29</td>
<td>19</td>
<td>16</td>
<td>53</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td># small VB’s</td>
<td>58</td>
<td>346</td>
<td>75</td>
<td>52</td>
<td>82</td>
<td>29</td>
<td>3</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td># S 1’s</td>
<td>-</td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td># S 2’s</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (S) solenostele; (VB) vascular bundle.
Table 13: Anatomical characteristics of the leaves of the *Rhynchospora*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Rhynchospora</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R. barrosiana</td>
<td>R. brownii</td>
<td></td>
</tr>
<tr>
<td>Thickness of lamina (µm)</td>
<td>145±21</td>
<td>144±26</td>
<td></td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>205</td>
<td>151</td>
<td></td>
</tr>
<tr>
<td>Adaxial epidermis height (µm)</td>
<td>52±16</td>
<td>29±11</td>
<td></td>
</tr>
<tr>
<td>Abaxial epidermis height (µm)</td>
<td>12±4</td>
<td>7±1</td>
<td></td>
</tr>
<tr>
<td>Stomatal cavity height (µm)</td>
<td>13±5</td>
<td>8±2</td>
<td></td>
</tr>
<tr>
<td># HSS/girder at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td># HSS/girder at midrib (abaxial)</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>HSS/girders # adaxially</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>HSS/girders # abaxially</td>
<td>27</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>HSS/girder height adaxially (µm)</td>
<td>35±8</td>
<td>27±1</td>
<td></td>
</tr>
<tr>
<td>HSS/girder height abaxially (µm)</td>
<td>13±5</td>
<td>10±1</td>
<td></td>
</tr>
<tr>
<td>Lamina cavities height (µm)</td>
<td>-</td>
<td>69±10</td>
<td></td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>1-3</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>VB spacing</td>
<td>0-1</td>
<td>3-11</td>
<td></td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>no pattern</td>
<td></td>
</tr>
<tr>
<td># large VB</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td># intermediate VB</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td># small VB</td>
<td>5</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Symbols were as follows: (#) number; (HSS) hypodermal sclerenchymatous strands or girders; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
### Table 14: Anatomical characteristics of the bracts of the *Rhyncosporeae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Rhynchospora</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>R. barrosiana</em></td>
<td><em>R. brownii</em></td>
<td></td>
</tr>
<tr>
<td>Characters</td>
<td>R. barrosiana</td>
<td>R. brownii</td>
<td></td>
</tr>
<tr>
<td>Thickness of lamina (µm)</td>
<td>106±28</td>
<td>153±22</td>
<td></td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>173</td>
<td>151</td>
<td></td>
</tr>
<tr>
<td>Adaxial epidermis height (µm)</td>
<td>20±12</td>
<td>34±5</td>
<td></td>
</tr>
<tr>
<td>Abaxial epidermis height (µm)</td>
<td>10±3</td>
<td>10±3</td>
<td></td>
</tr>
<tr>
<td>Stomatal cavity height (µm)</td>
<td>17±4</td>
<td>8±3</td>
<td></td>
</tr>
<tr>
<td># HSS/girders at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td># HSS/girders at midrib (abaxial)</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>HSS/girders # adaxially</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>HSS/girders # abaxially</td>
<td>25</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>HSS/girders height adaxially (µm)</td>
<td>27±10</td>
<td>30±1</td>
<td></td>
</tr>
<tr>
<td>HSS/girders height abaxially (µm)</td>
<td>17±4</td>
<td>15±3</td>
<td></td>
</tr>
<tr>
<td>Lamina cavities height (µm)</td>
<td>-</td>
<td>63±13</td>
<td></td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>1-2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>VB spacing</td>
<td>0-1</td>
<td>4-8</td>
<td></td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>no pattern</td>
<td></td>
</tr>
<tr>
<td># large VB</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td># Intermediate VB</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td># small VB</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Symbols were as follows: (#) number; (HSS) hypodermal sclerenchymatous strands or girders; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
Table 15: Anatomical characteristics of the culms of the *Rhynchospora*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th><em>Rhynchospora</em></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><em>R. barrosiana</em></td>
<td><em>R. brownii</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean culm height (µm)</td>
<td>1172±173</td>
<td>487±25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Epidermal height (µm)</td>
<td>7±4</td>
<td>10±1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stomatal cavity height (µm)</td>
<td>10±6</td>
<td>7±2</td>
<td></td>
</tr>
<tr>
<td></td>
<td># HSS</td>
<td>49</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HSS height (µm)</td>
<td>40±17</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Height of cavity (µm)</td>
<td>122±73</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td># rows</td>
<td>6</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td># large bundles</td>
<td>22</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td># intermediate bundles</td>
<td>23</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td># small bundles</td>
<td>100</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

Symbols were as follows: (#) number; (HSS) hypodermal sclerenchymatous strands.
Table 16: Anatomical characteristics of the leaves of the *Schoeneae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Carpha</th>
<th>Cladium</th>
<th>Cyathocoma</th>
<th>Schoenus</th>
<th>Tetraria</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. bracteosa</em></td>
<td>C. glomerata</td>
<td>C. schlechteri</td>
<td><em>C. mariscus subsp. jamaicense</em></td>
<td><em>C. hexandra</em></td>
<td><em>S. nigricans</em></td>
</tr>
<tr>
<td>Mean thickness of leaf (µm)</td>
<td>537±91</td>
<td>399±118</td>
<td>241±71</td>
<td>528±211</td>
<td>409±66</td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>859</td>
<td>773</td>
<td>515</td>
<td>472</td>
<td>no midrib</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>14±5</td>
<td>16±3</td>
<td>15±4</td>
<td>8±1</td>
<td>33±9</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>8</td>
<td>8±1</td>
<td>10±4</td>
<td>13±2</td>
<td>17±4</td>
</tr>
<tr>
<td>Stomatal cavity height (µm)</td>
<td>8</td>
<td>4±2</td>
<td>13±2</td>
<td>2±2</td>
<td>15±4</td>
</tr>
<tr>
<td># HSS/girders at midrib (adaxial)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>no midrib</td>
</tr>
<tr>
<td># HSS/girders at midrib (abaxial)</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>1</td>
<td>no midrib</td>
</tr>
<tr>
<td>HSS/girders # adaxially</td>
<td>18</td>
<td>106</td>
<td>174</td>
<td>42</td>
<td>5</td>
</tr>
<tr>
<td>HSS/girders # abaxially</td>
<td>84</td>
<td>136</td>
<td>161</td>
<td>137</td>
<td>19</td>
</tr>
<tr>
<td>Mean HSS/girders height adaxially (µm)</td>
<td>20±3</td>
<td>10±2</td>
<td>16±4</td>
<td>25±11</td>
<td>73±29</td>
</tr>
<tr>
<td>Mean HSS/girders height abaxially (µm)</td>
<td>19±4</td>
<td>14±2</td>
<td>17±2</td>
<td>28±13</td>
<td>83±14</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>374±177</td>
<td>337±57</td>
<td>86±14</td>
<td>409±122</td>
<td>125±31</td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>-</td>
<td>2-4</td>
<td>1 in midrib</td>
<td>-</td>
<td>3-5</td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>VB spacing</td>
<td>8-12</td>
<td>8-14</td>
<td>6-8</td>
<td>5-9</td>
<td>4-6</td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>no pattern</td>
</tr>
<tr>
<td># large VB</td>
<td>10</td>
<td>27</td>
<td>12</td>
<td>37</td>
<td>13</td>
</tr>
<tr>
<td># intermediate VB</td>
<td>18</td>
<td>14</td>
<td>14</td>
<td>63</td>
<td>6</td>
</tr>
<tr>
<td># small VB</td>
<td>3</td>
<td>42</td>
<td>22</td>
<td>52</td>
<td>6</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (VB) vascular bundle(s).
Table 17: Anatomical characteristics of the bracts of the *Schoeneae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Carpha</th>
<th>Cladium</th>
<th>Cyathocoma</th>
<th>Schoenus</th>
<th>Tetraria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean thickness of bract ($\mu$m)</td>
<td>387±127</td>
<td>205±28</td>
<td>213±35</td>
<td>511±197</td>
<td>369±24</td>
</tr>
<tr>
<td>Midrib thickness ($\mu$m)</td>
<td>730</td>
<td>515</td>
<td>387</td>
<td>558</td>
<td>no midrib</td>
</tr>
<tr>
<td>Mean adaxial epidermis height ($\mu$m)</td>
<td>10±5</td>
<td>15±1</td>
<td>11±3</td>
<td>9±2</td>
<td>17±3</td>
</tr>
<tr>
<td>Mean abaxial epidermis height ($\mu$m)</td>
<td>8±2</td>
<td>11±1</td>
<td>8±3</td>
<td>12±2</td>
<td>15±3</td>
</tr>
<tr>
<td>Stomatal cavity height ($\mu$m)</td>
<td>2±2</td>
<td>11±6</td>
<td>15±2</td>
<td>1±1</td>
<td>13±3</td>
</tr>
<tr>
<td># HSS/girders at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>no midrib</td>
</tr>
<tr>
<td># HSS/girders at midrib (abaxial)</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>1</td>
<td>no midrib</td>
</tr>
<tr>
<td>HSS/girders # adaxially</td>
<td>12</td>
<td>48</td>
<td>35</td>
<td>114</td>
<td>5</td>
</tr>
<tr>
<td>HSS/girders # abaxially</td>
<td>58</td>
<td>47</td>
<td>92</td>
<td>66</td>
<td>19</td>
</tr>
<tr>
<td>Mean HSS/girders height adaxially ($\mu$m)</td>
<td>26±4</td>
<td>13±4</td>
<td>10±2</td>
<td>37±14</td>
<td>108±39</td>
</tr>
<tr>
<td>Mean HSS/girders height abaxially ($\mu$m)</td>
<td>16±3</td>
<td>13±2</td>
<td>16±3</td>
<td>32±13</td>
<td>76±17</td>
</tr>
<tr>
<td>Mean lamina cavities height ($\mu$m)</td>
<td>303±115</td>
<td>114±20</td>
<td>58±16</td>
<td>223±119</td>
<td>114±10</td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>-</td>
<td>-</td>
<td>1 in midrib</td>
<td>3-7 in midrib</td>
<td>3-5</td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>VB spacing</td>
<td>8-16</td>
<td>6-10</td>
<td>6-8</td>
<td>5-9</td>
<td>2-4</td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>no pattern</td>
</tr>
<tr>
<td># large VB</td>
<td>8</td>
<td>20</td>
<td>11</td>
<td>32</td>
<td>11</td>
</tr>
<tr>
<td># Intermediate VB</td>
<td>14</td>
<td>20</td>
<td>9</td>
<td>64</td>
<td>7</td>
</tr>
<tr>
<td># small VB</td>
<td>7</td>
<td>16</td>
<td>14</td>
<td>42</td>
<td>6</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundles; (L) large bundles; (VB) vascular bundle(s).
Table 18: Anatomical characteristics of the culms of the *Schoeneae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Carpha</th>
<th>Cladium</th>
<th>Cyathocoma</th>
<th>Schoenus</th>
<th>Tetraria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characters</td>
<td>C. bracteosa</td>
<td>C. glomerata</td>
<td>C. schlechteri</td>
<td>C. mariscus subsp. jamaicense</td>
<td>C. hexandra</td>
</tr>
<tr>
<td>Mean culm height (µm)</td>
<td>1'021</td>
<td>2'884±769</td>
<td>1'304±401</td>
<td>2'112±312</td>
<td>1'645±241</td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>6±1</td>
<td>10±1</td>
<td>8±1</td>
<td>10±2</td>
<td>13±2</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>3±3</td>
<td>8±3</td>
<td>7±2</td>
<td>1±1</td>
<td>14±6</td>
</tr>
<tr>
<td># HSS/girders</td>
<td>55</td>
<td>201</td>
<td>58</td>
<td>69</td>
<td>26</td>
</tr>
<tr>
<td>Mean HSS/girders height (µm)</td>
<td>26±4</td>
<td>54±34</td>
<td>53±13</td>
<td>25±11</td>
<td>139±17</td>
</tr>
<tr>
<td>Mean height of outer cavities (µm)</td>
<td>130±29</td>
<td>147±51</td>
<td>55±30</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean height of central cavities (µm)</td>
<td>314±43</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rows or arrangement of VB's</td>
<td>2</td>
<td>?</td>
<td>3</td>
<td>7</td>
<td>2, then ?</td>
</tr>
<tr>
<td># large VB's</td>
<td>15</td>
<td>159</td>
<td>31</td>
<td>138</td>
<td>71</td>
</tr>
<tr>
<td># intermediate VB's</td>
<td>11</td>
<td>49</td>
<td>8</td>
<td>36</td>
<td>18</td>
</tr>
<tr>
<td># small VB's</td>
<td>9</td>
<td>29</td>
<td>18</td>
<td>36</td>
<td>9</td>
</tr>
</tbody>
</table>

Symbols are as follows: (?) scattered arrangement of vascular bundles; (#) number; (HSS) hypodermal sclerenchymatous strands; (VB) vascular bundle(s).
Table 19A: Anatomical characteristics of the leaves of the genera *Bolboschoenus* and *Ficinia* of the *Scirpeae*.

<table>
<thead>
<tr>
<th>Genera</th>
<th><em>B. maritimus</em></th>
<th><em>B. arenicola var. arenicola</em></th>
<th><em>F. bulbosa</em></th>
<th><em>F. cinnamomea</em></th>
<th><em>F. dura</em></th>
<th><em>F. fascicularis</em></th>
<th><em>F. filiformis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean thickness of leaf (µm)</td>
<td>466±111</td>
<td>133±115</td>
<td>223±56</td>
<td>284±10</td>
<td>314±43</td>
<td>135±41</td>
<td>157±23</td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>773</td>
<td>246</td>
<td>269</td>
<td>344</td>
<td>215</td>
<td>184</td>
<td>184</td>
</tr>
<tr>
<td>Mean trichome length (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>22±14</td>
<td>14±2</td>
<td>11±3</td>
<td>20±12</td>
<td>16±2</td>
<td>25±12</td>
<td>12±6</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>12±2</td>
<td>12±2</td>
<td>6±1</td>
<td>9±2</td>
<td>8±1</td>
<td>9±1</td>
<td>8±2</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>25±8</td>
<td>19±4</td>
<td>28±9</td>
<td>26±5</td>
<td>19±5</td>
<td>18±4</td>
<td>13±4</td>
</tr>
<tr>
<td># HSS/girders at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td># HSS/girders at midrib (abaxial)</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HSS/girder # adaxially</td>
<td>27</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>HSS/girder # abaxially</td>
<td>37</td>
<td>13</td>
<td>15</td>
<td>10</td>
<td>18</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>23±4</td>
<td>33±3</td>
<td>24±6</td>
<td>28±1</td>
<td>26±4</td>
<td>17±2</td>
<td>11±4</td>
</tr>
<tr>
<td>Mean HSS/girder height abaxially (µm)</td>
<td>19±3</td>
<td>31±5</td>
<td>18±4</td>
<td>27±8</td>
<td>18±1</td>
<td>20±3</td>
<td>12±3</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>150±52</td>
<td>-</td>
<td>-</td>
<td>40±5</td>
<td>-</td>
<td>108±10</td>
<td>63±12</td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
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<td>1-5</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VB spacing</td>
<td>5-15</td>
<td>1-5</td>
<td>2-4</td>
<td>4-8</td>
<td>1-3</td>
<td>9-11</td>
<td>6</td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># large VB</td>
<td>16</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># Intermediate VB</td>
<td>18</td>
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<td>4</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># small VB</td>
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<td>0</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
### Table 19B: Anatomical characteristics of the leaves of the genus *Ficinia* (continued) of the *Scirpeae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Characters</th>
<th><em>F. indica</em> var. indica</th>
<th><em>F. lateralis</em> (coastal)</th>
<th><em>F. lateralis</em> (inland)</th>
<th><em>F. pinguior</em></th>
<th><em>F. stolonifera</em></th>
<th><em>F. tenuifolia</em></th>
<th><em>F. tribracteata</em></th>
<th><em>F. zeyheri</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean thickness of leaf (µm)</td>
<td>376±102</td>
<td>184±15</td>
<td>187±25</td>
<td>172±10</td>
<td>108±31</td>
<td>177±50</td>
<td>284±10</td>
<td>205±46</td>
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</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>-</td>
<td>216</td>
<td>284</td>
<td>284</td>
<td>184</td>
<td>344</td>
<td>344</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>Mean trichome length (µm)</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>19±1</td>
<td>17±11</td>
<td>33±12</td>
<td>9±3</td>
<td>18±10</td>
<td>26±16</td>
<td>13±5</td>
<td>12±1</td>
<td></td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>15±2</td>
<td>14±5</td>
<td>13±2</td>
<td>7±3</td>
<td>8±1</td>
<td>12±3</td>
<td>9±2</td>
<td>10±1</td>
<td></td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>21±10</td>
<td>19±5</td>
<td>37±5</td>
<td>15±11</td>
<td>9±3</td>
<td>26±9</td>
<td>20±3</td>
<td>18±4</td>
<td></td>
</tr>
<tr>
<td># HSS/girders at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td># HSS/girders at midrib (abaxial)</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>HSS/girder # adaxially</td>
<td>8</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>HSS/girder # abaxially</td>
<td>24</td>
<td>6</td>
<td>8</td>
<td>11</td>
<td>10</td>
<td>9</td>
<td>11</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>33±5</td>
<td>26±11</td>
<td>30±1</td>
<td>12±2</td>
<td>33±5</td>
<td>32±4</td>
<td>33±3</td>
<td>20±2</td>
<td></td>
</tr>
<tr>
<td>Mean HSS/girder height abaxially (µm)</td>
<td>26±8</td>
<td>26±6</td>
<td>20±3</td>
<td>14±1</td>
<td>20±5</td>
<td>34±4</td>
<td>26±5</td>
<td>23±1</td>
<td></td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>48±22</td>
<td>-</td>
<td>106±22</td>
<td>66±10</td>
<td>-</td>
<td>44±11</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2 in midrib</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>VB spacing</td>
<td>3-5</td>
<td>0-2</td>
<td>5-9</td>
<td>2-6</td>
<td>2-4</td>
<td>4-6</td>
<td>1-3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td># large VB</td>
<td>7</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td># Intermediate VB</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td># small VB</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 19C: Anatomical characteristics of the leaves of the genera *Fuirena* and *Isolepis* of the Scirpeae.

<table>
<thead>
<tr>
<th>Genera</th>
<th><em>F. coerulescens</em></th>
<th><em>F. hirsuta</em></th>
<th><em>F. pachyrrhiza</em></th>
<th><em>I. cernua</em></th>
<th><em>I. costata var. macra</em></th>
<th><em>I. diabolica</em></th>
<th><em>I. fluitans</em></th>
<th><em>I. natans</em></th>
<th><em>I. prolifera</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean thickness of leaf (µm)</td>
<td>210±6</td>
<td>333±30</td>
<td>185±16</td>
<td>223±56</td>
<td>168±23</td>
<td>173</td>
<td>101±6</td>
<td>54</td>
<td>110±40</td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>205</td>
<td>215</td>
<td>284</td>
<td>215</td>
<td>173</td>
<td>284</td>
<td>-</td>
<td>108</td>
<td>173</td>
</tr>
<tr>
<td>Mean trichome length (µm)</td>
<td>12±2</td>
<td>215±10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>44±12</td>
<td>17±16</td>
<td>47±17</td>
<td>36±16</td>
<td>6±2</td>
<td>23±1</td>
<td>11±4</td>
<td>14±6</td>
<td>43±28</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>12±4</td>
<td>27±1</td>
<td>13±2</td>
<td>20±4</td>
<td>5±2</td>
<td>10±1</td>
<td>8±4</td>
<td>7±2</td>
<td>11±2</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>14±5</td>
<td>40±13</td>
<td>25±7</td>
<td>33±13</td>
<td>11±4</td>
<td>19±7</td>
<td>15±1</td>
<td>11±7</td>
<td>17±4</td>
</tr>
<tr>
<td># HSS/girders at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># HSS/girders at midrib (abaxial)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>HSS/girder # adaxially</td>
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<td>2</td>
<td>14</td>
<td>0</td>
<td>8</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>HSS/girder # abaxially</td>
<td>9</td>
<td>16</td>
<td>16</td>
<td>0</td>
<td>28</td>
<td>12</td>
<td>8</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>23±8</td>
<td>17±7</td>
<td>24±2</td>
<td>-</td>
<td>9±1</td>
<td>15±3</td>
<td>18±1</td>
<td>9±1</td>
<td>-</td>
</tr>
<tr>
<td>Mean HSS/girder height abaxially (µm)</td>
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<td>-</td>
<td>11±2</td>
<td>15±1</td>
<td>10±2</td>
<td>8±1</td>
<td>29±5</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>53±20</td>
<td>92±27</td>
<td>78±16</td>
<td>-</td>
<td>100±50</td>
<td>54±13</td>
<td>41</td>
<td>43±3</td>
<td>40±11</td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># rows VB</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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</tr>
<tr>
<td>VB spacing</td>
<td>3-7</td>
<td>6-10</td>
<td>5-9</td>
<td>2-4</td>
<td>5-9</td>
<td>2-6</td>
<td>6-18</td>
<td>6-8</td>
<td>6-12</td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>1, sometimes</td>
<td>no pattern</td>
<td>1, sometimes</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
</tr>
<tr>
<td># large VB</td>
<td>7</td>
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<tr>
<td># Intermediate VB</td>
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<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
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</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 19D: Anatomical characteristics of the leaves of the genera *Schoenoplectus* and *Scirpus* of the *Scirpeae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th><em>Schoenoplectus</em></th>
<th><em>Scirpus</em></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S. paludicola</td>
<td>S. falsus</td>
<td>S. ficinoides</td>
<td>S. nodosus</td>
</tr>
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<td>Mean thickness of leaf (µm)</td>
<td>601±121</td>
<td>220±112</td>
<td>205±40</td>
<td>154±89</td>
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<tr>
<td>Midrib thickness (µm)</td>
<td>-</td>
<td>344</td>
<td>216</td>
<td>-</td>
</tr>
<tr>
<td>Mean trichome length (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>10±3</td>
<td>9±2</td>
<td>13±2</td>
<td>12±3</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>-</td>
<td>10±2</td>
<td>11±1</td>
<td>15±5</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>10±4</td>
<td>6±4</td>
<td>-</td>
<td>26±14</td>
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<tr>
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<td>0</td>
<td>0</td>
</tr>
<tr>
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<td>2</td>
<td>0</td>
</tr>
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<td>HSS/girder # adaxially</td>
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<td>3</td>
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</tr>
<tr>
<td>HSS/girder # abaxially</td>
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<td>29</td>
<td>56</td>
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<td>Mean HSS/girder height adaxially (µm)</td>
<td>30±1</td>
<td>17±2</td>
<td>27±9</td>
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<td>Mean HSS/girder height abaxially (µm)</td>
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<td>26±10</td>
<td>42±8</td>
<td>29±7</td>
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<td>Mean lamina cavities height (µm)</td>
<td>472±61</td>
<td>77±27</td>
<td>61±22</td>
<td>86±20</td>
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<td>Hypodermis adaxially</td>
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<td>-</td>
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<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
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<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>VB spacing</td>
<td>3-7</td>
<td>6-10</td>
<td>3-9</td>
<td>3-7</td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>-</td>
<td>no pattern</td>
<td>no pattern</td>
</tr>
<tr>
<td># large VB</td>
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<td>6</td>
<td>9</td>
</tr>
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<td># Intermediate VB</td>
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<td>4</td>
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<tr>
<td># small VB</td>
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<td>15</td>
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</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 20A: Anatomical characteristics of the bracts of the genera *Bolboschoenus* and *Ficinia* of the Scirpeae.

<table>
<thead>
<tr>
<th>Genera</th>
<th><em>Bolboschoenus</em></th>
<th><em>Ficinia</em></th>
<th><em>F. arenicola var. arenicola</em></th>
<th><em>F. cinnamomea</em></th>
<th><em>F. dura</em></th>
<th><em>F. fascicularis</em></th>
<th><em>F. filiformis</em></th>
<th><em>F. indica var. indica</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B. maritimus</td>
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<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Mean thickness of bract (µm)</td>
<td>171±56</td>
<td>304±35</td>
<td>284±27</td>
<td>178±8</td>
<td>108±10</td>
<td>108±10</td>
<td>173±31</td>
<td></td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>195</td>
<td>284</td>
<td>344</td>
<td>284</td>
<td>173</td>
<td>162</td>
<td>87</td>
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<tr>
<td>Mean trichome length (µm)</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>14±5</td>
<td>16±8</td>
<td>20±10</td>
<td>23±1</td>
<td>9±6</td>
<td>15±5</td>
<td>18±1</td>
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</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>11±4</td>
<td>11±2</td>
<td>9±3</td>
<td>9±1</td>
<td>8±3</td>
<td>8±2</td>
<td>11±1</td>
<td></td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>16±5</td>
<td>9±1</td>
<td>26±11</td>
<td>21±10</td>
<td>10±7</td>
<td>15±1</td>
<td>17±4</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
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</tr>
<tr>
<td>HSS/girder # adaxially</td>
<td>14</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>13</td>
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</tr>
<tr>
<td>HSS/girder # abaxially</td>
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<td>16</td>
<td>10</td>
<td>21</td>
<td>5</td>
<td>7</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>21±5</td>
<td>23±8</td>
<td>24±2</td>
<td>24±2</td>
<td>15±1</td>
<td>15±1</td>
<td>37±1</td>
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<tr>
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<td>2±2</td>
<td>27±4</td>
<td>27±4</td>
<td>13±3</td>
<td>16±4</td>
<td>12±4</td>
<td>16±1</td>
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<td>72±13</td>
<td>62±12</td>
<td>-</td>
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<td>61±3</td>
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<td>Hypodermis abaxially</td>
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<td>-</td>
<td>-</td>
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<td>no pattern</td>
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<td>-</td>
<td>-</td>
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<td>0</td>
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</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 20B: Anatomical characteristics of the bracts of the genus *Ficinia* (continued) of the *Scirpeae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th><em>F. lateralis</em> (coastal)</th>
<th><em>F. lateralis</em> (inland)</th>
<th><em>F. oligantha</em></th>
<th><em>F. pinguior</em></th>
<th><em>F. repens</em></th>
<th><em>F. stolonifera</em></th>
<th><em>F. tribracteata</em></th>
<th><em>F. zeyheri</em></th>
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</thead>
<tbody>
<tr>
<td>Mean thickness of bract (µm)</td>
<td>195±10</td>
<td>177±36</td>
<td>84±18</td>
<td>103±8</td>
<td>114±38</td>
<td>408±30</td>
<td>234±71</td>
<td>97±10</td>
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<td>243</td>
<td>284</td>
<td>162</td>
<td>130</td>
<td>-</td>
<td>-</td>
<td>284</td>
<td>173</td>
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<td>Mean trichome length (µm)</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>9±1</td>
<td>8±2</td>
<td>16±2</td>
<td>9±3</td>
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<td>13±5</td>
<td>11±3</td>
<td>8±1</td>
<td>9±1</td>
<td>12±7</td>
<td>-</td>
<td>9±1</td>
<td>10±2</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>20±6</td>
<td>21±3</td>
<td>20±3</td>
<td>9±6</td>
<td>20±8</td>
<td>20±11</td>
<td>9±1</td>
<td>11±1</td>
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<tr>
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<td>3</td>
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<td>-</td>
<td>-</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>HSS/girders # adaxially</td>
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<td>0</td>
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<td>3</td>
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<td>13</td>
<td>7</td>
<td>4</td>
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<tr>
<td>Mean HSS/girders height adaxially (µm)</td>
<td>26±5</td>
<td>-</td>
<td>-</td>
<td>14±4</td>
<td>-</td>
<td>-</td>
<td>23±1</td>
<td>-</td>
</tr>
<tr>
<td>Mean HSS/girders height abaxially (µm)</td>
<td>25±5</td>
<td>17±2</td>
<td>12±3</td>
<td>9±1</td>
<td>14±2</td>
<td>20±4</td>
<td>15±1</td>
<td>14±6</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
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<td>no pattern</td>
<td>-</td>
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</tr>
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<td>0</td>
<td>2</td>
<td>4</td>
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</tr>
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<td># Intermediate VB</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
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<td># small VB</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 20C: Anatomical characteristics of the bracts of the genera *Fuirena* and *Isolepis* of the *Scirpeae*.

<table>
<thead>
<tr>
<th>Genera</th>
<th><em>F. coerulescens</em></th>
<th><em>F. hirsuta</em></th>
<th><em>F. pachyrhiza</em></th>
<th><em>I. cernua</em></th>
<th><em>I. costata var. macra</em></th>
<th><em>I. diabolica</em></th>
<th><em>I. natans</em></th>
<th><em>I. prolifera</em></th>
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</tr>
<tr>
<td>Mean thickness of bract (µm)</td>
<td>102±15</td>
<td>223±15</td>
<td>188±47</td>
<td>151±31</td>
<td>108±31</td>
<td>123±33</td>
<td>92±8</td>
<td>104±62</td>
</tr>
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<td>Midrib thickness (µm)</td>
<td>130</td>
<td>284</td>
<td>260</td>
<td>173</td>
<td>130</td>
<td>151</td>
<td>141</td>
<td>195</td>
</tr>
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<td>Mean trichome length (µm)</td>
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<td>119</td>
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<td>21±12</td>
<td>43±12</td>
<td>41±6</td>
<td>8±2</td>
<td>11±2</td>
<td>16±6</td>
<td>15±5</td>
<td>60±20</td>
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<td>9±1</td>
<td>25±3</td>
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<td>9±1</td>
<td>12±3</td>
<td>10±1</td>
<td>15±4</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>17±5</td>
<td>46±14</td>
<td>38±8</td>
<td>16±2</td>
<td>12±1</td>
<td>27±11</td>
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<td>17±6</td>
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<tr>
<td># HSS/girders at midrib (adaxial)</td>
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<td>0</td>
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<td>0</td>
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<td>1</td>
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<td>HSS/girders # adaxially</td>
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<td>20</td>
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<td>10</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>Mean HSS/girders height adaxially (µm)</td>
<td>26±15</td>
<td>32±6</td>
<td>32±3</td>
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<td>16±8</td>
<td>15±1</td>
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<td>Mean HSS/girders height abaxially (µm)</td>
<td>16±5</td>
<td>41±12</td>
<td>37±7</td>
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<td>12±4</td>
<td>13±2</td>
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<td>29±5</td>
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<td>Mean lamina cavities height (µm)</td>
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<td>65±18</td>
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<tr>
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<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VB spacing</td>
<td>4-6</td>
<td>3-7</td>
<td>4-8</td>
<td>2-4</td>
<td>2</td>
<td>4-6</td>
<td>3-6</td>
<td>6-10</td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>no pattern</td>
<td>1, sometimes</td>
<td>1, sometimes</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>no pattern</td>
<td>1 sometimes</td>
</tr>
<tr>
<td># large VB</td>
<td>4</td>
<td>2</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td># Intermediate VB</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td># small VB</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 20D: Anatomical characteristics of the bracts of the genera *Schoenoplectus* and *Scirpus* of the Scirpeae.

<table>
<thead>
<tr>
<th>Genus</th>
<th></th>
<th><em>S. decipiens</em></th>
<th><em>S. paludicola</em></th>
<th><em>S. falsus</em></th>
<th><em>S. ficinioides</em></th>
<th><em>S. nodosus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean thickness of bract (µm)</td>
<td>494±74</td>
<td>1248±160</td>
<td>162±15</td>
<td>179±51</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Midrib thickness (µm)</td>
<td>1021</td>
<td>-</td>
<td>344</td>
<td>358</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean trichome length (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean adaxial epidermis height (µm)</td>
<td>25±3</td>
<td>-12±1</td>
<td>15±5</td>
<td>11±1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean abaxial epidermis height (µm)</td>
<td>11±2</td>
<td>-</td>
<td>11±3</td>
<td>12±2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>10±10</td>
<td>13±5</td>
<td>6±4</td>
<td>9±6</td>
</tr>
<tr>
<td></td>
<td></td>
<td># HSS/girders at midrib (adaxial)</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td># HSS/girders at midrib (abaxial)</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HSS/girder # adaxially</td>
<td>2</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HSS/girder # abaxially</td>
<td>43</td>
<td>33</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>19±5</td>
<td>-</td>
<td>61±5</td>
<td>67±1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean HSS/girder height abaxially (µm)</td>
<td>14±1</td>
<td>29±3</td>
<td>20±4</td>
<td>40±10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mean lamina cavities height (µm)</td>
<td>-</td>
<td>408±30</td>
<td>78±27</td>
<td>66±21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hypodermis adaxially</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VB spacing</td>
<td>2-6</td>
<td>3-5</td>
<td>5-7</td>
<td>4-8</td>
</tr>
<tr>
<td></td>
<td></td>
<td># small between L &amp; I</td>
<td>1, usually</td>
<td>no pattern</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td># large VB</td>
<td>6</td>
<td>12</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td># Intermediate VB</td>
<td>7</td>
<td>16</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td># small VB</td>
<td>3</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 21A: Anatomical characteristics of the culms of the genera *Bolboschoenus*, *Eleocharis* and *Ficinia* of the Scirpeae.

<table>
<thead>
<tr>
<th>Genera</th>
<th>Bolboschoenus</th>
<th>Eleocharis</th>
<th>Ficinia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B. maritimus</td>
<td>E. dregeana</td>
<td>E. limosa</td>
</tr>
<tr>
<td>Mean culm thickness (µm)</td>
<td>1'134±100</td>
<td>146±8</td>
<td>1'361±100</td>
</tr>
<tr>
<td>Mean trichome length (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>13±2</td>
<td>10±1</td>
<td>19±7</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>14±6</td>
<td>27±4</td>
<td>68±16</td>
</tr>
<tr>
<td># HSS/girder</td>
<td>31</td>
<td>81</td>
<td>162</td>
</tr>
<tr>
<td>Mean HSS/girder height (µm)</td>
<td>55±16</td>
<td>9±1</td>
<td>26±2</td>
</tr>
<tr>
<td>Mean cavity height (µm)</td>
<td>-</td>
<td>78±12</td>
<td>204±91</td>
</tr>
<tr>
<td>Rows or arrangement of VB’s</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td># large VB’s</td>
<td>19</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td># intermediate VB’s</td>
<td>5</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td># small VB’s</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 21B: Anatomical characteristics of the culms of the genus *Ficinia* (continued) of the *Scirpeae*.

<table>
<thead>
<tr>
<th>Genus Characters</th>
<th><em>F. filiculmea</em></th>
<th><em>F. filiformis</em></th>
<th><em>F. indica</em></th>
<th><em>F. lateralis</em> (coastal)</th>
<th><em>F. lateralis</em> (inland)</th>
<th><em>F. oligantha</em></th>
<th><em>F. pinguior</em></th>
<th><em>F. repens</em></th>
<th><em>F. stolonifera</em></th>
<th><em>F. tenuifolia</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean culm height (µm)</td>
<td>378±36</td>
<td>151±92</td>
<td>859±243</td>
<td>419±15</td>
<td>687±121</td>
<td>215±10</td>
<td>344±10</td>
<td>655±118</td>
<td>374±10</td>
<td>885±193</td>
</tr>
<tr>
<td>Mean trichome length (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>17±9</td>
<td>7±2</td>
<td>8±3</td>
<td>19±3</td>
<td>10±2</td>
<td>7±2</td>
<td>7±2</td>
<td>7±3</td>
<td>8±2</td>
<td>12±2</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>29±13</td>
<td>4±3</td>
<td>14±7</td>
<td>25±5</td>
<td>25±10</td>
<td>18±1</td>
<td>9±1</td>
<td>5±1</td>
<td>14±3</td>
<td>35±9</td>
</tr>
<tr>
<td># HSS/girder</td>
<td>5</td>
<td>17</td>
<td>21</td>
<td>13</td>
<td>16</td>
<td>10</td>
<td>17</td>
<td>59</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Mean HSS/girder height (µm)</td>
<td>28±4</td>
<td>14±2</td>
<td>35±3</td>
<td>21±4</td>
<td>41±1</td>
<td>23±5</td>
<td>16±3</td>
<td>24±10</td>
<td>14±2</td>
<td>85±10</td>
</tr>
<tr>
<td>Mean cavity height (µm)</td>
<td>72±31</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>49±8</td>
<td>118±57</td>
<td>-</td>
<td>215±10</td>
</tr>
<tr>
<td>Rows or arrangement of VB’s</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td># large VB’s</td>
<td>2</td>
<td>3</td>
<td>17</td>
<td>2</td>
<td>11</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>19</td>
</tr>
<tr>
<td># intermediate VB’s</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td># small VB’s</td>
<td>2</td>
<td>0</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 21C: Anatomical characteristics of the culms of the genera *Ficinia* (continued), *Fuirena* and *Isolepis* of the *Scirpeae*.

<table>
<thead>
<tr>
<th>Genera</th>
<th>F. tribracteata</th>
<th>F. zeyheri</th>
<th>F. coerulescens</th>
<th>F. hirsuta</th>
<th>F. pachyrrhiza</th>
<th>I. cernua</th>
<th>I. costata var. macra</th>
<th>I. diabolica</th>
<th>I. fluitans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean culm height (µm)</td>
<td>496±149</td>
<td>430±61</td>
<td>701±28</td>
<td>1'248±113</td>
<td>885±193</td>
<td>983±66</td>
<td>357±10</td>
<td>451±91</td>
<td>279±152</td>
</tr>
<tr>
<td>Mean trichome length (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>9±3</td>
<td>9±2</td>
<td>9±2</td>
<td>10±2</td>
<td>14±1</td>
<td>10±5</td>
<td>8±2</td>
<td>9±5</td>
<td>8±3</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>14±4</td>
<td>11±6</td>
<td>16±9</td>
<td>162±15</td>
<td>11±8</td>
<td>21±9</td>
<td>10±7</td>
<td>19±2</td>
<td>8±3</td>
</tr>
<tr>
<td># HSS/girder</td>
<td>21</td>
<td>14</td>
<td>12</td>
<td>29</td>
<td>17</td>
<td>31</td>
<td>48</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>Mean HSS/girder height (µm)</td>
<td>20±3</td>
<td>30</td>
<td>43±5</td>
<td>52±15</td>
<td>43±1</td>
<td>13±2</td>
<td>13±4</td>
<td>20±3</td>
<td>29±9</td>
</tr>
<tr>
<td>Mean cavity height (µm)</td>
<td>158±20</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>339±42</td>
<td>74±18</td>
<td>61±10</td>
<td>7±1</td>
</tr>
<tr>
<td>Rows or arrangement of VB’s</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td># large VB’s</td>
<td>8</td>
<td>5</td>
<td>13</td>
<td>34</td>
<td>19</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td># intermediate VB’s</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td># small VB’s</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 21D: Anatomical characteristics of the culms of the genera *Isolepis* (continued), *Schoenoplectus* and *Scirpus* of the Scirpeae.

<table>
<thead>
<tr>
<th>Genera</th>
<th>I. natans</th>
<th>I. pellocolea</th>
<th>I. prolifera</th>
<th>S. decipiens</th>
<th>S. paludicola</th>
<th>S. falsus</th>
<th>S. ficinioides</th>
<th>S. nodosus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean culm height (µm)</td>
<td>165±10</td>
<td>711±277</td>
<td>945±66</td>
<td>945±66</td>
<td>1'361±160</td>
<td>829±18</td>
<td>1'191±80</td>
<td>1'397±487</td>
</tr>
<tr>
<td>Mean trichome length (µm)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>10±1</td>
<td>7±3</td>
<td>11±1</td>
<td>7±1</td>
<td>7±1</td>
<td>9±2</td>
<td>12±2</td>
<td>12±2</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>23±1</td>
<td>5±2</td>
<td>21±3</td>
<td>14±5</td>
<td>9±2</td>
<td>6±3</td>
<td>7±4</td>
<td>39±17</td>
</tr>
<tr>
<td># HSS/girder</td>
<td>4</td>
<td>68</td>
<td>29</td>
<td>68</td>
<td>82</td>
<td>33</td>
<td>66</td>
<td>66</td>
</tr>
<tr>
<td>Mean HSS/girder height (µm)</td>
<td>10±2</td>
<td>17±2</td>
<td>22±6</td>
<td>15±2</td>
<td>20±3</td>
<td>48±12</td>
<td>69±5</td>
<td>54±3</td>
</tr>
<tr>
<td>Mean cavity height (µm)</td>
<td>-</td>
<td>165±75</td>
<td>177±32</td>
<td>121±39</td>
<td>212±111</td>
<td>74±16</td>
<td>62±17</td>
<td>-</td>
</tr>
<tr>
<td>Rows or arrangement of VB's</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td># large VB's</td>
<td>0</td>
<td>5</td>
<td>17</td>
<td>18</td>
<td>23</td>
<td>14</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td># intermediate VB's</td>
<td>3</td>
<td>7</td>
<td>13</td>
<td>12</td>
<td>17</td>
<td>3</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td># small VB's</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>5</td>
<td>20</td>
</tr>
</tbody>
</table>

Symbols are as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle(s); (L) large bundle(s); (VB) vascular bundle(s).
Table 22: Anatomical characteristics of the leaves of the *Sclerieae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Scleria</th>
<th>S. melanomphala</th>
<th>S. natalensis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean thickness of lamina (µm)</td>
<td></td>
<td>240±86</td>
<td>112±57</td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td></td>
<td>284</td>
<td>195</td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td></td>
<td>48±21</td>
<td>35±22</td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td></td>
<td>17±4</td>
<td>11±5</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td></td>
<td>18±3</td>
<td>17±4</td>
</tr>
<tr>
<td># HSS/girder at midrib (adaxial)</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td># HSS/girder at midrib (abaxial)</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HSS/girder # adaxially</td>
<td></td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>HSS/girder # abaxially</td>
<td></td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Mean HSS/girder height adaxially (µm)</td>
<td></td>
<td>62±23</td>
<td>24±19</td>
</tr>
<tr>
<td>Mean HSS/girder height abaxially (µm)</td>
<td></td>
<td>40±10</td>
<td>15±5</td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>No. rows VB</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VB spacing</td>
<td></td>
<td>5-7</td>
<td>4-12</td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td></td>
<td>1-3</td>
<td>no pattern</td>
</tr>
<tr>
<td># large VB</td>
<td></td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td># intermediate VB</td>
<td></td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td># small VB</td>
<td></td>
<td>27</td>
<td>17</td>
</tr>
</tbody>
</table>

Symbols were as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
Table 23: Anatomical characteristics of the bracts of the *Scleriae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Scleria</th>
<th></th>
<th>S. melanomphala</th>
<th>S. natalensis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Characters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean thickness of lamina (µm)</td>
<td>109±16</td>
<td>111±51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midrib thickness (µm)</td>
<td>195</td>
<td>184</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean adaxial epidermis height (µm)</td>
<td>18±8</td>
<td>32±19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean abaxial epidermis height (µm)</td>
<td>12±3</td>
<td>11±4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>24±12</td>
<td>14±2</td>
<td></td>
<td></td>
</tr>
<tr>
<td># HSS/girders at midrib (adaxial)</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td># HSS/girders at midrib (abaxial)</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSS/girder # adaxially</td>
<td>12</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSS/girder # abaxially</td>
<td>20</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean HSS/girder height adaxially (µm)</td>
<td>19±3</td>
<td>18±12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean HSS/girder height abaxially (µm)</td>
<td>17±17</td>
<td>12±4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean lamina cavities height (µm)</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypodermis adaxially</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypodermis abaxially</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td># rows VB</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VB spacing</td>
<td>3-7</td>
<td>5-11</td>
<td></td>
<td></td>
</tr>
<tr>
<td># small between L &amp; I</td>
<td>1</td>
<td>no pattern</td>
<td></td>
<td></td>
</tr>
<tr>
<td># large VB</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td># intermediate VB</td>
<td>7</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td># small VB</td>
<td>10</td>
<td>25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Symbols were as follows: (#) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
### Table 24: Anatomical characteristics of the culms of the *Sclerieae*.

<table>
<thead>
<tr>
<th>Genus</th>
<th>S. melanomphala</th>
<th>S. natalensis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean thickness of culm (µm)</td>
<td>1078±200</td>
<td>975±63</td>
</tr>
<tr>
<td>Mean epidermis height (µm)</td>
<td>9±2</td>
<td>8±3</td>
</tr>
<tr>
<td>Mean sub-stomatal cavity height (µm)</td>
<td>11±3</td>
<td>17±3</td>
</tr>
<tr>
<td># HSS/girders</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Mean HSS/girder height (µm)</td>
<td>45±18</td>
<td>33±17</td>
</tr>
<tr>
<td>Mean cavity height (µm)</td>
<td>-</td>
<td>63±26</td>
</tr>
<tr>
<td># rows VB</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td># large VB</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td># intermediate VB</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td># small VB</td>
<td>11</td>
<td>13</td>
</tr>
</tbody>
</table>

Symbols were as follows: (♯) number; (HSS) hypodermal sclerenchymatous strands; (I) intermediate bundle; (L) large bundle; (VB) vascular bundle(s).
Appendix 4: Characteristics of tissues within the leaves, bracts and culms of the Eastern Cape Cyperaceae

This appendix details the shapes, as well as the distribution of thickening within the walls of the various tissues and the diagnostic characteristics of the leaves, bracts and culms of the species investigated.
4.1 Structural characteristics of the leaves and bracts

Generally the leaves and bracts of the Eastern Cape Cyperaceae are dorsiventral. No isobilateral leaves or bracts are evident. Pseudo-dorsiventral leaves and bracts are only present in one genus and species, namely *Cladium mariscus* subsp. *jamaicense*, which is in accordance with the specimens of this species investigated by Fisher (1971) and Metcalfe (1971). Circular (cylindrical) or polygonal leaves are only present in the *Abildgaardieae* (*Bulbostylis humilis*), *Hypolytreae* (*Chrysithrix capensis*) and *Scirpeae* (*Schoenoplectus paludicola*). Whilst circular (cylindrical) or polygonal bracts are present in the *Hypolytreae* (*C. capensis*).

No leaves are present in the species *Cyperus longus* var. *tenuiflorus*, *C. marginatus*, the genus *Eleocharis*, *Ficinia filiculmea*; *F. oligantha*; *F. repens*; *Isolepis pellocolea* and *Schoenoplectus decipiens*. No bracts are present in the species *Bulbostylis hispidula*, the genus *Eleocharis*, *Ficinia bulbosa*; *F. filiculmea*; *F. tenuifolia*; *I. fluitans* and *I. pellocolea*.

Only a few shapes are species specific and may possibly be of use taxonomically. These shapes are as follows: thinly-V (*Fuirena pachyrhiza*, *Scirpeae*); true scutiform (*Schoenus nigricans*, *Schoeneae*); irregularly scutiform (*Tetraria cuspidata* [bracts], *Schoeneae*); true triangular (*Bulbostylis schoenoides* [leaves and bracts], *Abildgaardieae*); shallowly corrugate (*Cyperus textilis*, *Cypereae*); W-shaped (*C. immensis*, *Cypereae*). In the bracts diagnostic outlines are as follows: rectangular (*Fimbristylis dichotoma*, *Abildgaardieae*) and midrib V-shaped, with the lamina inversely crescentiform (*Carex zaluensis*, *Cariceae*). It is also interesting to note that scutiform leaves are present only in the *Schoeneae*, namely in *Schoenus nigricans* and *Tetraria cuspidata*. Scutiform bracts are only present in *Cyperus denudatus* of the *Cypereae*. Sub-triangular leaves that are adaxially concave are also present only in the *Scirpeae*, namely in *Ficinia cinnamomea* and *F. pingiour*. Inwardly curled margins are also present in the bracts of *C. distans* and *M. thunbergii* of the *Cypereae*. The *Hypolytreae*, *Rhynchosporeae* and *Sclerieae* species all have a specific leaf outline namely, oval, true V-shaped and flanged V-shaped, respectively. The shapes of the bracts are not as diagnostic as the leaves.

Trichomes in species are present in more xeric environments. Trichomes are absent in the C₄ species, though they are present in the C₃ species, where they are either unicellular or multicellular. Unicellular trichomes are present in the abaxial epidermis of the leaves of *Fuirena coerulescens*, *Carex aethiopica*, *C. glomerabilis*, *C. mossii* and *Schoenoxiphium sparteum*. The bracts of *C. aethiopica*, *C. mossii* and *Fuirena hirsuta* also contain unicellular abaxial trichomes. In *Carex aethiopica*, *C. glomerabilis*, *C. mossii*, *Fuirena hirsuta* and *Schoenoxiphium sparteum* these trichomes are papillate in shape. The multicellular trichomes are present in the mid-lamina regions of the bracts (*Carex aethiopica*), at random in the adaxial epidermis of the bracts (*F. coerulescens*), present in the leaf margins (*Fuirena hirsuta*, adaxial), or present in the bract margins (*Fuirena coerulescens*, *I. diabolica*, *I. prolifera* and *Pycreus mundii*).

An adaptation to xeromorphic conditions is the development of bulliform cells to reduce water loss (Esau 1977; Blackmore and Tootill 1986). Bulliform cells are present in the adaxial epidermis of the leaves of *Carex aethiopica*, *Carpha schlechteri*, *Cypereae* (except *Ascolepis capensis* and *Cyperus tennellus* var. *tennellus*), *I. prolifera*,
Rhynchospora brownii, Schoenoxiphium sparteum, S. schweikerdii and Scleria melanomphala. Bulliform cells are also present in the bracts of Ascolepis capensis, Carex zuluensis, Carpha bracteosa, Cyperus tennellus var. tennellus, C. textilis, Ficinia lateralis, I. prolifera, Rhynchospora brownii, Schoenoxiphium lehmannii, S. rufum, S. schweikerdii and Scleria natalensis. Generally, the adaxial epidermal cells are larger than the abaxial. The abaxial epidermal cells of the leaves are diagnostically larger than the adaxial epidermal cells in Carpha schlechteri, Cladium mariscus subsp. jamaicense, Cyperus denudatus, C. difforis, C. tennellus var. tennellus, Fairena hirsuta, Schoenus nigricans, Scirpus falsus and S. nodosus. Similarly the abaxial epidermal cells of the bracts are also larger than the adaxial epidermal cells in Cladium mariscus subsp. jamaicense, Cyperus difforis, C. marginatus, C. tennellus var. tennellus, Ficinia repens, F. zeyheri, I. prolifera, Schoenus nigricans and Scirpus ficinoides. The marginal epidermal cells of the leaves of Carpha schlechteri, Cladium mariscus subsp. jamaicense and Cyathocoma hexandra are diagnostically larger than the adaxial or abaxial epidermal cells. Similarly the marginal epidermal cells of the bracts of Bolboschoenus maritimus, Carpha schlechteri, Cladium mariscus subsp. jamaicense, Cyathocoma hexandra, Scirpus ficinoides and T. cuspidata are diagnostically larger than the adaxial or abaxial epidermal cells.

Raised stomata are mostly present in the hydromorphic species, flush stomata with hydromorphic to mesomorphic species and sunken stomata with xeromorphic species. Generally, the stomata are flush in the Eastern Cape Cyperaceae. Raised stomata are present in Carex zuluensis (bracts), Carpha schlechteri (bracts), Cyathocoma hexandra (bracts), Cyperus albostratus (bracts), Ficinia fascicularis (leaves), F. lateralis, F. oligantha (bracts), F. tribracteata (leaves), Fairena coerulescens (leaves and bracts), F. pachyrhiza (leaves and bracts), I. cernua (leaves), Schoenoplectus decipiens (bracts), Schoenus nigricans (bracts), Schoenoxiphium lehmannii (leaves), S. schweikerdii (bracts) and S. sparteum (bracts). Sunken stomata are present in Carex aethiopica (leaves), C. glomerabilis (leaves), C. mossii (leaves and bracts), Chrysihrix capensis (leaves and bracts), Cladium mariscus subsp. jamaicense (leaves and bracts), Cyperus difforis (bracts), C. sphaerosperrus (bracts), C. tennellus var. tennellus (leaves), Ficinia pingiour (leaves), Fairena hirsuta (leaves), P. mundii (leaves), Schoenoxiphium rufum (leaves and bracts) and Scirpus nodosus (bracts). Generally the stomata are in the abaxial hypodermis. Amphistomatous stomata are present in Bolboschoenus maritimus (leaves and bracts), Carpha glomerata (bracts), Cladium mariscus subsp. jamaicense (leaves and bracts), Cyathocoma hexandra (leaves and bracts), Ficinia arenicola var. arenicola (bracts), F. indica (leaves), F. pingiour (bracts), F. repens (bracts), F. tribracteata (bracts), I. costata var. macra (leaves and bracts), Schoenoxiphium bracteosum (leaves), S. schweikerdii (bracts) and Scleria melanomphala (leaves and bracts).

The lignification within the guard cells of the stomata is varied. The outer periclinal wall of the guard cells in the adaxial epidermis in Carpha glomerata (bracts) is relatively thin-walled compared with the abaxial guard cell. Both Cladium mariscus subsp. jamaicense (bracts) and T. cuspidata (bracts) have more thickening present on the abaxial pole of the guard cell. The lignification on the adaxial and abaxial poles in B. schoenoides, genus Carex, Cladium mariscus subsp. jamaicens, most Cyperaeae, Fimbristylis complanata, F. ferruginea, Hypolytreae, Rhynchosporeae, Schoenoxiphium lehmannii, S. rufum, S. schweikerdii, most Scirpeae, Scleria natalensis and T. cuspidata is extremely thick (almost one third of the cells are lignified at these poles). Some of the guard cells range from thick-walled to thin walled, namely A. ovata, Cyperus rubicundus, C. sphaerosperrus and Schoenus nigricans (bracts). All the walls in F. dichotoma are equally thick-walled and lignified. Both Bulbostyis contexta and B. hispidula have thin-walled guard cells, with no apparent lignification. The guard cells in B. humilis, S. bracteosum, Carpha
bracteosa, C. glomerata, C. schlechteri, Cyathocoma hexandra, Ficinia pingiour (bracts), Schoenus nigricans, Schoenoxiphium spartem and Scleria melanomphala are relatively thin-walled on both the adaxial and abaxial poles. The lignification in B. schoenoides, Carex aethiopica (bracts), C. mossii (bracts), F. filiformis, K. elatior, R. brownii and Schoenoplectus paludicola have the horn-shaped lignification on the adaxial pole of the guard cells. In genus Fuirenca (bracts) and Scirpus falsus (bracts) the horn-shaped thickening is present at the abaxial pole of the guard cells. In Carpha bracteosa, Cyperus fastigiatus, F. coerulescens and Scirpus nodosus these thickenings are present on both poles of the guard cell. B. schoenoides has an unusual trichome-like lignification on the adaxial and abaxial poles of the guard cells. Lignified and silica coated subsidiary cells are present only in the leaves and bracts of the Fuirenca species (F. coerulescens [leaves], F. coerulescens [bracts] and F. pachyrrhiza [bracts]).

The outline of the hypodermal sclerenchymatous strands (HSS) is variable within and between the genera. In a few instances the adaxial and abaxial HSS outlines are the same. These HSS outlines are as follows: rectangular (Bolboschoenus maritimus [bracts] and Bulbostylis schoenoides [bracts]); triangular (A. ovata [leaves], B. contexta [leaves], Fimbristylis complanata [leaves], F. ferruginea [leaves], Schoenoxiphium schwiekerdttii [bracts] and Scirpus ficinioides [bracts]); triangular to turbiniform (B. schoenoides [leaves] and Carex glomerabilis [leaves]); turbiniform (S. spartem [bracts]); turbiniform to pulviniform (B. contexta [bracts]); oval to square (Bolboschoenus maritimus [leaves]); oval (Ficinia lateralis, coastal [leaves]); oval to trapeziform (Bulbostylis hispidula [leaves] and Fimbristylis complanata [leaves]); trapeziform (B. humilis [bracts], Ficinia pingiour [bracts], Fimbristylis dichotoma [leaves], F. ferruginea [leaves] and I. natans [leaves]); trapeziform to square (I. costata var. macra [leaves]); square (I. costata var. macra [bracts]); bulbiform to turbiniform (Ficinia arenicola var. arenicola [bracts]) and bulbiform (F. lateralis, inland [leaves]).

The adaxial HSS outlines are as follows: T-shaped to triangular (Cyperus textilis [leaves]); square (B. contexta [leaves], C. tennellus var. tennellus [leaves] and K. brevifolia [leaves]); square to rectangular (C. immens [bracts] and I. diabolica [leaves]); square to trapeziform (C. albostratius [leaves]); square to oval (C. pulcher [leaves]); square to bulbiform (C. distans [leaves] and C. tennellus var. tennellus [bracts]); bulbiform (C. denudatus [bracts], C. sphaeroposperm [leaves], F. filiformis [bracts], I. fluidans [leaves], P. intactus [leaves] and T. cuspidata [leaves]); bulbiform to pentagonal (M. macrocarpus [leaves]); bulbiform to pulviniform (Carpha schlechteri [leaves]); bulbiform to triangular (Cyperus sphaeroposperm [bracts], C. tenax [bracts] and P. nitidus [bracts]); bulbiform to trapeziform (Carpha bracteosa [leaves], C. schlechteri [leaves], Cyperus distans [bracts] and M. solidus [leaves]); bulbiform to turbiniform (C. albostratius [bracts], C. differmis [leaves], C. immens [leaves], F. arenicola var. arenicola [bracts] and M. tabularis subsp. major [leaves]); turbiniform (C. esculentus [leaves], M. albomarginatus [bracts], M. congestus [leaves], M. macrocarpus [bracts], M. sumatrensis [leaves], P. maracanthus [bracts] and P. polyastachyos var. polyastachyos [leaves and bracts]); turbiniform to crescentiform (C. denudatus [leaves]); turbiniform to trapeziform (C. differmis [bracts] and F. fasciculare [leaves]); turbiniform to rectangular (most of genus Carex [leaves], Cyperus textilis [bracts], F. lateralis, coastal [bracts], P. cooperi [leaves] and P. mundii [bracts]); turbiniform to pulviniform (C. esculentus [bracts], C. natalensis [bracts], K. pauciflora [bracts], M. albomarginatus [leaves], M. capensis [bracts], M. sumatrensis [bracts], M. thunbergii [leaves], M. thunbergii [bracts] and P. maracanthus [leaves]); pulviniform (A. ovata [bracts], Fuirenca coerulescens [leaves], F. hirsuta [leaves], K. erecta [bracts], M. congestus [bracts], M. capensis [leaves], M. dubius [bracts] and Schoenus nigricans [leaves and bracts]); pulviniform to trapeziform (C. obtusiflorus [leaves] and M. solidus [bracts]); pulviniform to triangular (C. longus
The abaxial HSS outlines are as follows: T-shaped to triangular (C. textilis [bracts], C. obtusiflorus [bracts], C. semitrididus var. semitrididus [bracts], P. cooperi [bracts], P. intactus [bracts] and Scirpus ficinioides [leaves]); square to pulviniform (Ficinia indica var. indica [bracts]); pulviniform to rectangular (C. rupestris var. rupestris [leaves and bracts] and C. semitrididus var. semitrididus [leaves]); rectangular (Bolboschoenus maritimus [bracts], Bulbostylis hispidula [leaves], F. fascicularis [bracts], Fimbrystylis ferruginea [bracts], K. alata [leaves], K. elatior [bracts], M. uitenhagensis [bracts] and S. falsus [leaves]); rectangular to trapeziform (Carpha glomerata [leaves and bracts], C. schlechteri [bracts] and K. elatior [leaves]); rectangular to triangular (Cyperus fastigatus [leaves], C. natalensis [leaves], Fimbrystylis dichotoma [leaves and bracts], Furena coerulescens [bracts], F. pachyrhiza [leaves and bracts] and K. alata [bracts]); triangular (Cyathocoma hexandra [leaves and bracts], Cyperus marginatus [bracts], Ficinia dura [leaves and bracts], F. indica var. indica [bracts], F. stolonifera [leaves], F. trbracteata [leaves], Fimbrystylis complanata [leaves], I. cernua [bracts], K. brevifolia [bracts], P. mundii [leaves], Schoenoplectus paludicola [bracts], Schoenoxiphium lehmannii [leaves], Scirpus fascicularis [bracts] and S. ficinioides [bracts]); triangular to turbiniform (M. tabularis subsp. major [bracts]); triangular to trapeziform (P. nitidus [leaves]); trapeziform (Carpha bracteosa [bracts], Ficinia bulbosa [leaves], F. cinnamomea [leaves], F. pungion [leaves], Fimbrystylis complanata [bracts], F. ferruginea [leaves] and M. uitenhagensis [leaves]); V-shaped to baculiform (S. seutecosum [leaves]); baculiform (Cladium mariscus subsp. jamaicense [leaves and bracts]); baculiform to pulviniform (R. barrosiana [leaves and bracts]); baculiform to triangular (S. schweikerditii [leaves], securiform (M. dubius [leaves]); oval (Ficinia arenicola var. arenicola [leaves], F. filiformis [leaves], F. tenuifolia [leaves], F. zeyheri [leaves], F. trbracteata [bracts] and I. dioblica [bracts]); oval to triangular (F. cinnamomea [bracts]) and crescentiform (Cyperus pulcher [bracts] and Schoenoplectus decipiens [bracts]).
Girder outlines adaxially and abaxially vary. Adaxially, girder outlines are as follows: rectangular to turbiniform (most of the genus Carex [leaves]); rectangular (Schoenoxiphium rufum [leaves]); V-shaped to baculiform (S. bracteosum [leaves]); baculiform to triangular (S. schweikerdtii [leaves]); triangular (S. lehmannii [leaves]); triangular to rectangular (S. lehmannii [bracts]); triangular to V-shaped (Cyperus marginatus [bracts]); triangular to inverted triangular (R. brownii [leaves and bracts]); turbiniform to crescentiform (S. sparteum [leaves]) and turbiniform (S. lehmannii [bracts]). Abaxial girder shapes are as follows: rectangular (S. rufum [leaves]); turbiniform (C. aethiopica [leaves] and S. bracteosum [leaves]); turbiniform to triangular (most of the genus Carex [bracts], C. glomerabilis [leaves] and C. mossii [leaves]); turbiniform to baculiform (C. mossii [leaves]); turbiniform to rectangular (C. glomerabilis [bracts]); turbiniform to square (S. lehmannii [leaves]); square to rectangular (A. capensis [bracts], C. zuluensis [leaves]); rectangular (C. zuluensis [bracts], S. rufum [bracts] and S. sparteum [bracts]); rectangular to triangular (S. schweikerdtii [leaves and bracts]); triangular (Cladium mariscus subsp. jamaicense [leaves]); triangular to baculiform (Carex mossii [bracts]); baculiform (Cladium mariscus subsp. jamaicense [leaves] and bracts) and crescentiform (S. sparteum [leaves]). The abaxial midrib girder is less variable in outline, ranging from crescentiform (Carex aethiopica [leaves], C. glomerabilis
[leaves] and C. zuluensis [leaves]) to horizontally crescentiform (S. schweikerdtii [leaves]). The abaxial girders in R. brownii are winged crescentiform in the midrib, to triangular in the lamina.

The outline of the lamina cavities is variable. The outlines of the lamina cavities are as follows: circular to oval (A. capensis [leaves], Ficinia cinnamomea, I. diabolica [leaves], I. natans [leaves], Schoenoplectus paludicola [bracts, central cavity] and Scirpus falsus [bracts]); oval (Cyperus textilis [leaves], Schoenoplectus paludicola [leaves, central cavities], Schoenoxiphium bracteosum [leaves] and most Scirpeae [bracts]); oval to square (C. albostratiatus [leaves], C. marginatus [bracts] and F. tenuifolia [leaves]); lanceolate to oval (S. bracteosum [bracts] and S. lehmannii [leaves]); oval to triangular (Fuirena coerulescens [bracts], I. prolifera [bracts] and Schoenoplectus paludicola [leaves, between bundles]); oval to rectangular (Carex glomerabilis [bracts], C. mossii [bracts], Cyperus immensis [leaves], C. pulcher [leaves] and Schoenoxiphium ruftum [bracts]); rectangular with inwardly rounded edges (S. schweikerdtii [leaves]); rectangular (Carex zuluensis [bracts], Carpha bracteosa [leaves], Cyperus denudatus [leaves], C. difformis [leaves], C. esculentus [leaves], Ficinia filiformis [leaves and bracts], F. lateralis subsp. hexandra [leaves], I. natans [bracts], M. dubius [leaves], M. macrocarpus [bracts], M. tabularis subsp. major [leaves], P. mundii [leaves], P. nitidus [bracts], S. lehmannii [bracts], S. schweikerdtii [bracts] and S. sparteum [bracts]); rectangular to rectangular with bulbous ends or dumbbell-shaped (Carpha glomerata [leaves] and Cyathocoma hexandra [leaves]); rectangular to triangular (B. maritimus [leaves], Carex aethiopica [bracts], C. mossii [leaves], Cyperus denudatus [bracts], C. distans [bracts], C. longus var. tenuiflorus [bracts], C. sphaerospermus [leaves], I. costata var. macro [leaves], I. prolifera [leaves], M. congestus [bracts], M. macrocarpus [leaves], M. sumatrensis [bracts], Schoenoxiphium sparteum [leaves] and Scirpus nodosus [leaves]); rectangular to oval (C. difformis [bracts], C. pulcher [bracts], C. sphaerospermus [bracts], C. textilis [bracts], P. mundii [bracts] and S. ficinioides [leaves and bracts]); rectangular to square (A. capensis [bracts], most Carex [leaves], Carpha schlechteri [leaves], Cladium mariscus subsp. jamaicense [leaves and bracts], Cyperus fastigiatus [leaves], C. immensis [bracts], F. pingiour [leaves], F. tenuifolia [leaves], I. fluitans [leaves], and M. congestus [leaves]); rectangular to lanceolate (C. albostratiatus [bracts]); rectangular to irregularly polygonal (Fuirena coerulescens [leaves], F. pachyrhiza [leaves] and I. diabolica [leaves]); rectangular to trapeziform (Ficinia cinnamomea [bracts]); rectangular to deep U-shaped (M. solidus [leaves and bracts], M. sumatrensis [leaves], M. tabularis subsp. major [bracts], M. thunbergii [bracts], M. uitenhagensis [leaves] and P. cooperi [bracts]); triangular to Deep U-shaped (P. cooperi [leaves] and P. maracanthus [leaves and bracts]); triangular to square (Fuirena hirsuta [leaves] and Scirpus falsus [leaves]); square (Ficinia fascicularis [bracts]); scutiform with a wavy outline (Schoenus nigricans [leaves, central cavity]), square to V-shaped (Schoenoxiphium ruftum [leaves]); V-shaped (F. fascicularis [leaves]); irregularly polygonal (Ficinia dura [leaves]) and irregularly polygonal to inverted triangular (F. indica var. indica [leaves]). The widely U-shaped cavities in P. cooperi are inverted.

The C₃ species discussed in this thesis do not have Kranz structure, but do have complex internal structures, when compared with the regular or less complex structures of the C₄ species which do have Kranz anatomy. C₃ species will be discussed first and the C₄ species last.
4.1.1 Specific characteristics of these C₃ leaves and bracts

None of the warty, nodular, wedge-shaped, bridge-shaped, particulate, conglomerate, elliptical or rod shaped "bodies" or deposits are present in the lumen of the epidermal cells mentioned by Govindarajalu (1969) and Metcalfe (1971) in the case of the Eastern Cape Cyperaceae. However, most of these species have cone-shaped silica deposits in their leaves. Bit these cone shaped silica deposits are absent from the leaves of Chrysithrix capensis, Cyathocoma hexandra, Cyperus sphaerospermus, Fuirena coerulescens, I. cernua var. macra, Schoenoplectus paludicola, Schoenoxiphium rafum and S. schweikerdtii. Cone shaped silica deposits also are absent from the bracts of Carpha bracteosa, Carex mossii, Chrysithrix capensis, Cyathocoma hexandra, Cyperus pulcher, C. textilis, P. mundii, I. natans, Schoenoplectus paludicola, Schoenoxiphium lehmannii, Schoenus nigricans and T. cuspidata. In the species with no cone-shaped silica deposits abutting either the HSS or the girders, the adjacent epidermal cells are generally smaller than those epidermal cells between the either the HSS or the girders. In Chrysithrix capensis and Cyathocoma hexandra where as already stated cone-shaped silica deposits are absent, the cells of the epidermis of both leaves and bracts remain the same size whether they abut the girders or not, this is of diagnostic significance. Whereas in Carpha glomerata, C. schlechteri, I. prolifera and Schoenoplectus paludicola the epidermal cells are larger abutting the HSS and girders in the leaves. Additionally domed shaped silica deposits are present on the epidermal surfaces of Cyperus textilis. Also deposits of silica, in the shape of hyphae or rod are present on the adaxial epidermis of the bracts of P. mundii.

C₃ species can be delimited into nine structural groups based on the absence or presence of sclerenchymatous structures within the lamina. Sclerenchyma in the lamina is in the form of hypodermal sclerenchymatous strands, girders, sclerenchymatous strands and additional sclerenchyma. Within the presence of hypodermal sclerenchymatous strands four structural classes are present. These are as follows: present in abutting the vascular bundles (A. capensis [leaves and bracts], Bolboschoenus maritimus [leaves], Carex aethiopica [bracts], C. glomerabilis [leaves and bracts], C. mossii [bracts], Carpha glomerata [bracts], C. schlechteri [bracts], Cladium mariscus subsp. jamaicense [bracts], Cyathocoma hexandra [bracts], Cyperus albostratius [bracts], C. denuudatus [leaves and bracts], C. diffformis [leaves and bracts], C. pulcher [leaves and bracts], C. sphaerospermus [leaves and bracts], C. tennellus var. tennellus [leaves and bracts], C. textilis [leaves and bracts], Ficinia bulbosa [leaves], F. cinnamomea [leaves], F. dura [leaves], F. fascicularis [leaves], F. filiformis [leaves], Ficinia lateralisboth [leaves], F. pingiour [leaves], F. stolonifera [leaves], F. tenuifolia [leaves], F. zeyheri [leaves], Fuirena coerulescens [leaves], F. hirsuta [leaves], F. pachyrrhiza [leaves], I. costata var. macra [leaves], I. diabolica [leaves], I. fluitans [leaves], I. natans [leaves], I. prolifera [leaves], P. mundii [leaves and bracts], Schoenoxiphium rafum [bracts], S. schweikerdtii [leaves and bracts], Schoenus nigricans [bracts], Scirpus falsus [leaves], S. ficianoides [leaves] and T. cuspidata [leaves and bracts]); present in the adaxial flanges only (Scleria natalensis [leaves and bracts]); abutting the margins (Carpha schlechteri [leaves], Cyathocoma hexandra [leaves] and Schoenoxiphium schweikerdtii [leaves]) and occurring randomly (Carpha bracteosa [leaves], C. glomerata [leaves], C. schlechteri [leaves], Cladium mariscus subsp. jamaicense [leaves], Cyathocoma hexandra [leaves], R. brownii [leaves and bracts], Schoenus nigricans [leaves] and most Scirpeae [leaves and bracts]).

Within the girders, two structural classes are present, namely abutting the vascular bundles (A. capensis [leaves and bracts], tribe Cariceae [leaves and bracts], Carpha glomerata [leaves], C. schlechteri [leaves], Chrysithrix capensis
[leaves and bracts], *Cladium mariscus* subsp. *jamaicense* [leaves and bracts], *Cyathocoma hexandra* [leaves and bracts], *Cyperus denudatus* [leaves], *C. marginatus* [bracts], *Fuirena coerulescens* [bracts], *I. prolifera* [leaves], *R. brownii* [leaves and bracts], *Schoenoplectus paludicola* [leaves and bracts] and tribe *Scleriaceae* [leaves and bracts]) and present abutting the trans-lamina parenchymatous bridges (**Cladium mariscus** subsp. *jamaicense*).

Within the sclerenchymatous strands, there are four structural classes. These are as follows: abutting the vascular bundles (**A. capensis** [leaves and bracts], **B. maritimus** [leaves and bracts], *Carex aethiopica* [bracts], *C. glomerabilis* [leaves and bracts], *C. mossii* [bracts], *C. zuluensis* [leaves and bracts], *Chrysis trichroa* [leaves and bracts], *Cyperus denudatus* [leaves and bracts], *C. marginatus* [bracts], *C. pulcher* [leaves and bracts], *C. sphaerospersus* [leaves and bracts], *C. textilis* [bracts], *P. mundii* [leaves and bracts], *Ficinia arenicola var. arenicola* [leaves and bracts], *F. bulbosa* [leaves], *F. cinnamomea* [leaves and bracts], *F. dura* [leaves and bracts], *F. fascicularis* [leaves and bracts], *F. filiformis* [bracts], *F. indica var. indica* [leaves and bracts], *F. lateralis* [leaves], *F. lateralis* [bracts], *F. lateralis* [leaves and bracts], *F. oligantha* [bracts], *F. pingiour*[leaves and bracts], *F. repens* [bracts], *F. stolonifera* [leaves], *F. tenuifolia* [leaves], *F. trbracteata* [leaves and bracts], *F. zeyheri* [leaves and bracts], *Fuirena coerulescens* [bracts], *F. hirsuta* [leaves and bracts], *F. pachyrhiza* [leaves and bracts], *F. cernua* [leaves and bracts], *I. costata var. macra* [leaves and bracts], *I. diabolic* [leaves and bracts], *I. natans* [bracts], *I. prolifera* [leaves and bracts], *R. brownii* [leaves and bracts], genus *Schoenoplectus* [bracts], the genus *Schoenoxiphium* [leaves and bracts], tribe *Schoeneae* [leaves and bracts], *Scirpus falsus* [leaves and bracts], *S. ficinoides* [leaves and bracts], *S. nodosus* [bracts] and tribe *Scleriaceae* [leaves and bracts]); present in the margins (**Cyathocoma hexandra** [leaves], *Cyperus marginatus*. [bracts] and *T. cuspidata* [leaves]) and abutting the hypodermis (**Cyathocoma hexandra** [leaves]).

Additional lignified cells resembling the structure of the cells of either the MS or SS are present in and/or abutting the vascular bundles of *Carpha bracteosa* (leaves and bracts), *C. glomerata* (bracts), *C. schlechteri* (leaves), *Cladium mariscus* subsp. *jamaicense* (leaves and bracts) and *Ficinia cinnamomea* (leaves).

Of diagnostic importance are the girders of leaves and bracts of **Cladium mariscus** subsp. *jamaicense*, which extend across the lamina cavities from the xylem pole of the adaxial row of the large and/or intermediate bundles to the xylem pole of the abaxial row of large bundles. These girders are surrounded by the parenchymatous bridges that extend across these large central cavities of the laminae. In addition, a sheath of translucent parenchyma (1 cell thick) abuts the girders and hypodermal sclerenchymatous strands of the bracts of this species.

The reason for the tannin idioblasts remains unclear, as does the reason for the absence of these structures. Tannin idioblasts are absent only in the leaves of *Cyperus denudatus*, *Ficinia bulbosa*, *F. filiformis*, *I. cernua*, *Schoenoplectus paludicola* and *Schoenoxiphium schweikerdtii*; they are also absent in the bracts of *Carex glomerabilis*, *Cyperus tennellus* var. *tennellus*, *Ficinia filiformis*, *I. natans*, *I. prolifera*, *Schoenoplectus paludicola* and *Schoenoxiphium schweikerdtii*. Generally the tannin idioblasts are not present abutting a particular tissue or structure. The site or distribution of tannin with tissues and/or structures seems to be genus or species dependent. These structural classes in the leaves are as follows: in the margins (**Fuirena hirsuta**); in the abaxial epidermis (**Scirpus falsus**); abutting the HSS (**Cyperus textilis**); in the lamina cavities (**Carex aethiopica** and the genus
Schoenoxiphium); abutting the stellate parenchyma (Scleria melanomphala); with vascular bundles (Cyperus difformis, genus Fuirena and Rhynchospora brownii); abutting the midrib bundle (Scleria natalensis); within the parenchymatous sheaths of bundles (Ascolepis capensis). In the bracts, these groups are as follows: abutting the adaxial epidermis (Ficinia lateralis,
C. pulcher, Schoenoxiphium lehmannii and S. sparteum); abutting the parenchymatous bridges (Bolboschoenus maritimus); abutting the stellate parenchyma (Scleria melanomphala); with the vascular bundles (Carex mossii, Cyperus sphaerospermus; C. textilis, Fuirena hirsuta and Rhynchospora brownii); abutting the midrib bundle (Scleria natalensis) and abutting the outermost vascular bundle sheath (Ascolepis capensis).

Vascular bundles are generally solitary, with the exception of the vascular groupings of the genus Carpha. Within Carpha, three different structures of lateral vascular bundles may be recognised. In the first structural group, present in C. bracteosa, the lateral bundles are composed of one to two small bundles or intermediate bundles abutting the larger bundle. Most of the lateral vascular bundles lack vascular bundle sheaths on the xylem side of the bundle. In the large bundle, these sheaths are also absent, on that side of the large bundle. The xylem tissue of the large bundle and lateral coalesce. In the second type, which is present in C. glomerata, the midrib vascular bundle is solitary. The lateral bundles of the large bundles are mostly composed of small bundles. The xylem at the adaxial pole of the bundle of lateral vascular bundles and the large bundle may coalesce, when there is only one lateral. Generally lateral vascular bundles are separated from the larger bundle by a few cells of translucent parenchyma. In the third group, which is present in C. schlechteri, most vascular bundles are solitary. The midrib bundle and a few of the large bundles have one to two lateral vascular bundles (mostly small bundles). The xylem at the adaxial pole of the bundle of the midrib bundle and large bundles does not coalesce with the lateral vascular bundles.

Vascular bundles of the C₃ species are present in one row. In Bolboschoenus maritimus, Cladium mariscus subsp. jamaicense and Schoenoxiphium rufum there are two rows of vascular bundles. The vascular orientation of the small bundles of the adaxial row of bundles of the leaves and bracts of Cladium mariscus subsp. jamaicense (of the Schoeneae) lie with their long axis parallel to the adaxial surface. Similarly, in the leaves, the xylem of a few of the adaxial small and intermediate bundles of Cladium mariscus subsp. jamaicense face the abaxial epidermis. The vascular bundles of the bracts of Schoenus nigricans of the Schoeneae face the centre of the bract.

The mestome sheath (MS) of most species is thick-walled in the radial and inner tangential walls, especially on the phloem side of the bundles and abutting the large metaxytem vessels (MX, Plates 10.12 and 11.1). The thickening in the radial and inner tangential walls of the MS is more pronounced on the phloem side of the bundle in A. capensis (leaves and bracts), B. maritimus (leaves), Carpha bracteosa (midrib bundle, large, intermediate and marginal bundles), C. glomerata (midrib bundle, large, intermediate and small bundles), C. schlechteri (midrib bundle, large, intermediate and small bundles), Cladium mariscus subsp. jamaicense (large, intermediate and small bundles), Cyperus marginatus (bracts), Ficinia arenicola var. arenicola (leaves), F. dura (leaves), F. fascicularis (leaves), F. indica var. indica (leaves), F. lateralis (leaves), F. trinervata (leaves), I. costata var. macra (leaves), I. diabolica (leaves), I. natans (leaves), P. mundii (bracts, small bundles), Schoenus nigricans (midrib bundle, intermediate and small bundles), Schoenoxiphium rufum (bracts), Scirpus falsus (leaves), S. ficinioides (leaves), S.
nodosus [bracts, small bundles] and T. cuspidata (midrib bundle, large and intermediate bundles). Thick-walls are present in both in the radial and inner tangential walls of the MS abutting the large metaxylem vessels in Cladium mariscus subsp. jamaicense (midrib bundle), Cyperus albostriatus (bracts, large, intermediate and marginal bundles), C. denudatus (leaves) and C. difformis (leaves). In Carpha schlechteri (marginal bundles) and Cladium mariscus subsp. jamaicense (marginal bundles) the cells of the MS are thick-walled in the radial, as well as inner tangential walls, in the whole bundle. In Carex mossii (bracts) the thickening in the MS in the radial and inner tangential walls becomes relatively thin-walled at the xylem poles of the bundles.

The walls of the MS in P. mundii (leaves, midrib bundle, large and a few intermediate bundles) are thick-walled in the inner tangential walls on the phloem side of the vascular bundle. In C. aethiopica (bracts), Carpha bracteosa (small bundles), Cyperus tenuifolia var. tenuellus (leaves), C. textilis (leaves and bracts), F. stolonifera (leaves), F. tenuifolia (leaves), F. zeyheri (leaves and bracts), genus Fuirena (leaves), Fuirena coerulescens (bracts), F. pachyrhiza (bracts), Schoenoplectus paludicola (leaves, large bundles), Schoenoxiphium bracteosum (bracts) and T. cuspidata (marginal bundles), the thickening in the MS is similar in all walls. A few species, namely Ficinia bulbosa (leaves), F. cinnamomea (leaves), F. lateralis costal (leaves, midrib bundle and large bundles), I. cernua (leaves) and Scirpus nodosus (leaves) are thick-walled in all the walls, especially in the MS abutting the phloem side of the bundle. In Carex mossii (bracts) the walls of the MS at the xylem pole of the bundle are thin-walled, as are the cell walls of the MS in C. tenuellus var. tennellus (bracts), C. textilis (bracts) and Schoenoplectus paludicola [leaves, small and intermediate bundles].

The outline of the phloem tissue is complex. The phloem outlines have a few similarities but, are generally similar within the species between the bundles but not between individual bundle sizes between the species. Phloem outlines are as follows: semicircular (B. maritimus [leaves, marginal bundles; bracts, intermediate and small bundles], C. aethiopica [leaves, midrib bundle], C. mossii [leaves, midrib, small and marginal bundles], C. zuluensis [bracts, marginal bundles], Carpha schlechteri [bracts, intermediate, small and marginal bundles], Cyperus albostriatus [bracts, midrib bundle], C. denudatus [leaves, midrib bundle], C. difformis [leaves, marginal bundles; bracts, small and marginal bundles], F. dura [leaves, intermediate and small bundles; bracts, large, intermediate, small and marginal bundles], F. lateralis costal [leaves and bracts, marginal bundles], F. pingiour [bracts, intermediate and marginal bundles], F. stolonifera [bracts, small bundles], F. tribracteata [bracts, small and marginal bundles], F. zeyheri [leaves, marginal bundles], Fuirena coerulescens [leaves, small and marginal bundles; bracts, intermediate and small bundles], F. pachyrhiza [leaves, small bundles], I. cernua [bracts, marginal bundles], I. diabolica [bracts, marginal bundles], I. fluitans [leaves, marginal bundles], I. natans [leaves, midrib bundle and marginal bundles], P. mundii [leaves, midrib bundle, large and marginal bundles; bracts, midrib bundle], Schoenoplectus paludicola [leaves, large bundles], Schoenoxiphium bracteosum [bracts, intermediate and small bundles], S. rufum [leaves, small bundles; bracts, large intermediate, small and marginal bundles], Scleria melanophalala [leaves, marginal bundles] and T. cuspidata [bracts, intermediate bundles]; semicircular to bulbiform (Chrysithrix capensis [bracts, intermediate bundles]); semicircular to oval (Carex aethiopica [leaves, large bundles; bracts, midrib, large, intermediate and small bundles], C. mossii [bracts, large bundles], C. zuluensis [leaves, small bundles; bracts, midrib, large intermediate and small bundles], Carpha bracteosa [bracts, small and marginal bundles], C. glomerata [leaves, small bundles; bracts, midrib bundle, intermediate and small bundles], Chrysithrix capensis [leaves, large bundles], Cladium mariscus subsp. jamaicense [bracts, small and marginal
bundles], *Cyperus diffinis* [leaves, intermediate and small bundles; bracts, intermediate bundles], *C. marginatus* [bracts, small and marginal bundles; bracts, large bundles], *C. pulcher* [bracts, midrib bundle], *C. sphaerospermus* [leaves, midrib bundle and intermediate bundles; bracts, large bundles], *Ficinia pingia* [leaves, marginal bundles], *P. mundii* [bracts, large bundles], *R. brownii* [bracts, midrib bundle], *Schoenoxiphium lehmannii* [leaves, midrib bundle], *S. rufum* [leaves, marginal bundles], *S. schweikerdii* [leaves, marginal bundles] and *Scleria melanomphala* [leaves, small bundles]; semicircular to triangular (*C. denudatus* [bracts, small and marginal bundles] and *F. fascicularis* [bracts, marginal bundles]); semicircular to rectangular (*Chrysithrix capensis* [bracts, small bundles]); semicircular to scutiform (*Carex aethiopica* [leaves, intermediate bundles], *C. mossii* [leaves, large, intermediate and small bundles], *Cyperus marginatus* [bracts, large and intermediate bundles], *P. mundii* [leaves, intermediate and small bundles; bracts, large bundles] and *Schoenoxiphium schweikerdii* [bracts, large and marginal bundles]); scutiform (*Carex aethiopica* [leaves, small and marginal bundles; bracts, marginal bundles], *C. glomerabilis* [bracts, marginal bundles], *C. mossii* [bracts, intermediate, small and marginal bundles], *Cyperus alostriatus* [bracts, large, small and marginal bundles], *I. cernua* [leaves, intermediate bundles], *P. mundii* [bracts, small bundles], *S. schweikerdii* [leaves, large, intermediate and small bundles; bracts, midrib bundle] and *Scleria natalensis* [leaves, intermediate and small bundles; bracts, small bundles]; scutiform to diamond (*S. natalensis* [bracts, marginal bundles]); scutiform to V-shaped (*Carex glomerabilis* [bracts, intermediate bundles]); scutiform to triangular (*I. prolifera* [leaves, intermediate bundles] and *Schoenoxiphium spartem* [leaves, marginal bundles]); scutiform to oval (*Chrysithrix capensis* [bracts, large bundles], *Cyperus alostriatus* [bracts, intermediate bundles], *I. prolifera* [leaves, large and small bundles], *S. lehmannii* [leaves, small bundles; bracts, large bundles], *S. schweikerdii* [bracts, intermediate and small bundles] and *Scleria natalensis* [leaves, marginal bundles]); oval to triangular (*A. capensis* [bracts, small bundles]); oval to circular (*A. capensis* [leaves, midrib bundle], *Schoenoxiphium schweikerdii* [bracts, intermediate, small and marginal bundles; bracts, midrib bundle, large and intermediate bundles], *Carex glomerabilis* [leaves, intermediate bundles; bracts, large bundles], *C. mossii* [bracts, midrib bundle], *C. zuluensis* [leaves, intermediate and marginal bundles], *Carpha bracteosa* [leaves, small bundles], *C. glomerata* [leaves and bracts, large bundles], *Cladium mariscus* subsp. *jamaicense* [bracts, midrib bundle, large and intermediate bundles], *Cyperus denudatus* [leaves, large, intermediate and small bundles], *C. diffinis* [leaves and bracts, midrib bundles and large bundles], *C. marginatus* [bracts, midrib bundle], *C. pulcher* [leaves, midrib bundle, large, intermediate and marginal bundles; bracts, large, intermediate, small and marginal bundles], *C. sphaerospermus* [leaves, large, small and marginal bundles], *C. tennellus* var. *tennellus* [leaves, midrib bundle], *C. textilis* [leaves and bracts, all bundles], *R. brownii* [leaves, all bundles; bracts, intermediate bundles; bracts, marginal bundles], *Schoenoxiphium bracteosum* [leaves, all bundles; bracts, midrib and large bundles], *S. lehmannii* [bracts, intermediate bundles], *S. rufum* [leaves, midrib, large and intermediate bundles], *S. spartem* [leaves, midrib bundle; bracts, midrib bundle], most *Scirpeae* [leaves and bracts], *Scleria melanomphala* [leaves, midrib bundle; bracts, midrib and large bundles], *S. natalensis* [bracts, midrib bundle] and *T. cuspidata* [leaves, midrib bundle]); oval to rectangular (*Carpha glomerata* [leaves, leaves, marginal bundles], *Chrysithrix capensis* [leaves, intermediate and small bundles], *Cyperus denudatus* [bracts, midrib bundle], *R. brownii* [bracts, small bundles], *Schoenus nigricans* [leaves, small bundles] and *Schoenoxiphium schweikerdii* [leaves, midrib bundle]); oval to square (*Carex glomerabilis* [leaves, midrib, small and marginal bundles; bracts, midrib bundle], *C. zuluensis* [leaves, midrib and large bundles], *Cyperus sphaerospermus* [bracts, marginal bundles], *C. tennellus* var. *tennellus* [bracts, marginal bundles], *S. lehmannii* [bracts, midrib, small and marginal bundles] and *Scleria natalensis* [leaves, large bundle]); oval to triangular (*Carex glomerabilis* [leaves, large bundles], *Carpha bracteosa* [bracts, large and intermediate
C. bracteosa [bracts, large bundles], Cyperus denudatus [leaves, marginal bundles; bracts, large and intermediate bundles], C. pulcher [leaves, small bundles], C. sphaerospermus [bracts, midrib bundle, intermediate and small bundles], most Schoenae [leaves], Schoenoplectus paludicola [leaves, intermediate bundles; bracts, intermediate and small bundles], Schoenoxiphium sparteum [bracts, large, intermediate and small bundles] and Scleria melanomphala [leaves, large and intermediate bundles; bracts, large bundles]; oval to mixed (A. capensis [bracts, marginal bundles]); oval to pentagonal (Schoenoxiphium lehmannii [leaves, large and intermediate bundles]); pentagonal (S. lehmannii [leaves, marginal bundles]); square (A. capensis [leaves, large bundles], C. tennellus var. tennellus [leaves, marginal bundles; bracts, midrib bundle], S. sparteum [leaves, large and intermediate bundles]); inversely V-shaped (Carex glomerabilis [bracts, small bundles]); rectangular (S. bracteosa [bracts, marginal bundles]); rectangular to triangular (T. cuspidata [bracts, marginal bundle]); triangular (Carpha bracteosa [leaves and bracts, midrib bundle], C. schlechteri [bracts, midrib bundle], Ficinia arenicola var. arenicola [bracts, midrib bundle and intermediate bundles], F. bulbos a [leaves, midrib bundle and large bundles], F. cinnamomea [leaves, large bundles], F. fascicularis [leaves, midrib bundle and marginal bundles], F. lateralis var. coastal [leaves, midrib bundle], F. lateralis var. inland [leaves and bracts, midrib bundle, large and marginal bundles], F. tenuifolia [leaves, marginal bundles], F. tribracteata [bracts, midrib bundle], F. zeyheri [leaves, midrib bundle and marginal bundles; bracts, midrib bundle], Fuirena pachyrhiza [bracts, midrib bundle], I. cernua [leaves, midrib bundle], I. fluitans [leaves, large and intermediate bundles], Schoenoplectus decipiens [leaves and bracts, midrib bundle, large and marginal bundles; bracts, large, intermediate and small bundles], Schoenoxiphium rufum [bracts, midrib and large bundles], S. sparteum [leaves, small bundles; bracts, marginal bundles], Scirpus falsus [leaves, midrib bundle; bracts, midrib bundle and large bundles], S. nodosus [leaves, small bundles], Scleria natalensis [leaves, midrib bundle and T. cuspidata [bracts, midrib bundle]); mixed (C. glomerata [marginal bundles], Ficinia repens [bracts, intermediate and marginal bundles], I. costata var. macra [bracts, marginal bundles] and Schoenoplectus decipiens [bracts, marginal bundles]); mixed to circular (Scirpus ficianioides [bracts, marginal bundles]); crescentiform (S. melanomphala [bracts, intermediate, small and marginal bundles] and S. natalensis [bracts, intermediate bundles]) and hexagonal (I. diabolica [bracts, midrib bundle]).

The xylem outlines of the different genera and species have a few similarities, more than with the phloem outlines. The xylem outlines of the midrib bundle and large bundles of most species is V-shaped. Generally the xylem outlines of the intermediate, small and marginal bundles is V-shaped. Additional xylem outlines are as follows: V-shaped to scutiform (Schoenoplectus paludicola [bracts, small bundles]); V-shaped to oval (Scleria melanomphala [bracts, marginal bundles]); V-shaped to semicircular (C. bracteosa [bracts, small bundles] and Cladium mariscus subsp. jamaicense [bracts, intermediate bundles], Cyperus marginatus [bracts, intermediate bundles], Schoenoxiphium rufum [bracts, small bundles] and Scleria melanomphala [bracts, small bundles]); V-shaped to triangular (Carpha schlechteri [bracts, large bundles]; V-shaped to mixed (A. capensis [bracts, marginal bundles]); V-shaped to rectangular (Carex aethiopica [leaves, intermediate bundles, small and marginal bundles], C. glomerabilis [leaves, small and marginal bundles], C. mossii [leaves, small bundles; bracts, small and marginal bundles], C. zuluensis [bracts, small and marginal bundles], Carpha glomerata [leaves, small bundles], Chrysithrix capensis [leaves, small bundles], Cyperus denudatus [leaves, marginal bundles], C. difformis [bracts, marginal bundles], C. tennellus var. tennellus [leaves, marginal bundles], P. mundii [leaves, marginal bundles], Schoenoxiphium lehmannii [leaves, intermediate and bundles; bracts, small and marginal bundles], S. sparteum [bracts, marginal bundles], Scleria melanomphala [bracts, intermediate bundles] and S. natalensis [leaves, intermediate and marginal bundles]);
rectangular (*Carex aethiopica* [bracts, small and marginal bundles], *Carpha glomerata* [leaves, marginal bundles], *Cyperus difformis* [leaves, marginal bundles; bracts, small bundles], *C. textilis* [leaves, small and marginal bundles; bracts, small bundles], *Ficinia indica* var. *indica* [leaves, intermediate bundles], *Schoenoxiphium lehmannii* [leaves, marginal bundles] and *Scleria natalensis* [bracts, marginal bundles]; rectangular to oval (*S. natalensis* [bracts, small bundles]); rectangular to semicircular (*Cyathocoma hexandra* [leaves, intermediate bundles], *I. prolifera* [leaves, small bundles], *Schoenoxiphium schweikerdii* [leaves, small bundles] and *Scleria natalensis* [leaves, small bundles]); semicircular (*B. maritimus* [leaves, intermediate, small and marginal bundles; bracts, intermediate and small bundles], *Carpha schlechteri* [leaves and bracts, intermediate, small and marginal bundles], *Chrysithrix capensis* [bracts, large bundles], *Cladium mariscus* subsp. *jamaicense* [leaves, marginal bundles; bracts, marginal bundles], *Cyathocoma hexandra* [bracts, intermediate and marginal bundles], *Cyperus marginatus* [bracts, marginal bundles], *F. dura* [bracts, intermediate, small and marginal bundles], *F. indica* var. *indica* [leaves, small and marginal bundles], *F. lateralis* [bracts, marginal bundles], *F. pingiour* [bracts, marginal bundles], *F. tribracteata* [leaves and bracts, small and marginal bundles], *Fuirena coerulescens* [leaves, intermediate, small and marginal bundles; bracts, intermediate bundles], *F. hirsuta* [leaves, small bundles], *F. pachyrhiza* [leaves, small bundles; bracts, intermediate and small bundles], *I. cernua* [bracts, marginal bundles], *I. diabolica* [bracts, marginal bundles], *I. natans* [leaves and bracts, marginal bundles], *I. prolifera* [bracts, small and marginal bundles], *R. brownii* [leaves, small and marginal bundles; bracts, intermediate, small and marginal bundles], *Schoenoxiphium bracteosum* [bracts, intermediate bundles], *S. rufum* [leaves, marginal bundles], *S. sparteum* [leaves, small bundles], *Scirpus nodosus* [leaves, intermediate bundles; bracts, marginal bundles], *Scleria melanomphala* [leaves, marginal bundles] and *T. cuspidata* [bracts, midrib bundle, large and marginal bundles]); semicircular to triangular (*Ficinia lateralis* [coastal leaves, small bundles] and *I. cernua* [leaves, small bundles]); semicircular to oval (*Chrysithrix capensis* [bracts, intermediate bundles], *Cladium mariscus* subsp. *jamaicense* [bracts, small bundles], *Cyathocoma hexandra* [leaves and bracts, small bundles] and *S. melanomphala* [leaves, small bundles]); semicircular to scutiform (*Cyperus marginatus* [bracts, small bundles] and *Schoenoxiphium schweikerdii* [bracts, marginal bundles]); scutiform (*Schoenoplectus decipiens* [bracts, small bundles], *Schoenus nigricans* [leaves, intermediate and small bundles] and *Schoenoxiphium schweikerdii* [bracts, intermediate and small bundles]); scutiform to inverted-V-shaped (*S. Schweikerdii* [leaves, small bundles]); scutiform to crescentiform (*C. mariscus* subsp. *jamaicense* [leaves, small bundles]); inverse V-shaped (*Carex glomerabilis* [bracts, small bundles] and *Cladium mariscus* subsp. *jamaicense* [leaves, large and intermediate bundles]); inverse V-shaped to semicircular (*C. mariscus* subsp. *jamaicense* [leaves, small bundles]); inverse V-shaped to inverse W-shaped (*C. glomerabilis* [bracts, marginal bundles]); inverse V-shaped to inverse W-shaped (*C. glomerabilis* [bracts, marginal bundles]); bulbiform (*Chrysithrix capensis* [leaves, intermediate bundles]) and mixed (*Carpha glomerata* [bracts, marginal bundles], *F. repens* [bracts, large and marginal bundles] *I. costata* var. *macra* [bracts, midrib bundle and marginal bundles] and *Schoenoplectus decipiens* [bracts, marginal bundles]).
Protoxylem lacunae are not present in all species’ leaves and bracts. Protoxylem lacunae are present in the midrib bundle (*Bolboschoenus maritimus* [leaves], tribe *Cariceae* [leaves and bracts], most of the tribe *Cypereae* [leaves and bracts], genus *Fuirena* [leaves], *I. cernua* [leaves], *I. costata var. macra* [leaves], *I. diabolica* [leaves], *I. fluitans* [leaves], *I. natans* [leaves], *R. brownii* [bracts], tribe *Schoeneae* [leaves], *Scirpus falsus* [leaves], tribe *Scirpeae* [bracts except *Ficinia lateralis*	extsubscript{inland}, *Schoenoplectus decipiens* and *Scirpus nodosus*) and the tribe *Sclerieae* [leaves and bracts]), marginal (*Ficinia lateralis*	extsubscript{inland} [leaves], *F. stolonifera* [leaves], *F. tenuifolia* [leaves], *F. zeyheri* [leaves], and *Fuirena pachyrhiza* [leaves and bracts]) and large bundles (*Bolboschoenus maritimus* [leaves and bracts], tribe *Cariceae* [leaves and bracts], genus *Carpha* [bracts], genus *Cyathocoma* [bracts], most of the tribe *Cypereae* [leaves and bracts], *Ficinia arenicola* var. arenicola [leaves and bracts], *F. bulbo* [leaves], *F. cinnamomea* [leaves and bracts], *F. dura* [leaves and bracts], *F. lateralis*	extsubscript{inland} [leaves and bracts], *F. pingiour* [leaves], *F. tenuifolia* [leaves], *F. triracteata* [leaves], genus *Fuirena* [leaves and bracts], tribe *Hypolytreae* [leaves and bracts], *I. cernua* [leaves], *I. costata var. macra* [leaves], *I. diabolica* [leaves], *I. fluitans* [leaves], *I. natans* [leaves], *R. brownii* [leaves and bracts], tribe *Schoeneae* [leaves], *Schoenoplectus decipiens* [bracts], *S. paludicola* [leaves and bracts], genus *Schoenus* [bracts], *Scirpus falsus* [leaves], *S. nodosus* [leaves and bracts] and tribe *Sclerieae* [leaves and bracts]).

### 4.1.2 Specific characteristics of these C₄ leaves and bracts

As in the C₃ species, few C₄ species lacked adaxial bulliform cells (*C. immensis*, *C. natalensis*, *C. obtusiflorus*, *C. rupestris* var. *rupestris*, *K. elatior*, *M. dubius*, *M. macrocarpus*, *M. sumatrensis*, *M. tabularis* subsp. *major*, *M. thunbergii*, *M. uitenhagensis* and *P. polystachyos* var. *polystachyos*). In the bracts bulliform cells are absent in the species *C. laevigatus*, *C. rubicundus*, *C. rupestris* var. *rupestris*, *C. semitrifidus* var. *semitrifidus*, *C. sexangularis*, *C. tenax*, *K. elatior*, *M. capensis*, *M. dubius*, *P. cooperi*, *P. macranthus* and *P. nitidus*. Generally the adaxial epidermal cells are larger than the abaxial. The abaxial epidermal cells of the leaves are diagnostically larger than the adaxial epidermal cells in *C. albostriatus*, *C. distans*, *C. fastigiatus*, *C. immensis*, *C. laevigatus*, *C. obtusiflorus*, *C. rupestris* var. *rupestris*, *C. semitrifidus* var. *semitrifidus*, *K. alata*, *M. tabularis* subsp. *major*, *M. thunbergii*, *P. cooperi*, *P. maracanthus* and *P. nitidus*. Similarly, the abaxial epidermal cells of the bracts are diagnostically larger than the adaxial epidermal cells in *Bulbostylis humilis*, *C. distans*, *C. esculentus*, *C. immensis*, *C. longus* var. *tenuiflorus*, *C. obtusiflorus*, *C. rubicundus*, *C. rupestris* var. *rupestris*, *C. semitrifidus* var. *semitrifidus*, *C. sexangularis*, *M. solidus*, *M. thunbergii*, *P. cooperi*, *P. maracanthus* and *P. nitidus*. Diagnostic to *M. solidus* and *M. uitenhagensis* are the large pear-shaped marginal epidermal cells. The large oval-shaped abaxial epidermal cell at the tip of the midrib V is unique to *P. intactus*. Similarly, the abaxial median epidermal cells of the bracts of *R. barrosiana* are mostly larger than the abutting epidermal cells.

The stomata of the C₄ are generally flush with the epidermal surfaces, as with the C₃ species. Raised stomata are present in the leaves of *Bulbostylis humilis* (leaves-xerophytic), *Fimbristylis complanata* (leaves and bracts), *F. dichotoma* (bracts), *Cyperus esculentus* (leaves), *Kyllinga brevifolia* (leaves and bracts), *K. elatior* (leaves and bracts), *K. pauciflora* (bracts) and *M. dubius* (leaves). Sunken stomata are present in *Fimbristylis ferruginea* (bracts). Generally stomata are present in the abaxial hypodermis. Amphistomatous stomata are present in *Cyperus esculentus* (bracts), *C. immensis* (bracts), *C. longus* var. *tenuiflorus* (bracts) and *K. brevifolia* (leaves). The stomata of *K. erecta* and *K. pauciflora* are present in the point of the midrib V in the abaxial epidermis. The presence of
horn-shaped lignification is diagnostic to Bulbostylis schoenoides (leaves and bracts). Concertina-shaped cells are present only in the sub-stomatal cavities of M. thunbergii.

There is less sclerenchyma within the C₄ species than in the C₃ species, where girders abutting the vascular bundles are absent. There are six structural classes within sclerenchyma in the C₄ species versus the eight of the C₃ species. Within the hypodermal sclerenchymatous strands three structural groups may be recognised namely: adjacent to the vascular bundles (tribe Abildgaardieae [leaves], A. ovata [bracts], B. contexta [bracts], B. hispidula [bracts], B. humilis [bracts], Cyperus albostriatus [leaves], C. distans [leaves and bracts], C. esculentus [leaves and bracts], C. fastigiatus [leaves], C. immensis [leaves and bracts], C. longus var. tenuiflorus [bracts], C. natalensis [leaves and bracts], C. obtusiflorus [leaves and bracts], C. rubicundus [leaves and bracts], C. rupestris var. rupestris [leaves and bracts], C. semitrifidus var. semitrifidus [leaves and bracts], C. sexangularis [bracts], C. tenax [leaves], genus Fimbristylis [bracts], Kyllinga alata [leaves and bracts], K. brevifolia [leaves and bracts], K. elatior [leaves and bracts], K. erecta [bracts], K. pauciflora [leaves and bracts], M. congestus [leaves and bracts], M. dubius [leaves and bracts], M. macrocarpus [leaves and bracts], M. solidus [leaves and bracts], M. sumatrensis [leaves and bracts], M. tabularis subsp. major [leaves and bracts], M. thunbergii [leaves and bracts], M. uitenhagensis [leaves and bracts], P. cooperi [leaves and bracts], P. intactus [bracts], P. macranthus [leaves and bracts], P. nitidus [leaves and bracts], P. polystachyos var. polystachyos [leaves] and R. barrosiana [leaves and bracts]); in the margins (tribe Abildgaardieae [bracts], M. thunbergii [leaves], M. uitenhagensis [leaves and R. barrosiana [bracts]) and at random along the epidermal surfaces (B. schoenoides [bracts], C. laevigatus [leaves and bracts], C. sexangularis [leaves], K. erecta [leaves], K. pauciflora [bracts], M. albomarginatus [leaves] and P. intactus [bracts]).

There are four structural classes of sclerenchymatous strands, namely: within parenchymatous bridges (C. immensis [leaves]); adjacent to the parenchymatous bridges (M. tabularis subsp. major [leaves]); abutting the vascular bundles (B. humilis [leaves], Cyperus distans [bracts], C. esculentus [bracts], C. immensis [bracts], C. longus var. tenuiflorus [bracts], C. rubicundus [leaves], C. semitrifidus var. semitrifidus [leaves], K. pauciflora [bracts], M. congestus [bracts], M. tabularis subsp. major [bracts], M. thunbergii [leaves and bracts], P. cooperi [leaves], P. intactus [bracts], P. nitidus [bracts] and R. barrosiana [leaves and bracts]) and adjacent to the adaxial epidermis (F. ferruginea [leaves]).

Within the mesophyll of the dorsiventral C₄ species, six structural classes can be observed: species with lamina cavities (Mariscus congestus [leaves], M. dubius [leaves], M. macrocarpus [bracts] and M. sumatrensis [leaves and bracts]); with cavities and parenchymatous bridges (C. esculentus [leaves]); with cavities and hypodermal layers (Bulbostylis contexta [bracts], B. schoenoides [leaves], Cyperus albostriatus [leaves], C. natalensis [bracts], Fimbristylis ferruginea [leaves], M. congestus [bracts], M. thunbergii [bracts], Pycreus cooperi [leaves] and P. nitidus [bracts]); those with cavities, parenchymatous bridges and hypodermal layers (C. distans [leaves and bracts], C. fastigiatus [leaves], C. immensis [leaves and bracts], C. longus var. tenuiflorus [bracts], M. solidus [leaves and bracts], M. tabularis subsp. major [leaves and bracts], M. thunbergii [leaves], P. cooperi [bracts] and P. macranthus [leaves and bracts]); those with no cavities, parenchymatous bridges or hypodermal layers (the leaves and bracts of Abildgaardia ovata, C. tenax, K. brevifolia, K. elatior, K. erecta, K. pauciflora, M. albomarginatus, M. capensis, M. macrocarpus and P. intactus) and those with hypodermal layers only (B. contexta [leaves], B. hispidula [leaves and
distinctive silica deposits are evident in Eastern Cape C₄ Cyperaceae as they are with the C₃ species. In the leaves, rubicundus and epidermis (and in the mesophyll surrounding the outer vascular sheaths (C. immensis var. C. semitrifidus fastigiatus, P. nitidus var. polystachyos [leaves and bracts], Pycreus nitidus [leaves], P. polystachyos var. polystachyos [leaves and bracts] and Rhynchospora barrosiana [leaves and bracts]).

Translucent parenchyma is present in the C₄ species within a variety of tissues or abutting specific tissue structures. These structures are mostly species and genera independent and are as follows: in the midrib (Cyperus rubicundus [leaves]); within the margins (C. immensis [bracts], C. natalensis [bracts], C. rubicundus [bracts], M. dubius [leaves] and M. thunbergii, [bracts]); abutting the abaxial epidermis of the midrib (M. dubius [bract]); abaxially between the HSS in the midrib region (C. natalensis [leaves]); abutting the flange adaxial epidermis (K. elatior [leaves]); abutting the sub-stomatal cavities (Bulbostylis humilis [leaves] and M. capensis [leaves and bracts]); abutting the HSS of the margins (C. longus var. tenuiflorus [bracts] and P. cooperi [bracts]); abutting the abaxial HSS of the midrib (C. obtusiflorus [bracts] and C. rubicundus [bracts]); from the xylem pole of the vascular bundles to the centre of the leaves (B. humilis); scattered throughout the mesophyll (genus Bulbostylis [leaves], M. macroporus [leaves], M. sumatrensis [leaves and bracts], M. uitenhagensis [leaves] and Rhynchospora barrosiana [bracts]); scattered at random abutting the adaxial epidermis (C. esculentus [leaves], K. brevifolia [bracts], M. albomarginatus [leaves], M. dubius [bracts], M. uitenhagensis [bracts] and P. intactus [leaves]); scattered at random abutting the abaxial epidermis (C. rupestris var. rupestris [leaves] and C. semitrifidus var. semitrifidus [leaves]); scattered between the abaxial HSS (C. semitrifidus var. semitrifidus [bracts]); scattered between the RM of the lamina bundles (C. natalensis [bracts], M. thunbergii [leaves]); abutting the abaxial epidermis directly beneath the central row of bundles in the midrib and margins (M. solidus [bracts]) and abutting the abaxial bundles (P. nitidus [bracts]).

The reason for the presence of tannin idioblasts in the C₄ species, as with the C₃ species, remains unclear. As with the C₃ species, in the C₄ species, the tannin idioblasts are generally not present abutting a particular tissue or structure. Tannin idioblasts within or abutting tissues and/or structures seems to be genus or species dependent. These are as follows: abutting the adaxial epidermis (M. albomarginatus, M. capensis, M. congestus, M. macroporus, M. uitenhagensis); abutting the abaxial epidermis (K. pauciflora); abutting the adaxial hypodermis (C. fastigiatus, C. natalensis, C. obtusiflorus and C. sexangularis); in the lamina bridges of parenchyma (C. fastigiatus) and in the mesophyll surrounding the outer vascular sheaths (C. immensis, C. rubicundus, C. rupestris var. rupestris, P. nitidus and P. polystachyos var. polystachyos). In the bracts tannin idioblasts are present abutting the following structures: the adaxial epidermis (C. esculentus, K. erecta, K. pauciflora, M. albomarginatus, M. congestus, M. dubius and M. uitenhagensis); the abaxial epidermis (M. congestus); the margins (M. dubius); the adaxial hypodermis (C. sexangularis, K. alata, K. brevifolia and P. polystachyos var. polystachyos); the mesophyll surrounding vascular bundles (C. immensis, C. natalensis, C. rubicundus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus, M. capensis, M. thunbergii, P. macranthus, P. nitidus and Rhynchospora barrosiana) and the vascular bundles (C. longus var. tenuiflorus and K. elatior).

Distinctive silica deposits are evident in Eastern Cape C₄ Cyperaceae as they are with the C₃ species. In the leaves, cone-shaped silica deposits are present in all species but C. laevigatus and M. solidus. In the bracts, C. laevigatus
laevigatus; M. tabularis subsp. major, P. cooperi and P. macranthus lacked cones in the epidermal cells. Diagnostic to M. uitenhagensis is the unique characteristic that the cells beneath the abaxial HSS of the midrib and large bundles have 2-3 silica cones instead of one. Additional silica deposits are found as small bulbiform to baculiform deposits on the surfaces of the adaxial and abaxial epidermal cells of the leaves, as well as bracts of F. complanata.

In the leaves and bracts of C. sexangularis there are silica deposits that are crescentiform and/or domed and abut the outer periclinal walls of both the adaxial and abaxial epidermis.

Vascular bundles are all solitary in the laminae. In the midribs of the genus Kyllinga and Cyperus semitrifidus var. semitrifidus there is a small bundle adjacent the midrib bundle, similar to the C₃ species Bolboschoenus maritimus. It is possible that Cyperus semitrifidus var. semitrifidus should be placed in the genus Kyllinga because of its many similarities. It is also probable that the C₃ ancestor of the genus Kyllinga and Cyperus semitrifidus var. semitrifidus, could be Bolboschoenus maritimus, since it is the only C₃ species with this type of vascular bundle arrangement within the midrib. Within these small bundles, the xylem encircles the phloem. These small bundles that are found beneath the midrib bundle, and the xylem encircling the phloem, are of diagnostic significance. This condition of xylem surrounding phloem is termed a solenostele and is unusual since it is mostly found in the roots of the ferns Marsilea and Adiantum (Blackmore and Tootill 1986). This condition is also found in the culms of Mariscus solidus, M. thunbergii and M. uitenhagensis, where these solenosteles are present in the inner vascular bundles of the culm tissues (referred to in the thesis as solenostele type 1 or S1 and solenostele type 2 or S2 bundles).

Vascular bundles are generally found within two rows in the leaves. However, varying numbers of rows may be observed as follows: one (Abildgaardieae, Cyperus difformis, C. rubicundus, C. sexangularis, C. tenax, the genus Kyllinga, Pycreus intactus, P. macranthus, P. mundii, P. polystachyos var. polystachyos and Rhynchospora barrosiana); three (C. albostriatus, C. natalensis, Mariscus macrocarpus, M. solidus, M. sumatrensis, M. thunbergii and P. nitidus) and four (P. cooperi) may also be present in the lamina. The bracts of C₄ species in rows one, three and four mostly have different row composition to the leaves. One (C. esculentus, C. rubicundus, C. semitrifidus var. semitrifidus, C. sexangularis, C. tenax, the genus Kyllinga, M. dubius, P. intactus, P. macranthus, P. polystachyos var. polystachyos and Rhynchospora barrosiana), three (C. natalensis, M. macrocarpus, M. solidus, M. sumatrensis and P. cooperi) and four rows (M. thunbergii) within the mesophyll. The vascular bundle stacking in the leaves and bracts of P. cooperi is diagnostic to this species and is not present in any other of the Eastern Cape Cyperaceae.

The lignification within the mestome sheath (MS) cell walls is variable. The MS cells of most of the leaves and bracts are mostly thicker in the radial, as well as inner tangential walls, especially on the phloem side of the bundle and abutting the large metaxylem vessels. In B. contexta (leaves), B. hispidula (leaves), B. humilis (leaves), B. schoenoides (leaves), F. dichotoma (leaves) and F. ferruginea (leaves), the MS is more lignified on the phloem side of the vascular bundles. The MS walls in B. hispidula (leaves), B. schoenoides (leaves), F. complanata (leaves), F. dichotoma (bracts), F. ferruginea (bracts), K. erecta (leaves and bracts, midrib bundle, the large and intermediate bundles), M. congestus (bracts, midrib bundle and large bundles), M. macrocarpus (leaves, midrib bundle, the large and intermediate bundles), M. solidus (leaves and bracts, midrib bundle, the large and intermediate bundles), M. sumatrensis (leaves, midrib bundle, the large and intermediate bundles), M. tabularis subsp. major (leaves, intermediate bundles) and P. intactus (leaves, midrib bundle, the large and intermediate bundles) the lignification is
more pronounced abutting the large metaxylem vessels (MX). The lignification within the MS cells in *B. hispidula* (leaves), *B. schoenoides* (leaves), *C. albostriatus* (leaves, small bundles), *C. immenis* (bracts), *C. laevigatus* (leaves, small bundles), *C. longus* var. *tenuiflorus* (bracts), *C. sexangularis* (leaves, small bundles), *K. pauciflora* (leaves, small bundles), *M. albostriatus* (leaves, small bundles), *M. macrocarpus* (leaves, small bundles), *M. solidus* (leaves, small bundles), *M. thunbergii* (leaves, small bundles), *P. maracanthus* (leaves, small bundles) and *P. nitidus* (leaves, small bundles) is the same in all the walls. In *C. fastigiatus* (leaves, intermediate, small and marginal bundles), *C. immenis* (leaves, intermediate, small and marginal bundles; bracts all bundles), *C. laevigatus* (bracts), *C. longus* var. *tenuiflorus* (bracts), *C. rubicundus* (bracts), *C. semitrifidus* var. *semitrifidus* (leaves, intermediate, small and marginal bundles), *C. sexangularis* (bracts), *K. brevifolia* (leaves), *K. elatior* (leaves and bracts), *K. pauciflora* (leaves), *M. albomarginatus* (leaves and bracts), *M. capensis* (leaves and bracts), *M. congestus* (leaves), *M. rubicundus* (leaves and bracts), *M. macrocarpus* (leaves, small and marginal bundles), *M. solidus* (leaves, small bundles), *M. sumatrensis* (leaves, small bundles), *M. uitenhagensis* (leaves and bracts), *P. cooperi* (leaves and bracts), *P. nitidus* (bracts) and *P. polystachyos* var. *polystachyos* (leaves and bracts) the MS cells are thin-walled, with almost no lignification in these cell walls. The MS walls in *P. intactus* (bracts) are also thin-walled, but are thick-walled in the midrib bundle.

The MS cells abutting the MX in *F. dichotoma* (bracts) and *F. ferruginea* (bracts) are larger than the other MS cells (Plate 4.7-9). The MS cells on the phloem side of the bundles in *B. contexta* (bracts) are almost twice the size of all the other MS cells.

There are a great many variations in the outlines of the phloem tissues. The phloem outlines for *C₄* species are as follows: circular to oval (most *Abildgaardieae* (leaves and bracts), *C. albostriatus* [leaves, midrib bundle], *C. distans* [leaves, large bundles], *C. fastigiatus* [leaves, large, intermediate, small and marginal bundles], *C. immenis* [leaves, small bundles], *C. laevigatus* [leaves, large bundles; bracts, intermediate and marginal bundles], *C. natalensis* [leaves, midrib bundle and intermediate bundles], *C. obtusiflorus* [leaves, intermediate bundles; bracts, midrib bundle and large bundles], *C. rubicundus* [leaves, midrib bundle, large, intermediate and small bundles; bracts, midrib bundle and large bundles], *C. rupestris* var. *rupestris* [leaves, large and intermediate bundles; bracts, intermediate bundles], *C. semitrifidus* var. *semitrifidus* [leaves, intermediate bundles; bracts, midrib bundle], *C. sexangularis* [leaves, midrib bundle and intermediate bundles; bracts, midrib bundle and marginal bundles], *K. alata* [leaves, midrib bundle], *K. elatior* [leaves, large bundles; bracts, midrib bundle], *K. erecta* [leaves, intermediate bundles], *M. albomarginatus* [bracts, midrib bundle], *M. capensis* [bracts, midrib bundle] and *R. barrossiana* [bracts, midrib bundle, large and intermediate bundles]); oval to square (*C. albostriatus* [leaves, small bundles], *C. distans* [leaves, small bundles], *C. laevigatus* [leaves, small bundles], *C. longus* var. *tenuiflorus* [bracts, midrib bundle], *C. natalensis* [leaves, large bundles], *C. obtusiflorus* [leaves, midrib bundle], *C. rubicundus* [bracts, intermediate bundles], *C. rupestris* var. *rupestris* [leaves, midrib bundle], *C. tenax* [bracts, midrib bundle, large and intermediate bundles], *K. alata* [bracts, midrib bundle and intermediate bundles], *K. elatior* [bracts, large bundles], *M. congestus* [leaves, large bundles] and *M. sumatrensis* [leaves, intermediate bundles]); oval to scutiform (*C. immenis* [bracts, small bundles], *C. longus* var. *tenuiflorus* [bracts, large and intermediate bundles], *C. natalensis* [leaves, small bundles], *C. obtusiflorus* [bracts, intermediate bundles], *C. rupestris* var. *rupestris* [leaves, small bundles], *K. alata* [bracts, large bundles], *K. elatior* [leaves, intermediate bundles] and *K. pauciflora* [leaves and bracts, intermediate bundles]); oval to triangular (*C. obtusiflorus* [leaves, large bundles], *C. rupestris* var. *rupestris* [leaves, marginal
Appendix 4

bundles], C. semitrifidus var. semitrifidus [leaves, midrib bundle and large bundles], K. alata [leaves, large bundles], K. elatior [leaves, midrib bundle], K. erecta [leaves, large bundles; bracts, large and intermediate bundles], M. albomarginatus [bracts, large bundles] and M. dubius [bracts, large and intermediate bundles]; oval to rectangular (C. laevigatus [bracts, midrib bundle and large bundles], C. rupestris var. rupestris [bracts, marginal bundles], C. semitrifidus var. semitrifidus [leaves, marginal bundles], C. sexangularis [leaves, large bundles; bracts, large and small bundles], F. complanata [bracts, small bundles], K. alata [bracts, small bundles] and M. albomarginatus [leaves, large bundles]); oval to mixed (C. sexangularis [leaves, small bundles] and K. pauciflora [bracts, marginal bundles]); oval to pentagonal (M. solidus [bracts, midrib bundle], M. sumatrensis [leaves, large bundles] and P. polystachyos var. polystachyos [leaves, large bundles]); oval to semicircular (C. distans [bracts, large bundles], C. esculentus [leaves, midrib bundle, large and intermediate bundles], C. immensis [leaves, marginal bundles], C. rupestris var. rupestris [bracts, midrib bundle] and R. barrosiana [leaves, large and intermediate bundles; bracts, small bundles]); semicircular (C. distans [bracts, midrib bundle], C. esculentus [leaves, marginal bundles; bracts, midrib bundle], C. fastigiatus [leaves, midrib bundle], C. immensis [leaves, midrib bundle and large bundles; bracts, midrib bundle and large bundles], C. semitrifidus var. semitrifidus [bracts, intermediate bundles], K. pauciflora [bracts, midrib bundle and large bundles], M. congestus [leaves, midrib bundle], M. tabularis subsp. major [leaves, midrib bundle], M. thunbergii [leaves, midrib bundle and large bundles; bracts, midrib bundle and large bundles], P. cooperi [leaves, midrib bundle, bracts, midrib bundle and large bundles], P. intactus [leaves, midrib bundle], P. nitidus [leaves, midrib bundle], P. polystachyos var. polystachyos [bracts, midrib bundle] and R. barrosiana [leaves, midrib bundle]); semicircular to triangular (F. complanata [leaves, midrib and marginal bundles], F. ferruginea [leaves, intermediate bundles]); semicircular to pentagonal (P. intactus [leaves, large bundles]); semicircular to rectangular (C. tenax [bracts, small bundles] and R. barrosiana [bracts, marginal bundles]); semicircular to scutiform (C. distans [bracts, intermediate bundles], C. esculentus [bracts, large bundles], C. immensis [leaves and bracts, intermediate bundles], M. solidus [leaves, midrib bundle and large bundles], M. thunbergii [leaves, intermediate and small bundles; bracts, intermediate bundles] and P. cooperi [leaves, intermediate bundles; bracts, intermediate, small and marginal bundles]); scutiform (A. ovata [leaves, intermediate and marginal bundles], B. contexta [leaves, intermediate and marginal bundles], C. esculentus [bracts, intermediate, small and marginal bundles], C. natalensis [bracts, intermediate bundles], M. albomarginatus [bracts, intermediate bundles and marginal bundles], M. capensis [bracts, intermediate bundles], M. macrocarpus [bracts, intermediate bundles], M. tabularis subsp. major [bracts, intermediate bundles], M. uitenhagensis [leaves, intermediate bundles], P. intactus [leaves, marginal bundles; bracts, intermediate bundles], P. macranthus [leaves, intermediate, small and marginal bundles], P. nitidus [leaves, large, intermediate, small and marginal bundles; bracts, midrib bundle, large and intermediate bundles] and P. polystachyos var. polystachyos [bracts, intermediate, small and marginal bundles]); scutiform to mixed (K. pauciflora [leaves, marginal bundles]); scutiform to V-shaped (M. macrocarpus [leaves and bracts, small bundles], M. solidus [leaves and bracts, small bundles] and M. thunbergii [bracts, small and marginal bundles]); scutiform to pentagonal (P. macranthus [leaves, large bundles] and P. polystachyos var. polystachyos [leaves, intermediate bundles]); scutiform to trapeziform (M. capensis [leaves, intermediate bundles]); scutiform to triangular to rectangular (M. sumatrensis [bracts, small bundles]); scutiform to triangular (C. longus var. tenuiflorus [bracts, small bundles], C. natalensis [bracts, large bundles], C. semitrifidus var. semitrifidus [leaves, small bundles], K. erecta [bracts, small bundles], K. pauciflora [bracts, small bundles], M. capensis [leaves and bracts, small bundles] and M. uitenhagensis [leaves, small bundles; bracts, intermediate bundles]); scutiform to square (C. natalensis [leaves, marginal bundles], C. obtusiflorus [leaves, small bundles], K. brevifolia [bracts, small bundles], C. semitrifidus var. semitrifidus [leaves, marginal bundles], C. sexangularis [leaves, large bundles]; bracts, intermediate bundles] and
K. elatior [leaves, small bundles], M. congestus [leaves, intermediate bundles], M. solidus [bracts, intermediate bundles], M. tabularis subsp. major [leaves, intermediate bundles], P. macranthus [bracts, intermediate and small bundles] and P. nitidus [bracts, marginal bundles]); scutiform to rectangular to mixed (M. congestus [bracts, marginal bundles]); scutiform to rectangular (C. esculentus [leaves, small bundles], C. natalensis [bracts, small bundles], C. obtusiflorus [bracts, small bundles], C. rupestris var. rupestris [bracts, small bundles], C. tenax [bracts, small bundles], K. brevifolia [leaves, small bundles], K. elatior [bracts, intermediate and small bundles], K. erecta [leaves, small bundles], K. pauciflora [leaves, small bundles], M. albomarginatus [leaves, small bundles; bracts, small and marginal bundles], M. congestus [bracts, small bundles], M. sumatrensis [leaves, small bundles], M. tabularis subsp. major [bracts, large and small bundles], M. uitenhagensis [bracts, small bundles], P. cooperi [leaves, small bundles], P. intactus [leaves, intermediate and small bundles; bracts, small and marginal bundles], P. nitidus [bracts, small bundles] and P. polystachyos var. polystachyos [leaves, small and marginal bundles]); rectangular (B. schoenoides [bracts, midrib bundle], C. distans [bracts, marginal bundles], C. laevigatus [leaves, midrib bundle; bracts, marginal bundles], C. longus var. tenuiflorus [bracts, marginal bundles], C. sexangularis [leaves, marginal bundles], F. dichotoma [bracts, small bundles], K. alata [leaves, intermediate bundles], K. erecta [bracts, midrib bundle], K. pauciflora [leaves, midrib bundle], M. congestus [bracts, midrib bundle], M. solidus [bracts, marginal bundles], M. tabularis subsp. major [bracts, marginal bundles] and R. barrosiana [leaves, marginal bundles]); rectangular to trapeziform (K. erecta [leaves, midrib bundle]); rectangular to V-shaped (M. macrocarpus [leaves and bracts, marginal bundles] and M. thunbergii [leaves, marginal bundles]); rectangular to mixed (P. cooperi [leaves, marginal bundles]); rectangular to square (C. distans [leaves, intermediate bundles], C. laevigatus [bracts, small bundles], C. tenax [leaves, small bundles], K. brevifolia [leaves, intermediate bundles] and M. congestus [bracts, large bundles]); rectangular to inverted triangular (R. barrosiana [leaves, small bundles]); rectangular to triangular (C. distans [leaves, midrib bundle; bracts, small bundles], C. obtusiflorus [bracts, marginal bundles], C. semitri fridus var. semitri fridus [bracts, small and marginal bundles], K. alata [leaves, small bundles], M. albomarginatus [leaves, intermediate and marginal bundles], M. capensis [bracts, marginal bundles], M. congestus [leaves, marginal bundles], M. dubius [leaves, marginal bundles; bracts, small bundles], M. sumatrensis [bracts, marginal bundles] and M. uitenhagensis [leaves, marginal bundles]); triangular (B. schoenoides [bracts, marginal bundle], C. distans [leaves, midrib bundle], C. natalensis [bracts, midrib bundle], C. obtusiflorus [leaves, marginal bundles], C. tenax [leaves, midrib bundle and large bundles], K. alata [leaves, marginal bundles], K. brevifolia [bracts, midrib bundle], K. elatior [leaves, marginal bundles], K. erecta [leaves, marginal bundles], M. capensis [leaves, large bundles], M. dubius [leaves and bracts, midrib bundle], M. macrocarpus [leaves, midrib bundle], M. tabularis subsp. major [leaves, marginal bundles; bracts, midrib bundle] and M. uitenhagensis [leaves, midrib bundle and large bundles; bracts, midrib bundle]); triangular to trapeziform (M. congestus [bracts, intermediate bundles]); triangular to diamond (B. contexta [bracts, midrib bundle]); triangular to square (C. immensis [bracts, marginal bundles], M. dubius [leaves, large, intermediate and small bundles], M. macrocarpus [leaves, large and intermediate bundles; bracts, large, intermediate and marginal bundles], M. uitenhagensis [bracts, large bundles] and P. polystachyos var. polystachyos [bracts, large bundles]); square (C. albo striatus [leaves, marginal bundles], C. laevigatus [leaves, marginal bundles], C. rubicundus [bracts, small and marginal bundles], K. alata [bracts, marginal bundles], K. brevifolia [leaves, marginal bundles; bracts, large, intermediate and marginal bundles], K. pauciflora [leaves, large bundles], M. albomarginatus [leaves, midrib bundle], M. capensis [leaves, midrib bundle and marginal bundles], M. macrocarpus [bracts, midrib bundle], M. sumatrensis [bracts, intermediate bundles] and P. macranthus [bracts, marginal bundles]); square to V-shaped to mixed (M. dubius [bracts, marginal bundles]); square to V-shaped (M.
sulids [leaves, marginal bundles]); square to pentagonal (M. solidus [bracts, large bundles], M. sumatrensis [bracts, midrib bundle and large bundles], P. intactus [bracts, large bundles] and P. macranthus [bracts, large bundles]); pentagonal (M. sumatrensis [leaves, midrib bundle], P. intactus [bracts, midrib bundle], P. macranthus [leaves and bracts, midrib bundle] and P. polystachyos var. polystachyos [leaves, midrib bundle]); crescentiform (B. hispidula [leaves, intermediate bundles]); trapeziform (C. albostriatus [leaves, intermediate bundles]) and mixed (C. tenax [leaves, marginal bundles], K. elatior [bracts, marginal bundles] and K. erecta [bracts, marginal bundles]).

Most of the xylem outlines of the midrib bundle and large bundles in the C4 species are V-shaped. Additional outlines are as follows: rectangular (A. ovata [bracts, midrib bundle], C. esculentus [leaves, marginal bundles], C. laevigatus [leaves, small and marginal bundles; bracts, intermediate bundles], C. natalensis [bracts, marginal bundles], C. obtusiflorus [bracts, marginal bundles], K. elatior [bracts, intermediate bundles], M. solidus [leaves and bracts, marginal bundles], P. nitidus [leaves and bracts, marginal bundles], P. polystachyos var. polystachyos [leaves, marginal bundles] and R. barrosiana [marginal bundles]); rectangular to square (C. ruprestris var. ruprestris [bracts, marginal bundles] and K. alata [bracts, small bundles]); rectangular to triangular (C. natalensis [bracts, small bundles], C. obtusiflorus [leaves, small bundles], C. ruprestris var. ruprestris [leaves, small and marginal bundles; bracts, small bundles], C. semitridifus var. semitridifus [leaves and bracts, small bundles], C. sexangularis [bracts, small bundles], C. tenax [leaves, small bundles; bracts, marginal bundles] and F. complanata [leaves, intermediate and small bundles]); rectangular to V-shaped to oval (M. macrocarpus [leaves, small bundles], M. sumatrensis, M. thunbergii [leaves, small bundles] and P. nitidus [bracts, small bundles]); rectangular to oval (C. albostriatus [leaves, marginal bundles], C. esculentus [leaves, small bundles], C. distans [bracts, marginal bundles], C. fastigiatus [leaves, intermediate, small and marginal bundles] and C. tenax [bracts, small bundles]); oval to V-shaped (C. distans [leaves, small bundles], C. esculentus [bracts, small and marginal bundles], C. longus var. tenuiflorus [bracts, small bundles], C. sexangularis [leaves, marginal bundles], K. erecta [bracts, small bundles], M. sumatrensis, M. thunbergii [leaves, small bundles] and P. nitidus [bracts, small bundles]); oval to circular (B. humilis [bracts, all bundles], C. distans [leaves, marginal bundles], C. longus var. tenuiflorus [bracts, marginal bundles], C. obtusiflorus [leaves, marginal bundles], C. sexangularis [bracts, marginal bundles], F. complanata [bracts, small bundles], K. elatior [leaves, marginal bundles] and P. cooperi [bracts, marginal bundles]); oval to mixed (C. rubicundus [leaves, marginal bundles]); oval to triangular (C. albostriatus [leaves, small bundles] and K. elatior [bracts, small bundles]); oval to square (C. distans [bracts, intermediate bundles] and C. sexangularis [leaves, intermediate and small bundles]); square to C. rubicundus [bracts, intermediate bundles]); square to trapeziform (C. rubicundus [leaves, intermediate bundles]); square to triangular (C. natalensis [leaves, marginal bundles], C. obtusiflorus [bracts, small bundles], C. rubicundus [leaves, small bundles; bracts, small and marginal bundles], C. semitridifus var. semitridifus [leaves, marginal bundles] and R. barrosiana [leaves, small and marginal bundles]); square to V-shaped (K. brevifolia [bracts, marginal bundles], M. solidus [bracts, small bundles], M. sumatrensis [bracts, small bundles], P. intactus [leaves, marginal bundles] and P. polystachyos var. polystachyos [bracts, marginal bundles]); V-shaped to mixed (K. pauciflora [leaves, marginal bundles], M. capensis [leaves, marginal bundles], M. congestus [leaves, marginal bundles], M. dubius [bracts, marginal bundles] and P. cooperi [leaves, marginal bundles]); V-shaped to mixed to W-shaped (M. congestus [bracts, marginal bundles]); V-shaped to semicircular (A. ovata [bracts, intermediate bundles] and C. distans [leaves, intermediate bundles]); V-shaped to crescentiform (F. ferruginea [leaves, intermediate bundles] and B. schoenoides [leaves, marginal bundles]); V-
shaped to rectangular (C. distans [bracts, small bundles], B. contexta [bracts, intermediate bundles], C. immensis [leaves and bracts, small bundles], C. laevigatus [leaves, midrib bundle and large; bracts, small and marginal bundles], C. rubicundus [bracts, large bundles], genus Kyllinga [leaves, small bundles], K. alata [bracts, intermediate and marginal bundles], K. brevifolia [bracts, intermediate and small bundles], K. erecta [leaves, marginal bundles], K. pauciflora [bracts, intermediate bundles], C. semitrifidus var. semitrifidus [bracts, marginal bundles]); circular to triangular in (C. textilis [leaves, marginal bundles], K. elatior [bracts, marginal bundles], K. erecta [bracts, marginal bundles] and M. tabularis subsp. major [bracts, marginal bundles]); mixed to scutiform (K. pauciflora [bracts, marginal bundles] and P. macranthus [bracts, marginal bundles]); scutiform (K. brevifolia [leaves, marginal bundles]); crescentiform (B. hispidula [leaves, intermediate bundles]); crescentiform to rectangular (B. humilis [leaves, intermediate bundles]); triangular (A. ovata [leaves, small bundles], C. albostriatus [leaves, intermediate bundles] and C. semitrifidus var. semitrifidus [bracts, marginal bundles]); semicircular (B. schoenoides [bracts, all bundles]) and semicircular to Z-shaped (C. immensis [bracts, marginal bundles]).

Protoxylem lacunae are not present in most species’ leaves and bracts; they are in the midrib bundle (tribe Abildgaardieae [leaves], Bulboystilis contexta [bracts], B. humilis [bracts], Fimbristylis complanata [bracts], F. dichotoma [bracts], most of the tribe Cypereae [leaves and bracts] and R. barrosiana [leaves and bracts]), as well as in the large bundles (tribe Abildgaardieae [leaves], most of the tribe Cypereae [leaves and bracts] and R. barrosiana [leaves and bracts]).

No phloem is found in the abaxial small bundles of the Mariscus species, M. solidus (leaf), M. sumatrensis and M. thunbergii (leaf). Phloem is also absent in a few of the small bundles of the bracts of the Mariscus species, M. capensis, M. macrocarpus and M. thunbergii. Similarly, phloem is also absent in the marginal bundles of the bracts of the Mariscus species, M. solidus and M. tabularis subsp. tabularis. In a few of the small bundles of M. tabularis subsp. tabularis tannin is present in place of the xylem. Solenosteles are present in a few of the bract small bundles of M. albomarginatus. This is of diagnostic significance for this species. Similarly, the vascular orientation of the abaxial row small bundles of M. macrocarpus (leaves), M. sumatrensis (leaves), M. tabularis subsp. tabularis (bracts) and M. thunbergii (leaves) of the Cypereae, lies with their long axis parallel to the adaxial surface. Similarly, the xylem of a few of the abaxial small bundles in the leaves of M. thunbergii (Cypereae) faces the abaxial epidermis.

4.2 Structural characteristics of these Culms

Diagnostic culm shapes are as follows: triangular with concave sides in the Cypereae (Cyperus pulcher, K. elatior and K. pauciflora); circular to triangular in C. textilis (Cypereae); thickly crescentiform in the Schoeneae (Carpha bracteosa, Cladium mariscus subsp. jamaicense and Cyathocoma hexandra); hexagonal in I. natans (Scirpeae); rectangular in Fuirena pachyrrhiza (Scirpeae) and oval to rectangular in I. pellocolea (Scirpeae). Diagnostic to
**Appendix 4**

Eleocharis pauciflora, Fuirena coerulescens, Schoenoplectus decipiens, S. paludicola, Schoenoxiphium lehmannii are the outer periclinal walls of the epidermal cells, where circular to bulbous lignin deposits are found opposite the middle lamellae of each of the cells.

Conical silica deposits in the epidermal cells that abut the HSS are absent only in Chrysithrix capensis, Cyperus albostraitus, C. immensis, C. laevigatus, C. rupestris var. rupestris, C. sexangularis, Ficinia filiformis, F. lateralis, F. tenuifolia, the genus Fuirena, Kylinga pauciflora, Mariscus congestus, M. macrocarpus, M. solidus, M. sumatrensis, M. tabularis subsp. major, Pycreus cooperi, P. macranthus, P. mundii, P. polystachyos var. polystachyos, tribe Rhynchosporae, tribe Schoeneae (except Carpha bracteosa and Cladium mariscus subsp. jamaicense), Scirpus ficioides and S. nodosus. The cells of the epidermis abutting the HSS that lacked cone-shaped silica deposits, are mostly smaller than the epidermal cells that are present between the HSS. The epidermal cells of Chrysithrix capensis, Rhynchospora brownii, Schoenus nigricans, that lacked the silica deposits are the same size as the epidermal cells that are found between the HSS. In the epidermal cells that have the cone-shaped silica deposits, the cells are of similar size to the cells that are present between the HSS in Carex aethiopica. In Cyathocoma hexandra, Scirpus ficioides and S. nodosus the epidermal cells are larger abutting the HSS than those cells that are present between the HSS. Additional silica deposits other than the conical silica deposits on the epidermis are found in C. sexangularis and C. textilis, where numerous dome-shaped silica deposits present on the outer periclinal walls of the epidermal cells.

Generally the stomata are flush. Raised stomata are found in Cyperus difformis, C. tenellus var. tenellus, Eleocharis dreggeana, E. limosa, Ficinia cinnamomea, F. lateralis, F. oligantha, F. tenuifolia, F. zeyheri, Fuirena coerulescens, F. pachyrhiza, I. cernua, I. natans, I. prolifera, M. solidus, M. uitenhagensis, P. cooperi, Schoenus nigricans, Scirpus falsus and Scleria melanomphala. Sunken stomata are present in Bolboschoenus maritimus, Carex mossii, Chrysithrix capensis, Cladium mariscus subsp. jamaicense, Cyperus pulcher, Ficinia filiformis, Fimbristylis ferruginea, P. mundii, Schoenoxiphium bracteosum and Scirpus nodosus.

There is variable thickening on the adaxial and abaxial poles of the guard cells. The guard cells of the stomata are generally thick-walled on the adaxial and abaxial poles of the cells. Lignification within the walls of the guard cells of E. limosa, Ficinia filiformis, Fuirena coerulescens, F. pachyrhiza and I. cernua is variable. In C. denudatus, M. sumatrensis and T. cuspidata the adaxial pole is thick-walled but less thickened at the abaxial pole. The converse is true for genus Carex, Cyperus difformis, C. sphaerospermus and K. alata. The adaxial and abaxial poles of the guard cells in both C. albostraitus, and C. pulcher are thin-walled. In Fuirena hirsuta and I. natans there is no lignification of the guard cells.

There are five forms of sclerenchyma present within the culms: namely, HSS, girders, SS, sclerenchymatous layers and sclerenchymatous cells. Within the first three forms of sclerenchyma there are nine structural classes. These are as follows: HSS adjacent to the vascular bundles (Cyperus difformis, C. immensis, C. obtusiflorus, C. tenax, Eleocharis pauciflora, Ficinia dura, F. lateralis, F. oligantha, F. tenuifolia, F. triracteata, Fuirena hirsuta, Isolepis prolifera, Kylinga erecta, Scirpus falsus, S. ficioides and Tetraria cuspidata); HSS not adjacent to the vascular bundles (Abildgaardieae, Carex mossii, genus Carpha, most of the Cyperaeae, Rhynchospora barrosiana, Schoenoxiphium bracteosum and most of the Scirpeae); HSS and girders adjacent to or abutting the vascular bundles.
(Bolboschoenus maritimus, Cladium mariscus subsp. jamaicense, Cyperus distans, Fuirena coerulescens, F. pachyrrhiza, Schoenoxiphium lehmannii and Schoenus nigricans); HSS found between bundles, with girders abutting bundles (Chrysisrix capensis and tribe Sclerieae); girders only (genus Carex, Cyathocoma hexandra, Schoenoxiphium rufum, S. schweikerdii and S. spurtem); SS abutting bundles on the phloem poles (Ascolepis capensis, Bulbostylis contexta, Carex mossii, Carpha glomerata, C. schlechteri, Cladium mariscus subsp. jamaicense, Cyathocoma hexandra, Cyperus difformis, C. immensus, C. marginatus, C. natalensis, C. obtusiflorus, C. tenax, I. costata var. macra, I. diabolia, M. albomarginatus, M. solidus (S1), M. sumatrensis, M. uitenhagensis, R. barrosiana, Schoenoxiphium lehmannii, S. rufum, S. schweikerdii, S. spurtem and tribe Sclerieae); SS abutting bundles on the xylem poles (Ascolepis capensis, Bulbostylis contexta, B. humilis, Carex aethiopica, C. mossii, Chrysithrix capensis, Cyperus albostriatius, C. denudatus, C. distans, C. esculentus, C. immensus, C. laevigatus, C. longus var. tenuiflorus, C. marginatus, C. natalensis, C. obtusiflorus, C. pulcher, C. rubicundus, C. rupestris var. rupestris, C. semitrifidus var. semitrifidus, C. sexangularis, C. textilis, Fimbristylis dichotoma, K. brevifolia, K. elatior, K. erecta, K. pauciflora, genus Mariscus, genus Pycreus, R. barrosiana, tribe Schoeneae, Schoenoxiphium lehmannii, S. rufum, S. schweikerdii, tribe Scirpeae and tribe Sclerieae), SS abutting bundles, as well as absent abutting the bundles (Schoenoplectus decipiens and S. paludicola) and SS not abutting the bundles (Carpha glomerata and Cyperus denudatus). The girders of Schoenoxiphium rufum (Cariceae) of the first row bundles extend to form a lignified sheath of sclerechyma (sclerenchymatous layer) that extends to the xylem pole of the second row bundles. A similar arrangement of sclerechyma is present in the Sclerieae, where there is a discontinuous sheath of sclerechyma between the first row vascular bundles with girders and extends to the second row large bundles with girders. Similarly girders bridge most of the corners of the triangular culms of Bolboschoenus maritimus (Scirpeae) and the corners of the Sclerieae culms. A similar arrangement where the SS fuse to form a sclerenchymatous layer is present in Schoenoxiphium spurtem (Cariceae). In this species, the SS of the first row bundles extend to the second row of bundles forming a sclerenchymatous layer. The SS and girders form a sclerenchymatous layer which is unique to Schoenoxiphium rufum, S. schweikerdii and the Sclerieae. A variation of the sclerenchymatous structure of Schoenoxiphium spurtem is present in Cyathocoma hexandra (Schoeneae), where the SS of the first row large and intermediate bundles form a sclerenchymatous layer that coalesces with the girders of the first row large bundles. A second variation of this sclerenchymatous layer is present in Carpha glomerata (Schoeneae) and Schoenoxiphium schweikerdii (Cariceae). In these species, the SS coalesce between the first row bundles and form a discontinuous layer of sclerechyma. The SS of Schoenoxiphium schweikerdii and the Sclerieae also form partial lignified bridges. In Schoenoxiphium schweikerdii a few of the SS of the first row and second row large bundles coalesce to form lignified bridges across the cavities. In the Sclerieae a few of the small and intermediate bundle SS extend and coalesce with the SS on the phloem pole of the second row large bundles forming small lignified bridges. As with the parenchymatous bridges of the bracts, SS are also present in the aerenchyma of Cyperus denudatus (Cypereae). Similarly, the HSS and the SS of Carpha glomerata (Schoeneae) are present abutting or adjacent the parenchymatous bridges. The presence of sclerenchymatous layers in these genera is supported by Metcalfe (1971) and Bruhl (1993) in Bolboschoenus, Cyathocoma and Schoenoxiphium. Also in Scleria by Bruhl (1993). This, from the determinations in this thesis is the first report of sclerenchymatous layers in the culms of the genus Carpha. Diagnostic cells of sclerechyma are found abutting the vascular bundles in genus Carpha, Ficinia arenicola var. arenicola, F. bulbosa, F. dura, F. stolonifera, F. trichacteata, F. zeyheri, M. solidus, M. thunbergii, M. uitenhagensis, R. barrosiana, Schoenoxiphium schweikerdii, Schoenus nigricans, Sclerieae and T. cuspidata. Lignified cells are present at the phloem pole inside the MS of the
inner large bundles of Cypereae (M. thunbergii and M. uitenhagensis, R. barrosiana (Rynchosporeae) and Schoenoxiphium schweikerdtii (Cariceae). Similar, lignified cells are present at the phloem pole in side the MS of the large bundles of the Scirpeae species Ficinia arenicola var. arenicola, F. bulbosa, F. dura, F. stolonifera, F. tribracteata and F. zeyheri. These cells are present at the phloem pole of the intermediate bundles of F. stolonifera, inside the MS. A multi-layered MS is present in the Cypereae, Schoeneae and Scirleae. In the Schoeneae (genus Carpha, Schoenus nigricans and T. cuspidata) and Sclerieae (all species) a multi-layered MS is present on the phloem and xylem poles of the inner large bundles. In M. solidus, M. thunbergii and M. uitenhagensis (Cypereae) a multi-layered MS surrounds the solenostele bundles.

Of diagnostic significance, are the hypodermal sclerenchymatous strands (HSS) of E. limosa and I. cernua of the Scirpeae, which are so small that they are almost the same size as the abutting epidermal cells. As with the bracts, the girders and HSS of Cladium mariscus subsp. jamaicense are ensheathed in a layer of translucent parenchymatous cells.

The outlines of the HSS are variable, as with the leaves and bracts. The outlines of the HSS is as follows: inverted triangular to pulviniform (Carex mossii); inverted triangular to square (Schoenoxiphium lehmannii); inverted triangular (S. schweikerdtii); triangular (B. maritimus, Cyperus sexangularis Ficinia filiculmea, Fuirena coerulescens, F. pachyrhiza, K. alata, Scirpus ficiinioides and S. nodosus); triangular to oval (C. albostriatus); rounded triangular (Ficinia arenicola var. arenicola and F. bulbosa); triangular to rectangular (Carpha glomerata and C. schlechteri); triangular to baculiform (Cladium mariscus subsp. jamaicense); triangular to pulviniform (F. filiformis and F. tenuifolia); triangular to trapeziform (I. fluitans); triangular to bulbiform (Cyperus natalensis, C. pulcher, F. lateralis, F. oligantha, F. repens, I. costata var. macra, I. pellocolea, M. congestus, M. dabius, M. macrocarpus, M. solidus, P. intactus Schoenoplectus decpiens, S. paludicola and Schoenus nigricans); triangular to crescentiform (F. indica var. indica); triangular to turbiniform (B. contexta, Cyperus marginatus and Scirpus falsus); turbiniform (C. rubicundus and F. zeyheri); turbiniform to rectangular (C. difformis); turbiniform to pulviniform (E. pauciflora, M. capensis, M. thunbergii, P. marcanthus and P. nitidas); turbiniform to bulbiform (most Cypereae); bulbiform (I. prolifera, K. brevifolia, K. erecta, M. albomarginatus and M. sumatrensis); bulbiform to pulviniform (A. capensis, Cyperus esculentus, C. longus var. tenuiflorus, C. rupestris var. rupestris, C. semitrididus var. semitrididus, F. lateralis, K. pauciflora and T. cuspidata); bulbiform to crescentiform (A. ovata, B. schoenoides, F. fascicularis, F. pingiour, F. trubracteata and I. diabolica); bulbiform to rectangular (Fimbriystylis dichotoma); bulbiform to trapeziform (B. humilis, C. denudatus, C. tenellus var. tenellus and F. ferruginea); trapeziform (F. complanata); pentagonal to hexagonal (Schoenoxiphium bracteosum); pulviniform (C. distans, C. laevigatus, Ficinia stolonifera and E. dregeana); pulviniform to square (E. limosa and I. cernua); rectangular (C. sphaerosperrum); baculiform to T-shaped (C. textilis); baculiform to pulviniform (Carpha bracteosa); trapeziform (I. natans) and crescentiform (F. cinnamomea and F. dura).

The outlines of the girders is also variable. The girders are generally inverted triangular to rectangular in outline. Additional girder shapes are as follows: triangular to turbiniform (Carex aethiopica); turbiniform to rectangular (C. glomerabilis); inverted triangular (C. mossii and Schoenoxiphium schweikerdtii); triangular (Cyperus distans) and inverted triangular to baculiform (S. lehmannii and S. rufum).
The outlines of the cavities is also variable. The outer cavity outlines are as follows: triangular (most Cariceae, Ficinia pingiour and F. tenuifolia); triangular to square (Carex aethiopica and I. cernua); triangular to rectangular (S. schweikerditii and most Scirpaceae); rectangular (Carpha schlechteri); rounded rectangular (F. indica var. indica); rectangular to square (Schoenoxiphium lehmannii, S. rafum and Scirpus ficinioideis); rectangular to oval (C. glomerabilis, most of the Cyperaeae and Schoenoxiphium sparteum); rectangular to Deep U-shaped (Carex mossii and Cyperus pulcher); rectangular to turbiniform (Fuirena hirsuta); rectangular to irregularly polygonal (Bolboschoenus maritimus, Carpha glomerata, F. coerulescens, F. pachyrhiza and I. prolifera); irregularly polygonal (Ficinia filiculmea); trapeziform (F. stolonifera) and V-shaped (C. bracteosa). The shapes of the central cavities are as follows: oval to irregularly polygonal (most of the Cyperaeae); irregularly polygonal (Carpha bracteosa and C. glomerata); triangular (Cyperus pulcher, K. erecta, K. pauciflora, M. sumatrensis, P. marcanthus and P. mundii); triangular to rectangular (C. denudatus); rectangular (K. brevifolia); rectangular to oval (A. capensis and P. cooperi); oval to square (C. textilis) and oval with wavy outlines (F. dura, F. tribracteata, Schoenus nigricans and T. cuspidata).

Tannin idioblasts are absent only in C. laevigatus, F. filiformis, F. lateralisland, Isolepis cernua, I. fluittans, I. natans, I. prolifera, M. albo-marginatus, M. uitenhagensis, P. cooperi, P. intactus, R. barossiana and Schoenoxiphium schweikerditii. Tannin idioblasts are generally scattered throughout the ground tissues. In a few instances the specific site where tannin idioblasts are present is species specific. The site or distribution of tannin idioblasts with tissues is as follows: in the concertina-shaped cells that are present in the sub-stomatal cavities (M. thunbergii); present in the chlorenchymatous tissues close to the epidermis (Cyperus albostratius, C. denudatus, C. distans, C. pulcher, C. sphaeroerpermus, P. mundii and Scleria nataleensis); within the chlorenchyma (most Cariceae, Cyperus rubicundus, C. semitrifidus var. semitrifidus, C. sexangularis, K. alata, K. brevifolia, K. erecta, K. pauciflora, M. capensis, M. congestus, M. dubius, M. sumatrensis, P. macranthus, P. nitidus, tribe Schoeneae [except Cladium mariscus subsp. jamaicense] and Scleria melanomphala); specifically on the boundary between the outer chlorenchymatous layer and the central translucent parenchymatous regions (Cyperus esculentus, C. longus var. tenuiflorus, C. natalensis, C. rupesiris var. rupesiris, C. textilis, K. alata, M. solidus, M. tabularis subsp. major and P. polystachvos var. polystachvos); in the translucent parenchyma (Cyperus marginatus and C. obtusiflorus); with the cavities (Schoenoxiphium lehmannii and S. sparteum); with the hypodermal sclerenchymatous strands (genus Fuirena); abutting bundles (Bolboschoenus maritimus, Cyperus diiformis, the genus Fuirena and K. elatior); within vascular bundles (Ascolepis capensis). Tannin idioblasts were also absent in the culms of Rhynchospora investigated by Metcalfe (1971), but were present in those investigated by Bruhl (1993). The common environmental character between the species with no tannin idioblasts is wet soils, where these species occur on riverbank habitats. The absence of tannin may be related to these two factors. The role or relationship between the absence of tannin in these species in relation to habitat is unclear.

Generally vascular bundles are solitary. The large bundles of Carpha bracteosa and C. glomerata have lateral/lateral vascular bundles. Vascular bundles are present in rows (most species) or are scattered within the ground tissues (Carpha glomerata, Cyathocoma hexandra, Cyperus immensis, C. laevigatus, C. natalensis and C. textilis). Generally vascular bundles are present within two rows. The bundles of the C3 species are mostly present in one to two rows within the culms, whilst in the C4 species they are mostly present in more than two rows. The vascular bundles may be present from one to eleven rows of bundles, as set out below. A few species have one (most of the
tribe Abildgaardieae, A. capensis, Carex glomerabilis, Cyperus tenellus var. tenellus, tribe Hypolytreae, Schoenoxiphium bracteosum, most of the Scirpeae and T. cuspidata); three (Carex aethiopica, Carpha schlechteri, Cyperus denudatus, C. obtusiflorus, C. rupestris var. rupestris, Ficinia fascicularis, Fuirena hirsuta, Isolepis prolifera, genus Kyllinga (except K. erecta), M. albomarginatus, M. capensis, Pycreus maracanthus and Scleria natalensis); four (Carex zuluensis, Cyperus distans, C. esculentus, C. longus var. tenuiflorus, C. sexangularis, M. dubius, M. sumatrensis, M. tabularis subsp. major, P. cooperi, P. nitidus, P. polystachyos var. polystachyos, Rhynchospora brownii, Schoenoxiphium rufum and S. schweikerdtii), five (M. congestus, M. uitenhagensis, P. intactus), six (Cladium mariscus subsp. jamaicense, Cyperus marginatus, Rhynchospora barrosiana), seven (M. macrocarpus), eight (M. solidus) and eleven (M. thunbergii) rows of vascular bundles. In the culms of a few of the C3 species (Carpha glomerata, Cyathocoma hexandra and Cyperus textilis) and the C4 (Cyperus immensis, C. laevigatus and C. natalensis), the vascular bundles are present in an outer peripheral row of vascular bundles, whilst the inner rows of bundles are scattered within the ground tissues.

Solenosteles are present in a few of the inner row large bundles of R. brownii (Rhynchosporeae). In this species, the protoxylem lacunae are extremely large. The phloem is absent in a few of the small bundles of the Cypereae species, M. solidus and P. cooperi. Similarly, the xylem is absent in M. solidus and M. thunbergii. A few of the large and intermediate bundles of Cladium mariscus subsp. jamaicense (Schoeneae) coalesce or merge on the xylem poles. Similarly, a few of the first row and second row large bundles, coalesce. The xylem of the first row bundle abuts the phloem of the second row bundle and the sheaths of the two bundles coalesce. A few of the small bundles in the corners of B. maritimus have the xylem facing the epidermis and not the centre of the culm.

Both Metcalfe (1971) and Bruhl (1993) note that the culms of most genera have outer layers of chlorenchyma with the peripheral bundles and translucent parenchyma or spongy parenchyma internal to this, which is evident in most of the culms of the Eastern Cape Cyperaceae. The composition and distribution of ground tissues is variable. There are three C4 and six C3 structural classes recognisable within the composition of the ground tissues.

4.2.1 Specific characteristics of the ground tissues of these C3 culms

In the C3 species, the arrangements of ground tissues are complex. There are six different structures of ground tissues present in these species. In the first structural group, which is present in C. tennellus var. tennellus (Cypereae) and Ficinia filiformis (Scirpeae), the chlorenchyma is present in a small layer abutting the epidermis. Inside the chlorenchyma is translucent parenchyma. The bundles of these species are present in the layer of translucent parenchyma. In the second structural group, which is present within most of the C3 species, the chlorenchyma is present abutting the first row of bundles. Endarch to this layer and extending to the centre of the culm is translucent parenchyma. A variation of this second structural group is present in Cyathocoma hexandra (Schoeneae) and the Sclerieae, where the chlorenchyma extends from the epidermis to the phloem side of the first and second row large bundles. Translucent parenchyma abuts this layer and extends to the centre of the culm. A second variation of this second structural group, is present in R. brownii (Rhynchosporeae) and Cladium mariscus subsp. jamaicense (Schoeneae), where chlorenchyma extends from the epidermis to the inner sclerenchymatous layer. Inside this sclerenchymatous layer, extending to the centre of the culm, is translucent parenchyma. In the third structural group, the chlorenchyma is present abutting the first row of bundles, aerenchyma is present endarch.
to this layer of chlorenchyma in *Cyperus albostriatus, C. denudatus, C. marginatus, C. sphaerospermus, C. textilis, E. dregeana, E. limosa, Ficinia repens, I. cernua, I. natans and I. pellocolea*. A variation of this third type is present in *Bolboschoenus maritimus* and the genus *Schoenoplectus* of the *Scirpeae*. In these species the chlorenchyma extends from the epidermis to the first row of bundles; endarch to this is a layer of translucent parenchyma, which extends to the second row bundles. Present inside the translucent parenchyma layer is aerenchyma. In the fourth structural group, chlorenchyma extends from the epidermis to the first row of bundles, while translucent parenchyma abuts the chlorenchyma and extends to the central cavity. The members of this group are as follows: *Carex schlechteri* of the *Cariceae; Cyperus pulcher* and *P. mundii* of the *Cypereae; the Hypolytreae; Ficinia dura, F. stolonifera, F. tenuifolia and F. tribracteata* of the *Scirpeae*. A variation of this fourth structural group, is present in *Schoenus nigricans* of the *Schoeneae*, where the chlorenchyma extends from the epidermis to the phloem side of the first and second row large bundles. A layer of translucent parenchyma abuts the chlorenchyma. Inside this translucent parenchyma is the central cavity. The fifth structural group is present in *T. cuspidata* (*Schoeneae*) and *F. pingiour* (*Scirpeae*), where chlorenchyma extends to the first row of bundles; endarch to this is the central cavity. In the sixth structural group, chlorenchyma extends to the first row of bundles; parenchymatous bridges abut a few of the first row bundles and extend to the central region of translucent parenchyma. Its species are as follows: *Carex glomerata, C. mossii, Fuirena coerulescens* and *F. pachyrhiza*. Central cavities have been previously noted in the following *C₄* genera: *Bolboschoenus* (Bruhl 1993); *Cladium* (Metcalfe 1971; Bruhl 1993); *Cyathocoma* (Bruhl 1993); *Eleocharis* (Metcalfe 1971; Govindarajalu 1985; Bruhl 1993); *Fuirena* (Govindarajalu 1985; Bruhl 1993); *Pycreus* (Metcalfe 1971; Govindarajalu 1978; Bruhl 1993); *Rhynchospora* (Metcalfe 1971); *Schoenoxiphium* (Metcalfe 1971); *Schoenus* (Metcalfe 1971; Bruhl 1993); *Scirpus* (Govindarajalu 1976; Bruhl 1993) and *Scleria* (Metcalfe 1971; Govindarajalu 1985; Bruhl 1993).

### 4.2.2 Specific characteristics of the ground tissues of these *C₄* culms

The ground tissues within the culms of the *C₄* species may be divided into three structural groups. In the first structural group, the RM is present up to the xylem pole of the large bundles and translucent parenchyma extends to the centre of the culm (the tribe *Abildgaardieae* and most of the *Cypereae*). The second structural group is present in the hydrophytic species *C. immensis, C. sexangularis, M. congestus* and *M. tabularis subsp. major*; in these species, the RM surrounds the first row of bundles, abutting this and extending to the centre of the culms is aerenchyma. In the third group, the RM is present around the first row of bundles, abutting which is a layer of translucent parenchyma. Inside this layer of translucent parenchyma is the central cavity. The third structural group is present in the species of *K. brevifolia, K. elatior, K. erecta, K. pauciflora, P. maracanthus* and *R. barrosiana*. Central cavities have been previously recognised in the following *C₄* genera: *Cyperus* (Bruhl 1993); *Mariscus* (Metcalfe 1971); *Pycreus* (Metcalfe 1971; Govindarajalu 1978; Bruhl 1993) and *Rhynchospora* (Metcalfe 1971). In many of the Eastern Cape *C₄* genera, central cavities are not present in the ground tissues.

A few cells of translucent parenchyma are also present at specific places within the ground tissues of the culms of the *C₄* *Cypereae*. A hypodermal layer is present between the HSS abutting the epidermis of *C. esculentus, C. immensis* and *M. albo-marginatus*. In *M. dubius, M. sumatrensis, M. tabularis subsp. tabularis, M. thunbergii* and *P. nitidus* a sheath of translucent parenchyma abuts the HSS, but does not extend to the epidermis.
4.2.3 Specific characteristics of the vascular tissues of these C₃ culms

In the C₃ species, most of the inner rows consist of large bundles. In *Carpha glomerata* and *C. schlechteri* of the Schoeneae, as well as *Ficinia fascicularis, Fuirena hirsuta* and *I. prolifera* of the Scirpeae, the second row of bundles is composed of large, intermediate and small bundles. Large and intermediate bundles are present in the second row of bundles of *Cyperus textilis* (Cypereae), *R. brownii* (Rhynchosporeae) and *Cladium mariscus* subsp. jamaicense (Schoeneae). The inner rows of these species are composed of large bundles. Diagnostic of *Fuirena coerulescens* is the second row of bundles present at right angles to the first row. These vascular bundles lie with their long axis parallel to the epidermal surface.

Generally the thickening in the radial and inner tangential walls of the MS is more pronounced on the phloem side and abutting the MX. In *F. bulbosa* (intermediate and small bundles) the MS are more thick-walled on the phloem side of the bundle. In *E. dregeana, E. limosa, Fuirena hirsuta, F. pachyrrhiza, Schoenoxiphium bracteosum* and *S. sparteum* the thickening in the radial and inner tangential walls of the MS is comparatively thin-walled in all the MS cells of the vascular bundles.

The MS cells of most of the Scirpeae are thick-walled in the inner tangential walls. The MS cells are thick-walled on the phloem side of the bundle and adjacent the large metaxylem vessels in *Ficinia arenicola* var. *arenicola* (intermediate bundles), *F. fascicularis* (intermediate and small bundles), *F. lateralis* (large and intermediate bundles), *I. costata* var. *macra* (large and intermediate bundles), *I. fluitans* (large bundles), *I. prolifera* (large, intermediate and small bundles), *Schoenoplectus paludicola* (large and small bundles) and *Scirpus falsus* (large, intermediate and small bundles). The MS cells of in *F. arenicola* var. *arenicola* (large bundles), *F. bulbosa* (large bundles), *F. fascicularis* (large bundles), *F. indica* var. *indica* (large and intermediate bundles), *F. lateralis* (small bundles), *F. repens* (large, intermediate and small bundles), *I. pellocolea* (large and intermediate bundles) and *Scirpus ficinioides* (large, intermediate and small bundles) are thick-walled in the inner tangential walls on the phloem side of the bundle.

In *B. maritimus* (intermediate and small bundles), *F. arenicola* var. *arenicola* (small bundles), *F. cinnamomea* (all bundles), *F. lateralis* (large bundles), *F. oligantha* (large bundles), *F. tenaifolia* (large and intermediate bundles), *Schoenoxiphium rufum, S. schweikerdtii* and *Scirpus nodosus* (all bundles) the thickening is similar in all the walls of the MS cells. Where the lignification within the MS cells of *F. cinnamomea* (all bundles), *F. lateralis* (large bundles), *F. oligantha* (large bundles), *F. tenaifolia* (large and intermediate bundles), *Schoenoxiphium rufum* and *Scirpus nodosus* (all bundles) is extenuated at the phloem side of the bundles as well as abutting the MX. In *B. maritimus* (intermediate and small bundles), *F. arenicola* var. *arenicola* (small bundles) and *Schoenoxiphium schweikerdtii* the lignification of the MS cells is extenuated only on the phloem side of the vascular bundles.

The MS cells in *F. cinnamomea, F. oligantha, F. lateralis*, *F. stolonifera, F. tenaifolia, F. zeyheri* and *S. ficinioides* are so thick-walled that the entire MS cell is filled with lignin (Plate 51.6). These MS cells are also so large that they are almost the same size as the PS cells. Extremely thick deposits of lignin in the MS cells are also present in *F. dura, F. filiculmea, F. repens* and *S. falsus*. 
The outlines of the phloem tissue are variable, with the following observable: oval to circular (C. aethiopica [intermediate and small bundles], Cyperus albostriatus [large and intermediate bundles], C. denudatus [large bundles], C. pulcher [all bundles], C. sphaerospermus [large and intermediate bundles], S. lehmannii [intermediate bundles], S. rufum [intermediate bundles], S. sparteum [large and small bundles] and Scleria melanomphala [large bundles]); oval (C. difformis [large bundles], C. marginatus [large bundles], C. tennellus var. tennellus [intermediate bundles] and Schoenus nigricans [intermediate and small bundles]); oval to square (Carex aethiopica [large bundles], C. glomerabilis [intermediate bundles], Cyperus sphaerospermus [small bundles], C. tennellus var. tennellus [large bundles], Schoenoxiphium bracteosum [large and small bundles], S. lehmannii [large bundles], most Scirpeae and Scleria natalensis [intermediate bundles]); oval to triangular (E. pauciflora [small bundles], F. filiculmea [large bundles], F. lateralis [small bundles], F. oligantha [large bundles], F. pingiour [large and intermediate bundles], F. stolonifera [large and intermediate bundles], I. cernua [large, intermediate and small bundles], I. diabolica [large and intermediate bundles], I. prolifera [intermediate bundles], most Schoeneae, Schoenoplectus decipiens [intermediate and small bundles], S. paludicola [large, intermediate and small bundles], Schoenoxiphium rufum [large bundles], S. sparteum [intermediate bundles], Scirpus falsus [large, intermediate and small bundles], S. ficinioides [large, intermediate and small bundles] and S. natalensis [intermediate bundles]); oval to rectangular (Chryzithrix capensis [intermediate and small bundles]); oval to rectangular to triangular (C. denudatus [intermediate bundles]); oval to scutiform (Carex mossii [intermediate and small bundles], C. glomerabilis [large bundles], C. zuluensis [intermediate and small bundles], Cyperus marginatus [small bundles], R. brownii [all bundles] and Schoenoxiphium rufum [small bundles]); oval to semicircular (B. maritimus [intermediate and small bundles], Carex mossii [large bundles], C. zuluensis [large bundles], Carpha schlechteri [small bundles], Chryzithrix capensis [large bundles], Cladium mariscus subsp. jamaicense [intermediate bundles], Cyperus marginatus [intermediate bundles], C. textilis [all bundles], F. repens [intermediate bundles], I. fluitans [small bundles], P. mundii [all bundles] and Scleria melanomphala [intermediate bundles]); semicircular (Carpha glomerata [small bundles], Cladium mariscus subsp. jamaicense [small bundles], Cyathocoma hexandra [intermediate and small bundles], Cyperus denudatus [small bundles], C. difformis [intermediate and small bundles], E. dregeana [intermediate bundles], F. arenicola var. arenicola [small bundles], F. dura [large and small bundles]. F. lateralis [small bundles] and F. tribracteata [small bundles]); semicircular to triangular (Carpha glomerata [intermediate bundles]); semicircular to scutiform (Schoenoxiphium schweikerditii [all bundles] and Scleria melanomphala [small bundles]); scutiform (Carex glomerabilis [small bundles] and S. natalensis [small bundles]); V-shaped to rectangular (Schoenoxiphium bracteosum [small bundles]); triangular (A. capensis [large bundles], Carpha bracteosula [large bundles], C. glomerata [large bundles], F. lateralis [small bundles] and Scirpus nodosus [large and small bundles]); V-shaped to oval (Cyperus textilis [intermediate bundles]); V-shaped to semicircular (A. capensis [small bundles], generally the xylem outlines of the vascular bundles are V-shaped. Additional xylem outlines are as follows: V-shaped to rectangular (genus Carex, Carpha glomerata [small bundles], I. prolifera [small bundles], S. bracteosula, S. rufum, S. sparteum, Scleria melanomphala [intermediate bundles] and S. natalensis [intermediate bundles]; V-shaped to buliform (R. brownii [small bundles]); V-shaped to crescentiform (Schoenoxiphium schweikerditii); V-shaped to oval (Cyperus textilis [intermediate bundles]);
Carpha schlechteri [intermediate bundles], Cyathocoma hexandra [intermediate bundles], F. arenicola var. arenicola [small bundles], F. filiculmea [small bundles], I. pellocolea [intermediate and small bundles] and R. brownii [outer large bundles]; semicircular (B. maritimus [intermediate and small bundles], Carpha schlechteri [small bundles], Chrysithrix capensis [large and intermediate bundles], Cyathocoma hexandra [small bundles], Cyperus textilis [small bundles], F. lateralis [intermediate and small bundles], F. repens [small bundles], F. tribracteata [small bundles] and Schoenoxiphium lehmannii); semicircular to inverted V-shaped (T. cuspidata [small bundles]); semicircular to rectangular (Cladium mariscus subsp. jamaicense [small bundles] and Scleria melanomphala [small bundles]); rectangular (Chrysithrix capensis [small bundles], Cyperus difformis [small bundles], Fuirena hirsuta [small bundles] and S. natalensis [small bundles]); rectangular to square (C. sphaerospermus [small bundles]); circular to oval (F. hirsuta [large and intermediate bundles] and R. brownii [inner large bundles]); bulbiform to scutiform (R. brownii [intermediate bundles]) and inverted V-shaped (T. cuspidata [intermediate bundles]).

4.2.4 Specific characteristics of the vascular tissues of these C₄ culms

The first row of bundles in the culms of the C₄ species is mostly composed of large, intermediate and small bundles. The first row of bundles of the Abildgaardieae and R. barrosiana (Rhynchosporeae) is composed of intermediate and small bundles. The inner rows of the Abildgaardieae species consist of large and intermediate bundles. In the Cypereae most of the inner rows of bundles are composed of large bundles. In Cyperus laevigatus the second row is composed of large and intermediate bundles, while in C. rupestris var. rupestris the second row consists of small bundles; the inner rows of both species consist of large bundles. In R. barrosiana the second row consists of intermediate bundles and the inner rows of large bundles.

In the MS walls are more thickened in the radial and inner tangential walls of the cells in A. ovata (large and intermediate bundles), Bulboystis contexta (large and intermediate bundles), C. esculentus (large bundles), C. laevigatus (large bundles), C. longus var. tenuiflorus, C. rubicundus (large bundles), C. rupestris var. rupestris (large bundles), C. semitridius var. semitridius (large bundles), Fimbristylis complanata (large bundles), F. dichotoma (large and intermediate bundles), K. elatior (large and intermediate bundles), M. congestus (large and intermediate bundles), M. macrocarpus (large bundles), M. sumatrensis (large and intermediate bundles), M. thunbergii (large and intermediate bundles), P. intactus (large and intermediate bundles), P. maracanthus (large and intermediate bundles) and P. nitidus (large and intermediate bundles). Where the lignification within the walls of these MS cells is more extenuated on the phloem side, as well as abutting the large metaxylem vessels in A. ovata (large bundles), Bulboystis contexta (large and intermediate bundles), C. esculentus (large bundles), C. rubicundus (large bundles), C. rupestris var. rupestris (large bundles), C. semitridius var. semitridius (large bundles), Fimbristylis dichotoma (large bundles), M. congestus (large and intermediate bundles), M. macrocarpus (large bundles), P. maracanthus (large and intermediate bundles) and P. nitidus (large and intermediate bundles). In C. laevigatus (large bundles), C. longus var. tenuiflorus, K. elatior (large and intermediate bundles), M. thunbergii (large and intermediate bundles) and P. nitidus (large bundles) the lignification is the most extenuated on the phloem side of the large bundles. The lignification is most extenuated in the walls of the MS abutting the MX in A. ovata (intermediate bundles), C. complanata (large bundles), F. dichotoma (intermediate bundles), M. sumatrensis (large and intermediate bundles) and P. intactus (large and intermediate bundles).
All the cells of the MS are similarly thickened B. contexta, B. hispidula, B. humilis, B. schoenoideas, C. natalensis, C. obtusiflorus, F. ferruginea, K. alata, K. erecta (outer row large bundles), M. albomarginatus (outer row large bundles), M. capensis (inner row large bundles), M. dubius (outer row large bundles), M. tabularis subsp. major (inner row large bundles) and P. cooperi (outer row large bundles). Where the lignification is extenuated on the phloem side of the bundle in B. contexta and in B. humilis. In B. hispidula, B. schoenoideas and F. ferruginea the lignification within the walls of the MS is more extenuated on the phloem side, as well as abutting the MX of the bundle.

The MS cells in C. distans, C. esculentus (intermediate and small bundles), C. semitrifidus var. semitrifidus (intermediate and small bundles), C. sexangularis, K. brevifolia, K. elatior (small bundles), K. erecta (intermediate and small bundles), M. albomarginatus (intermediate and small bundles), M. congestus (small bundles), M. dubius (intermediate and small bundles), M. solidus, M. sumatrensis (intermediate and small bundles), M. tabularis subsp. major (intermediate and small bundles), M. thunbergii (small bundles), M. uitenhagensis (intermediate and small bundles), P. intactus (small bundles) and P. polystachyos var. polystachyos are thin-walled.

The phloem outlines of the different bundles varies. Phloem outlines are as follows: oval to circular (most Abildgaardieae, C. distans [large bundles] and C. sexangularis [large bundles]); oval (C. distans [intermediate bundles], C. longus var. tenuiflorus [large bundles], C. natalensis [large bundles] and C. obtusiflorus [intermediate bundles]); oval to square (C. laevigatus [small bundles], C. rupestris var. rupestris [large bundles], C. tenax [intermediate bundles] and K. brevifolia [intermediate bundles]); oval to semicircular (M. tabularis subsp. major [large bundles]); oval to scutiform (C. immensis [small bundles], C. natalensis [intermediate bundles], C. rupestris var. rupestris [small bundles], K. erecta [intermediate bundles], K. pauciflora [intermediate bundles] and M. solidus [small bundles]); oval to rectangular (A. ovata [intermediate bundles], C. laevigatus [large bundles] and C. tenax [large bundles]); oval to rectangular to triangular (C. obtusiflorus [large bundles]); oval to crescentiform (B. humilis [small bundles]); oval to triangular (B. hispidula [large bundles], C. distans [intermediate bundles], C. esculentus [large bundles], C. semitrifidus var. semitrifidus [large bundles], F. dichotoma [small bundles], K. brevifolia [large bundles], K. elatior [large bundles], K. erecta [large bundles], K. pauciflora [large bundles], M. albomarginatus [large bundles], M. congestus [large bundles], M. dubius [intermediate bundles] and M. sumatrensis [large bundles]); triangular (B. schoenoideas [large bundles], F. dichotoma [small bundles], M. dubius [large bundles], P. cooperi [large bundles], P. intactus [large bundles], P. polystachyos var. polystachyos [large bundles] and R. barrosiana [large bundles]); triangular to square (K. alata [large bundles], M. capensis [large bundles], M. macrocarpus [large bundles] and M. solidus [large bundles]); triangular to semicircular (B. schoenoideas [intermediate bundles] and M. thunbergii [large bundles]); triangular to scutiform (C. esculentus [small bundles], C. semitrifidus var. semitrifidus [small bundles], K. elatior [small bundles], K. erecta [small bundles], K. pauciflora [small bundles], M. congestus [intermediate and small bundles], M. thunbergii [intermediate bundles], M. uitenhagensis [large bundles] and P. intactus [intermediate bundles]); triangular to semicircular (P. polystachyos var. polystachyos [intermediate bundle]); triangular to rectangular (K. brevifolia [small bundles] and M. capensis [small bundles]); rectangular (C. semitrifidus var. semitrifidus [intermediate bundles]); rectangular to pentagonal (B. schoenoideas [small bundles] and P. macranthus [large bundles]); rectangular to square (K. elatior [intermediate bundles] and M. sumatrensis [intermediate bundles]); rectangular to scutiform (C. natalensis [small bundles], C. obtusiflorus [small bundles], C. tenax [small bundles], M. dubius [small bundles], M. thunbergii [small bundles], M.
uitenhagensis [intermediate and small bundles] and P. macranthus [intermediate and small bundles]); rectangular to semicircular (C. esculentus [intermediate bundles] and R. barrosiana [intermediate and small bundles]); semicircular (C. immensis [large bundles]); semicircular to pentagonal (P. nitidus [large bundles]); semicircular to scutiform (C. immensis [intermediate bundles], M. tabularis subsp. major [intermediate bundles], P. cooperi [intermediate and small bundles] and P. nitidus [intermediate bundles]); scutiform (M. albomarginatus [intermediate and small bundles], P. intactus [small bundles], P. nitidus [small bundles] and P. polystachyos var. polystachyos [small bundles]); scutiform to circular (M. solidus [intermediate bundles]); scutiform to V-shaped (M. macrocarpus [small bundles]); scutiform to square (C. longus var. tenuiflorus [intermediate and small bundles], K. alata [intermediate and small bundles], M. capensis [intermediate bundles], M. sumatrensis [small bundles] and M. tabularis subsp. major [small bundles]); square to V-shaped (M. macrocarpus [intermediate bundles]); circular (C. laevigatus [intermediate bundles], C. rubicundus [large and intermediate bundles] and C. sexangularis [intermediate bundles]); crescentiform (B. hispidula [intermediate and small bundles]) and crescentiform to rectangular (B. contexta, small bundles).

Xylem outlines as with the leaves and bracts is generally V-shaped. The additional xylem outlines are as follows: V-shaped to oval (B. humilis [small bundles], C. distans [intermediate and small bundles], C. longus var. tenuiflorus [small bundles], M. albomarginatus [small bundles], M. congestus [small bundles] and M. dubius [small bundles]); V-shaped to scutiform (R. barrosiana [large and intermediate bundles]); V-shaped to rectangular (most Abildgaardieae [intermediate bundles], C. esculentus [intermediate bundles], C. natalensis [intermediate bundles], C. obtusiflorus [intermediate bundles], C. rubicundus [intermediate bundles], C. tenax [intermediate bundles], genus Fimbristylis [small bundles], K. elatior [intermediate bundles], K. erecta [intermediate bundles], K. pauciflora [intermediate bundles], M. albomarginatus [intermediate bundles], P. intactus [intermediate bundles], P. nitidus [intermediate bundles] and P. polystachyos var. polystachyos [intermediate bundles]); rectangular (C. laevigatus [intermediate bundles] and C. sexangularis [small bundles]); V-shaped to oval to rectangular (K. pauciflora [small bundles]); rectangular to square (C. tenax [small bundles] and R. barrosiana [small bundles]); rectangular to oval (A. ovata [intermediate bundles], C. laevigatus [small bundles], K. elatior [small bundles]); rectangular to triangular (C. natalensis [small bundles], C. obtusiflorus [small bundles], C. rubicundus [small bundles], C. rupestris var. rupestris [small bundles] and C. semitridis var. semitridis [small bundles]); crescentiform (B. contexta [small bundles] and B. hispidula [intermediate bundles]) and crescentiform to semicircular (B. schoenoides [intermediate bundles]). S 1 bundles have circular xylem. The xylem is present in a single layer of metaxylem vessels, which surrounds the phloem tissue. S 2 bundles have V-shaped to circular xylem (Plates 23.12 and 24.1). The xylem mostly resembles the intermediate bundles. In a few bundles there is a similarity to the S 1 bundles, with xylem surrounding the phloem (Plate 23.11).
Appendix 5: List of Eastern Cape Cyperaceae species

The following is a listing of the Cyperaceae present in the Eastern Cape region of Southern Africa. This list was constructed using the Pretoria Precis listing from specimens housed in PRE and TM. This appendix also lists all the specimens that the author collected, as well as those housed in the Schönland Herbarium (GRA) in Grahamstown. The list also details where all the author's specimens are housed in: GRA, MG, NU and NE.

The listing of genera, species, subspecies and varieties is in alphabetical order, as well as the localities where the specimens were collected. The naming is according to the names and synonymy used in Gordon-Gray (1995) and Arnold and de Wet (1993).

A CD containing this list in microssoft word 97 is attached below for your information.
PREFACE
The following list is a listing of the Cyperaceae in the Eastern Cape region of Southern Africa. This list was constructed using the Pretoria Precis listing (PRE and TM), and from the actual specimens themselves, in the then known Albany Museum (GRA) and Rhodes University (GRA) Herbaria. Most of the Species that I have collected are housed both in GRA, some at the University of Natal Herbarium (UN) in Pietermaritzburg and a few at the University of New England Herbarium (NE) in Armindale, Australia.

The listing of genera, species, subspecies and variety's is in alphabetical order, as well as the localities were the specimens were collected. It must be stated that the Pretoria Precis listings were inaccurate and thus the Specimens where possible, were used for the accurate descriptions of habitat.

The table of contents is a helpful guide to see what has been collected in the Eastern Cape region. This listing of localities and species is only the second edition and thus is not totally representative of all the Cyperaceae species collected in the region but is representative of what workers within the region have collected. It is however, hoped that this publication will be an aid to Cyperologists and systematists. The naming is according to the names and synonymy used according to Gordon-Gray (1995) and the list of species of South African plants, Arnold and de Wet (1993).
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<td>F. FICILUMEA B.L.BURTT 2650</td>
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<td>F. FILIFORMIS (LAM.) SCHRAD. 2700</td>
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<td>F. GRACILIS (POIR.) SCHRAD. 2800</td>
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<td>F. INDICA (LAM.) PFEIFFER VAR. INDICA 2900</td>
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<td>E. INVOLUTA NEES 3000</td>
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<td>F. LACINIATA (THUNB.) NEES 3300</td>
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<td>F. LATERALIS (VAHL.) KUNTH. 3500</td>
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<td>F. LEIOCARPA NEES 3540</td>
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<td>E. NIGRESCENS (SCHRAD.) J.RAYNAL 3950</td>
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<td>E. OIGANATHA (STUD.) J.RAYNAL 3950</td>
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<td>E. PINGOUR C.B.Clarke 4300</td>
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<td>E. POLYSTACHYA LEVYNS 435</td>
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<td>F. RAMOSISSIMA KUNTH. 4850</td>
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<td>E. REPENS (NEES) KUNTH. 4900</td>
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<td>F. STOLONIFERA BOECK. 5300</td>
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<td>E. SYLVIATICA KUNTH. 5500</td>
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<td>E. TENUIFOLIA KUNTH. 5600</td>
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<td>E. TRISTACHYA (ROGTTB.) NEES 5800</td>
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<td>E. TRUNCATA (THUNB.) SCHRAD. 5900</td>
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<td>F. ZEYHERI BOECK. 6000</td>
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<td>F. COMPLAINATA (RETZ.) LUSK. 400</td>
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<td>F. DICHOTOMA (L.) VAHL. 500</td>
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<td>E. FERRUGINEA (L.) VAHL. 600</td>
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<td>F. COERULESCENS STEUD. 300</td>
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<td>E. ECKLONJI NEES 400</td>
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<td><em>I. costata</em> (Boeck.) Rich. var. <em>macra</em> (Boeck.) B.I. Burtt</td>
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<td><em>I. incommuta</em> Nees</td>
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<td><em>I. natans</em> (Thunb.) Dietr.</td>
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<td><em>I. prolifera</em> (Rottb.) R.Br.</td>
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<td><em>I. sepulcralis</em> Steud.</td>
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<td>SCIRPUS</td>
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ABILDGAARDIA Vahl. 0471020

A. ovata (Burm.f.) Kral 150

Woodstock Farm, on the hill above the railway line, 3226DD, Alice District, GIFFEN 175 (PRE).

The hill East of the main peak of Menziesberg, 975m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1310 (PRE).

Round Hill (Oribi Reserve), in a grassy area, 50m from the Conservation house, near the path leading to the trig beacon, 375m above sea level, 3326BD, Bathurst District, SONNENBERG 277 (GRA, UN).

Round Hill (Oribi Reserve), grassland, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 161 (GRA).

3327BB, East London, RATTRAY 815 (GRA).

Overton Farm, 11 miles West of East London, common on all veld, a ½ to 2 miles from the sea, 3227BB, East London District, HILNER 180 (GRA, PRE).


Road to Hagga Hagga, 4 kilometre's from the Hagga Hagga turnoff, on a slope above a large dam, opposite large Eucalyptus and Eleocharis species, sandy soil, 3228CD, Hagga Hagga District, SONNENBERG 444 (GRA, UN).

Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth, SONNENBERG 403 (GRA, UN).

1000m above sea level, 3228CB, Kentani District, PEGLER 1096 (GRA).

Common on sandy soils, on a hill above the Cemetery, on the Eastern slopes, 3000ft above sea level, 3227CD, King William’s Town District, HILNER 105 (GRA).

Near Keiskammahoek, on a dry rocky slope, on the common, 2000ft above sea level, 3227CA, King William’s Town District, DYER 319 (GRA).

Stockton Farm, Kei road, in the grassveld between the main road and the railway fence, 3227DA, King William’s Town District, COMINS 1778 (GRA).

Pastures near Komga, in grassland, 610m above sea level, 3227DB, Komga District, FLANAGAN 914 (GRA, PRE).

Near a damp water course, in grassveld, 4000ft above sea level, 3227DB, Komga District, DYER 8024 (GRA).

Rockcliff near Sidbury, 3326AC, Sidbury District, DALY 824 (GRA, PRE).

Dohne Research Station, in grassland, 3227CB, Stutterheim District, ACOCKS 9266 (PRE).

ASCOLEPIS Nees ex Steud. 0454000

A. capensis (Kunth) Ridley 100

In a marsh, 1463m, 3226DB, Alice, RATTRAY 1 (GRA, PRE).

Gaika's Kop area, beneath the mountain, in a marsh, 1399m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 173 (PRE).
The main ridge above the Foresters Cottage, towards the Hogsback, in a marsh, 1675m above sea level, 3226DB, Hogsback District, DYER 776 (GRA, PRE).

Central Hog, in a marsh on the Gaika's Kop side of the Hog, half way up the Hog, 3226DB, Hogsback, SONNENBERG 314 (GRA, UN).

Tore Doone, 1214m above sea level, 3226DB, Hogsback, GIFFEN 1344 (PRE).

**BOLBOSCHOENUS PALLA 0468030**

*B. maritimus* (L.) Palla 100

Fish River Lighthouse, in a salt marsh, somewhat decumbent, upright, 3327CA, Bathurst District, HILL, DB. 2230 (GRA).

Fish River Mouth, in a small vlei, 250m from the sea, plants in the water surrounded by clumps of *Juncus* sp., 3327CA, Bathurst District, SONNENBERG 212 (GRA).

Riet River Mouth, at the edge of the water, salt marsh, clay-mud, 3326DB, Bathurst District, LUBKE 93 (GRA).

Watersmeeting Nature Reserve, on the muddy banks of the Kowie River, 3326BC, Grahamstown District, BURROWS 2787 (GRA).

Marshy spots, 200ft above sea level, 3228CB, Kei Mouth, FLANAGAN 1892 (GRA).

Ghio marsh, on the farm Spadona, under a slope hill, 3326CA, Kenton-on-Sea District, SKEAD A7503 (GRA).

Ntshala River Mouth, going is the dune sand, on the side opposite Morgan's Bay, close to the Nature Conservation offices, 3228CB, Morgan's Bay, SONNENBERG (GRA, UN).

Salt vlei, at the edge of the water, partially submerged, Port Alfred, BRITTEN 2997 (GRA).

Salt vlei, at the margin of a pond, in the dunes behind the beach, 10m above sea level, 3326DB, Port Alfred, MAUVE & WELLS 9 (GRA).

Creek, ground covered at times with sea water, 3325DC, Port Elizabeth, DREGE 647 (GRA).

Perseverance, Swartkops River, on the mud banks, near landing stage, ±1/4 miles below ebb and flow, 3325DC, Port Elizabeth District, ARCHIBALD 5180 (GRA).

Redhouse, Port Elizabeth, PATERSON 445 (GRA).

Swartkops estuary, amongst *Sporobolus pungens*, in a sluit intermediate between fresh and salt water zones, Port Elizabeth District, ARCHIBALD 5014 (GRA).

**BULBOSTYLIS Kunth. 0471010**

*B. contexta* (Nees) Bodard 700

Bushman's River Farm, on the Southern facing Witteberg outcrop, Salem-Alexandria road, 3326CB, Alexandria District, MARTIN 8207 (GRA).

Bushman's River Mouth, in a grassland, 30m above sea level, 3326DA, Alexandria District, KILLICK 1768 (PRE).

31.4 Kilometre’s from Bathurst, travelling towards the Grahamstown Hills, 3326BD, Bathurst District, ARNOLD 611 (PRE).
Bathurst commonage, in the grass between the bushclumps, 200m from the Waters Meeting Reserve-Bathurst road, 2 kilometre’s from Bathurst, 3326BD, Bathurst District, SONNENBERG 226 (GRA).

12.5 Kilometre’s from Coombs, on the road to Trappes Valley, on stony ground, in a grassland, 3326BD, Bathurst District, ARNOLD 638 (PRE).

8 Kilometre’s from Port Alfred, travelling towards Fish River Mouth, 3326DB, Bathurst District, ARNOLD 589 (PRE).

Round Hill (Oribi Reserve), in bushclump grassland, 50m from the Conservation house, near the path leading to the trig beacon, 3326BD, Bathurst District, SONNENBERG 272 (GRA, UN).

Trappes Valley, 3326BD, Bathurst District, DALY (GRA).

4 Miles South of Guildford, in a grassland, 1370m above sea level, 3226BB, Cathcart District, ACOCKS 20138 (PRE).

3326BC, Grahamstown, DALY & SOLE 221, 237, 1046 (GRA); BRITTEN sn. (GRA un-numbered).

Above Featherstone Kloof near Woest Hill, 1900ft above sea level, 3326BC, Grahamstown, LUBKE 159 (GRA).

Near Grey Dam, 3326BC, Grahamstown, DALY & SOLE 44 (GRA).

Gunfire Hill, 3326BC, Grahamstown, BRITTEN 5911 (GRA).

Sandy Drift near Grahamstown, 3326BC, Grahamstown District, DALY (GRA).

Mountains near Humansdorp, in the grassy fynbos, sandy soil, 3324DD, Humansdorp District, SONNENBERG 498 (GRA, UN).

Buffelsbos, in derived sourveld, in the mountains, 90m above sea level, 3424BB, Humansdorp District, COWLING 1480 (GRA).

On grassy slopes, 200ft above sea level, 3228CB, Kei Mouth, FLANAGAN 2360 (GRA).

Kei Mouth golf course, sandy soil, 3228CB, Kei Moth, SONNENBERG 399 (GRA).

Common on a hill above the Cemetery, on the Eastern slopes, on sandy soil, 3000ft above sea level, 3227CD, King William’s Town District, HILNER 106 (GRA).

Van Stadens Flower Reserve, on the sandflats, on the shales cleared of bush, 100m above sea level, 3325CC, Port Elizabeth District, DAHLSTRAND 2526, 2527 (GRA).

5 Kilometre’s before Van Stadens River Mouth, on a hill, in grassland, 3325CC, Port Elizabeth District, ARNOLD 649 (PRE).

Suurberg Mountains, 3325BC, Port Elizabeth District, LUBKE 23 (GRA).

Northern foothills of the Suurberg, 500m up the road, travelling from Ann’s Villa, in fynbos, on stony ground, 650m above sea level, 3325BD, Port Elizabeth District, TAYLOR 9431 (PRE).

The Western end of Kabaku Hills, in a forest, on stony ground, 3227CB, Stutterheim District, ACOCKS 9180 (PRE).

Stutterheim Commonage, in grassland, 855m above sea level, 3227CB, Stutterheim, ACOCKS 9157 (PRE).

Stutterheim Commonage, near the Cumakala River, in grassland, 825m above sea level, 3227CB, Stutterheim District, ACOCKS 9246 (PRE).

\textit{B. densa} (Wall.) Hand.-Mazz. 730

Fort Fordyce, 1160m above sea level, 3226CB, Fort Beaufort District, KILLICK 865 (PRE).
Top of the Hogsback Plateau, on a cliff, 1830m above sea level, 3226DB, Keiskammahoek District, KILLICK 1762 (PRE).

*B. hispidula* (Vahl.) R.Haines 770


Paradise Kloof, in the grassveld under a ridge, 2000ft above sea level, 3326BC, Grahamstown District, LUBKE 79 (GRA).

Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth, SONNENBERG 408 (GRA).

*B. humilis* (Kunth.) C.B.Clarke 800

Witteberg Quartzite outcrops, in the Highlands area, "Mill Hills", 18.2 miles from Grahamstown, 1500ft above sea level, 3326AD, Albany District, COMMINS 957 (GRA).

Bushman’s River Mouth, in grassland, 30m above sea level, 3326DA, Alexandria District, KILLICK 1762 (PRE).

Kenton-on-Sea, in a forest, 30m above sea level, 3326DA, Alexandria District, ACOCKS 18336 (PRE).

Cape Padrone, on the Coast road, in town, in grassland, 90m above sea level, 3326DC, Alexandria District, ARCHIBALD 5532 (PRE).

On the path to Alice, in the Hogsback Forestry Reserve, 750m above sea level, 3226DB, Amatole Mountains, DAHLSTRAND 2679 (PRE).

Bathurst Common, in the grassland between the bushclumps, 3 kilometre’s from Bathurst, on the Southwell road, 150m from the road, 33326DB, Bathurst District, SONNENBERG 230 (GRA).

1.2 Miles from Forestdale, on the road to Bathurst, in a grassland, 460m above sea level, 3326BD, Bathurst District, KILLICK 755 (PRE).

Tharfield Private Nature Reserve, in the grassland 700m from the Port Alfred-Fish River Mouth road, on the fourth dune ridge from the sea, 3327CA, Bathurst District, SONNENBERG 210 (GRA).

1.5 Kilometre’s West of Cintsa West, on a farm road verge, 500m from the sea, in coastal thicket, 3227CC, East London District, SONNENBERG 247 (GRA, UN).

Overton Farm, 11 miles West of East London, 3327BB, East London District, HILNER 192 (PRE).

Faraway, Portion 3 of Coldsprings, on a trampled track between the main house and the labourers quarters, 700m above sea level, 3326AD, Grahamstown District, JACOT-GUILLARMOD 10217 (GRA).

Grahamstown Golf Course, next to the second tee, in sandy soil of a grassy thicket, 3326BC, Grahamstown, SONNENBERG 268 (GRA, UN).

Near Grey Dam, 3326BC, Grahamstown, DALY & SOLE 43 (GRA).

In a donga, ½ a mile past Hamilton Dam, on the Eastern aspect, shaded by trees at the foot of the Koppie, 1800ft above sea level, 3326BC, Grahamstown, DYER 100 (GRA).

Above the Quarry, in the grass and on bare ground, in grassland, 2000ft above sea level, 3326BC, Grahamstown, LUBKE 66 (GRA).

Rhodes University, near Brickfields, in Ericoid Scrub, on damp sandy soil, 3326BC, Grahamstown, BELL 6 (GRA).

Thomas Baines Nature Reserve, disturbed thorn savannah, 3326BC, Grahamstown, ANON 59 (GRA).
Waterloo Farm, 100m from the Grahamstown-Port Alfred road, 200m from the Grahamstown-King William’s Town bypass, 1.5 kilometre’s from Grahamstown, in Acacia sp. invaded grassland, on dry ground, 650m above sea level, 3326BC, Grahamstown District, SONNENBERG 239 (GRA).

Auckland Trust Forest, 750m above sea level, 3226DB, Hogsback, DAHLSTRAND 2679, 2707 (GRA).

Brandewynkop near Oyster Bay, in derived grassland, 30m above sea level, 3424BB, Humansdorp District, COWLING 200 (GRA).

Nquamaya Ridge, 6.5 kilometre’s from Keiskammahoek Bridge, on the road to Debe Nek, in forest, 762m above sea level, 3227CC, Keiskammahoek District, STORY 3413 (GRA, PRE).

Pirie, 3227CB, King William’s Town District, SIM 2841 (PRE).

11 Miles from Keiskammahoek, on the road to King William’s Town, 915m above sea level, 3227CC, King William’s Town District, KILLICK 884 (GRA, PRE).

5 Kilometre’s from the Van Stadens River Mouth, in grassland, 3325CC, Port Elizabeth District, ARNOLD 650 (PRE).

Elandsrivier Catchment Basin, 100m West of Nounek, Groendal Wilderness, in fynbos, on a rock face, 520m above sea level, 3325CA, Uitenhage District, SCHARF 1080 (PRE).

B. oritrephes (Ridl.) C.B.Clarke subsp. oritrephes 1000

Baviaansrivierberg, on Schone’s Farm, in grassland, 1525m above sea level, 3226AC, Bedford District, KILLICK 837 (PRE).

3226BC, Grahamstown, BRITTEN sn. (GRA No. 7th September).

Above Featherstone Kloof, near Woest Hill, amongst the grasses, on a rocky slope, 1900ft above sea level, 3326BC, Grahamstown, LUBKE 21, 160 (GRA).


3226DB, Hogsback, RATTRAY 256, 257 (GRA).

Keiskammahoek area, near Ghulu Kop, in an experimental plot, 4000ft above sea level, 3227CA, King William’s Town District, DYER 291 (GRA).

Keiskammahoek area, above Nyameni Forest, 4000ft above sea level, 3227CA, King William’s Town District, DYER 797 (GRA).

Pastures near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 923 (GRA, PRE).

Suurberg Mountains, near the Hotel, on the mountain slopes, 3325BD, Port Elizabeth District, HILL, P. sn. (GRA No. 9862).

Fort Cunynghame, 3000ft above sea level, 3227CB, Stutterheim District, SCHÖNLAND, S. 79 (GRA).

B. schoenoides (Kunth.) C.B.Clarke 1070

In a marsh, on the main ridge above the Forester’s Cottage, near the Hogsback, 5500ft above sea level, 3226DB, Amatole Mountains, DYER 778 (GRA).

Below Gaika’s Kop, 0.1 kilometre’s North of the waterfall, 1440m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 103 (PRE).
in a marsh, exactly halfway between Gaika's Kop, Tore Doone and the Hogs, 3226DB, Hogsback District, SONNENBERG 393 (GRA, UN).

Siberia, in a marsh, halfway to Gaika's Kop, looking down from Tore Doone, 3226DB, Hogsback District, SONNENBERG 344, 378 (GRA, UN).

Third Hog, in a marsh on the Gaika's Kop side of the Hog, 3226DB, Hogsback District, SONNENBERG 315 (GRA, UN).

11 Miles West of Berlin, opposite the wood, 520m above sea level, 3227DC, King William’s Town District, ACOCKS 20096 (PRE).

Katberg, in the grassveld, below the high forest region, 3000ft above sea level, 3226DA, Stokenstroom District, DYER 360 (GRA).

Dohne Research Station, in grassland, 915m above sea level, 3227CB, Stutterheim District, ACOCKS 9350 (PRE).

**CAREX L. 0525000**

*C. aethiopica* Schkuhr. 200

Waai Farm, on the Kap River, 3326BD, Bathurst District, ANON *sn.* (GRA No. 1446)

Grahamstown Nature Reserve, in a woodland clearing, 3326BC Grahamstown, MARTIN 525 (GRA).

On a hillside, 90m above sea level, 3424BB, Humansdorp, GALPIN 4843 (PRE).

Witelsbos State Forest, near Kwaaibrandbos, in a forest, 3424AA, Humansdorp District, GELDENHUYS 962 (PRE).

Orange Grove Farm, 4 miles West of King William’s Town, 3227CD, King William’s Town District, HILNER 131 (PRE).

On a river bank, 610m above sea level, 3227DB, Komga, FLANAGAN 1007 (PRE).

Cape Morgan Nature Reserve, on the margin of coastal thicket, in high grass, in wet soil, 3228CB, Morgan's Bay District, SONNENBERG 423 (GRA, UN).

Van Stadens Nature Reserve, on the forest floor, in rocky places, 500ft above sea level, 3325CC, Port Elizabeth District, WELLS 3327 (GRA).

Van Stadens Pass, on a river bank, 3325CC, Port Elizabeth District, ARNOLD 656 (PRE).

*C. austro-africana* (Kukenth) Raymond 320

Below Gaika's Kop Waterfall, 200m North of the waterfall, at the confluence of the streams, 1440m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 128 (PRE).

Maden Dam, at the waters edge, 610m above sea level, 3227CB, King William’s Town District, ACOCKS 9281 (PRE).

*C. clavata* Thunb. 500

Brak Kloof, 3326BA, Albany District, WHITE 127 (GRA).

Longvale Post Office De Kol, on a river bed, 3326CB, Alexandria District, GANT 38 (GRA).
Kasouga Lagoon, East shore, on a wet slope near the waters edge, 0.75m above the mouth, 3326DA, Bathurst District, MARTIN sn. (GRA No. 8768).

Martindale, 3326BD, Bathurst District, SALISBURY sn. (GRA No. A7374).

Round Hill (Oribi Reserve), in the lilies on the river bank, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 186 (GRA).

3327DD, East London, RATTRAY 839 (GRA).

Overton Farm, 11 miles West of East London, near the brak marsh and the running stream, 3327BB, East London District, HILNER 172 (GRA, PRE).

Blaauwkrantz, common in damp shady places, on the river banks, 3326BC, Grahamstown District, HILNER 734 (GRA).

Foresters Cottage, in large clumps along stream, in damp soil, 4000ft above sea level, 3226DB, Hogsback, LUBKE 134 (GRA).

Kettle Spout Falls, in the swamp at edge of falls, 3226DB, Hogsback, MARTIN sn. (GRA No. 8878).

14m From the sea, 3228CB, Kei River Mouth, ARNOLD 554 (PRE).

Along the streams near Komga, 2000ft above sea level, 3228DB, Komga District, FLANAGAN 1891 (GRA).

Baakens River Valley, 3325DC, Port Elizabeth, DREGE 623 (GRA).

Walmer, 3325DC, Port Elizabeth, PATERSON 902 (GRA).

On the road to Walmer, at a robot, in a marsh, 3325DC, Port Elizabeth, ARNOLD 641 (PRE).

*C. cognata* Kunth. var. *cognata* 600

Near Gaika’s Kop, beneath the mountain, in a marsh, 1398m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 172 (PRE).

Toise River, 3227DA, Cathcart District, HILNER 521 (GRA, PRE).

In the tall grass, on a stream bank, 3226DB, Hogsback, PALMER, E. sn. (GRA No. 10269).

Auckland Forest Reserve, in shade of the Pine trees and below the Foresters Office, on a river bank, 3226DB, Hogsback, REID 1205 (PRE).

Forestry Department, 3226DB, Hogsback, MARTIN sn. (GRA No. 8879).

15 Yards from the sea, in grassveld, on clay-loam soil, 3228CB, Kei River Mouth, ARNOLD 554 (GRA).

In a marsh, 356m above sea level, 3228CB, Kentani District, PEGLER 151 (PRE).
C. ecklonii Nees 800

Kidd's Beach, on the side of channel through the sand, just above the uppermost sea rocks, 3327BA, East London District, HILLIARD 18897 (PRE).

Port Alfred East, in a salt marsh, 3326DB, Port Alfred District, MARTIN sn. (GRA No. 8442).

3325DC, Port Elizabeth, KEWSLEY 186 (GRA).

C. glomerabilis Krecz. 900

Blaauwkrantz Nature Reserve, near the rivers' edge, 10m from the main pool, under a large rock, 3326BC, Albany District, SONNENBERG 265 (GRA, UN).

Oakwell Farm, 33° 17' 33" S, 26° 20' 21" E, in the valley beneath the house, below the Kraal, on the "alluvial plain" at the big dam, in a seepage area at the big dam outlet, 3326AB, Albany District, HOBSON, S. 1319 (GRA).

Great Winterberg, 2315m above sea level, 3226AD, Adelaide District, GALPIN 5602 (PRE).

Tyume River, near the road bridge to King William's Town, in grassland, on a river bank, 518m above sea level, 3226DD, Alice District, PHILLIPSON 227 (PRE).

New Years River Dam, in a marsh, 3326AC, Alickdale District, JACOT-GUILLIARMOD 7461 (GRA, PRE).

Turpin Dam, 900m above sea level, 3226CA, Bedford District, ACOCKS 16303 (PRE).

Featherstone Kloof, 3326BC, Grahamstown, ANON sn. (GRA No. 115).

Pottery Works, 3326BC, Grahamstown, SWIFT sn. (GRA No. 6216).

Marsh Sands, in the grassy area, at the entrance to the village, in a small marsh, 3228CD, Hagga Hagga District, SONNENBERG 449 (GRA, UN).

2.2 Kilometre's from Hamburg, 3327AD, Hamburg District, ARNOLD 576 (PRE).

Lower margin of Zingcuka Forest, South of the Hogsback Peaks, at the edge of the forest, 732m above sea level, 3226DB, Hogsback District, PHILLIPSON 788 (PRE).

Maden Dam, 610m above sea level, 3227CB, King William's Town, ACOCKS 9280 (PRE).

Orange Grove Farm, 4 miles West of King William’s Town, on a river bank, 1250ft above sea level, 3227CD, King William’s Town District, HILNER 136 (GRA).

3326DB, Port Alfred, BRITTEN 519 (PRE).

7 Miles up the Kowie River, 3326BD, Port Alfred District, BRITTEN 2659 (GRA).

Rockcliff near Sidbury, 3326AC, Albany District, DALY 800 (GRA, PRE).

Glen Avon Farm, in a marsh, 3225DA, Somerset-East District, REID 1202 (PRE).

Dohne Hill, 3227CB, Stutterheim District, SIM 2832 (GRA).

In water courses, 3325CD, Uitenhage District, ALEXANDER-PRIOR 39115 (PRE).

Upper Zwart Kei, on a riverside, 5000ft above sea level, 3325CB, Uitenhage District, GALPIN 5602 (GRA).

Swartkops River, 3325CD, Uitenhage District, ECKLON 118 (PRE).
C. mossii Nelmes 1500

University of Fort Hare, 516m above sea level, 3226DD, Alice, GIFFEN 703 (PRE).

Along the Hogback Pass, on the forest margin, 1097m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 940 (PRE).

Turpin Dam, on the dam bank, 3226CA, Bedford District, ARNOLD 764 (PRE).

Hogsback Forest Reserve, 60 miles north-north-east of Grahamstown, 800m above sea level, 3226DB, Fort Beaufort District, DAHLSTRAND 1847 (GRA).

In the natural forest, 4000ft above sea level, 3226DB, Hogsback, LUBKE 111 (GRA).

Auckland Forest Reserve, in the shade, at the picnic site, near the Arboretum, in a marsh, 3226DB, Hogsback District, REID 1204 (PRE).

Central Hog, near a small waterfall, in the grassland 20m to the left of the fall, 3226DB, Hogsback District, SONNENBERG 308 (GRA).

Central Hog, near a small waterfall, in the grassland 200m to the left of the fall, 3226DB, Hogsback District, SONNENBERG 310 (GRA, UN).

Kettle Spout Falls, on the banks of the small stream that feeds the falls, 500m from the falls, 3226DB, Hogsback, SONNENBERG 297 (GRA, UN).

Kettle Spout Falls, in the marsh at the source of the stream that feeds the falls, wet sandy soil, 3226DB, Hogsback, SONNENBERG 331 (GRA, UN).

Katberg, in the forest, 915m above sea level, 3226DA, Fort Beaufort District, GALPIN 1741 (GRA, PRE).

Dontsa Forest, 10 miles north-east of Keiskammahoek, on a stream bank, 1065m above sea level, 3227CA, Keiskammahoek District, STORY 3687 (GRA, PRE).

Maden Dam, 610m above sea level, 3227CB, King William’s Town, ACOCKS 9282 (PRE).

On a river bank, 610m above sea level, 3227DB, Komga, FLANAGAN 919 (PRE).

Along the streams near Komga, 2000ft above sea level, 3227DB, Komga District, FLANNAGAN 1891 (GRA).

Fort Cunynghame, in a wooded Kloof, 1035m above sea level, 3227AD, Stutterheim District, GALPIN 2475 (GRA, PRE).

C. spicato-paniculata C.B.Clarke 2000

In the Popular Grove, 3226DB, Hogsback, NOEL sn. (GRA No. 11077).

C. zuluensis C.B.Clarke 2300

Menziesberg, on a north-eastern facing slope, in grassland, 1097m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1170 (PRE).

Ntsosana Indigenous Forest, 4000ft above sea level, 3226DB, Amatole Mountains, JACOT-GUILLARMOD 5514 (GRA).

In a plantation of Pine, near Ntsosana Indigenous Forest, on the moist slopes, along the paths, 3226DB, Amatole Mountains, MARTIN sn. (GRA No. 9673).

Coldspring, 3326AD, Grahamstown District, HILNER 396 (GRA).
Featherstone Kloof, amongst the Phragmites on the higher drier ground above the river, 1400ft above sea level, 3326BC, Grahamstown, LUBKE 72 (GRA).

Grahamstown Nature Reserve, on grass slopes, near streams and gullies, 3326BC, Grahamstown, MARTIN sn. (GRA No. 9642).

Howieson's Poort, 3326AD, Grahamstown District, BRITTEN 975 (GRA).

Paradise Kloof, under trees in a natural forest, 3326BC, Grahamstown District, LUBKE 80 (GRA).

Woest Hill, on a grassy slope that has been invaded by exotics, sandy soil, 3326BC, Grahamstown District, SONNENBERG 99 (GRA).

3226DB, Hogsback, RATTRAY 286 (GRA).

Auckland Forest Reserve, in sunlit places, under Pine trees, at the picnic site, 3226DB, Hogsback District, REID 1203 (PRE).

Forestry Department Arboretum, in the undergrowth of the forest, 1220m above sea level, 3226DB, Hogsback District, JOHNSON 1150 (GRA, PRE).

Wolfsridge Forest Reserve, 8 miles from the Hogsback Village, along the edge of the road, in the natural forest, 3226DB, Hogsback District, LUBKE 352 (GRA).

On the ridge above Evelyn Valley, in a shrub clearing, 1220m above sea level, 3227CA, Keiskammahoek District, ACOCKS 15730 (PRE).

Maden Dam, in the forest, 610m above sea level, 3227CB, King William’s Town, ACOCKS 9291 (PRE).

Top of Pierie, 3227CD, King William’s Town District, SIM 923 (GRA).

Near Komga, in a marsh, 610m above sea level, 3227DB, Komga District, FLANAGAN 915 (PRE).

Dohne Mountains, near the summit, in a clearing in the forest, 1340m above sea level, 3227CB, Stutterheim District, GALPIN 2454 (PRE).

**CARPHA Banks & Soland 0456000**

*C. bracteosa* C.B.Clarke 100

3226DB, Hogsback, RATTRAY 215 (GRA).

5 Kilometres from the Central Hog, in a marsh, near the forestry road, 3226DB, Hogsback District, SONNENBERG 301 (GRA, NE & UN).

Robertson Falls, overlooking the Tyumie Basin, on the rocky river banks of the river above the falls, 3226DB, Hogsback, SONNENBERG 336 (GRA, NE & UN).

West of Mount Thomas, on the Southern face, in a marsh, 1370m above sea level, 3227CA, Keiskammahoek District, STORY 3682 (PRE).

On the summit of the Pierie Mountains, 1220m above sea level, 3227CC, King William’s Town District, GALPIN 5945 (PRE).

*C. capitellata* (Nees) Boeck. 200

Hopewell, in a seepage area, 185m above sea level, 3326BD, Bathurst District, ACOCKS 23507 (PRE).

2000ft above sea level, 3326BC, Grahamstown, SONDER 351 (GRA).
Assagai Bosch, 900-1000ft above sea level, 3324CD, Humansdorp District, ROGERS 2010 (GRA).

Swamps near Kei Mouth, 200ft above sea level, 3228CB, Komga District, FLANAGAN 920 (GRA, PRE).

Near Southwell, in the woodlands, in a river, 245m above sea level, 3326DA, Southwell District, ACOCKS 23912 (PRE).

**C. glomerata (Thunb.) Nees 300**

On the Hogsback Pass, in the open places, along the side of the road, in a marsh, 1102m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 935 (PRE).

Coldsprings, 3326AD, Grahamstown District, DALY & SOLE 266 (GRA).

Featherstone Kloof, on a stream bank, 3326BC, Grahamstown District, BRITTEN 6402 (PRE).

Governors Kop, the highest point in the district, on a stream bank, semi-aquatic, 3326BC, Grahamstown District, HILNER 254 (GRA).

Near Grahamstown, 2000ft above sea level, 3326BC, Grahamstown District, BAKER 651 (GRA).

Howieson's Poort, 640m above sea level, 3326BC, Grahamstown District, SCHÖNLAND, S. 760 (GRA, PRE).

Kettle Spout Falls, in the stream that feeds the falls, at the Pine forest margin, 3226DB, Hogsback, SONNENBERG 295 (GRA, UN).

700m up the hill from the Robertson Falls Dam, on the slope of the first Hog, in a small stream in Pine forest, 3226DB, Hogsback District, SONNENBERG 387 (GRA, UN).

500ft above sea level, 3424BB, Humansdorp, ROGERS 2930 (GRA).

Kloof above Humansdorp, in a wooded area, 450ft above sea level, 3424BB, Humansdorp, GALPIN 4841 (GRA, PRE).

Near Humansdorp, 3424BB, Humansdorp District, THERON 691 (PRE).

Witte Els Bosch, on the forest margin, 3424AA, Humansdorp District, FOURCADE 1418 (GRA).

Otterford Forest Reserve, 3325CC, Port Elizabeth District, DAHLSTRAND 797 (GRA).

Otterford Forestry Research Area, 30 miles North of Port Elizabeth, in a river bed, 3325CC, Port Elizabeth District, RODIN 1158 (PRE).

Walmer, 3325DC, Port Elizabeth, PATERSON 835 (GRA).

Witteklip, in the shrub, 30m above sea level, 3325DC, Port Elizabeth District, LONG 625 (PRE).

Van Staden's Gorge, 400ft above sea level, 3325CC, Port Elizabeth District, LONG 625 (GRA); PATERSON 2478 (GRA).

Auckland Forest, 910m above sea level, 3226DB, Seymour District, GIFFEN 509 (PRE).

23 Kilometre's from Uitenhage, on the road travelling from the Groendal Dam, in a stony riverbed, 3325CD, Uitenhage District, ARNOLD 1065 (PRE).

**C. schlechteri C.B.Clarke 400**

Witelsbos SAFCOL forest, in wet soil, in an area cleared of *Eucalyptus* sp. trees, 1 kilometre from the SAFCOL Offices, 500m from the N2, 3424AA, Humansdorp District, SONNENBERG 458 (GRA, NE & UN).
CHRYSTHRIX L. 0500000

*C. capensis* L. 100

3224BB, Humansdorp District, HORN 2469 (PRE).

Witelsbos SAFCOL forest, on the slopes of the Tsitsikammaberg, on the grassy road verge, in Pine forest, 3424AA, Humansdorp District, SONNENBERG 478 (GRA, UN).

Witte Els Bosch Peak, on the Northern slopes, 915 m above sea level, 3424AA, Humansdorp District, ESTERHUYSEN 6767 (PRE).

*C. dodii* C.B.Clarke 300

Along the mountain path, on the East slopes of Witte Els Bay, 425m, 3424AA, Humansdorp District, FOURCADE 3018 (PRE).

Witte Els Bosch, on the flats, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 2416 (GRA).

CLADIUM R.Br. 0489000

*C. mariscus* (L.) Pohl Subsp. *jamaicense* (Crantz) Kukenth 100

Cape St. Francis, in a rocky, dry marsh, on the side of the road to Humansdorp 2 kilometres from the entrance to the town, 3324DD, Humansdorp District, SONNENBERG 493 (GRA, UN).

Along the coast, 3228CB, Kentani District, PEGLER 2021 (PRE).

3325DC, Port Elizabeth, DYER 142 (GRA).

Schoenmakers, in swampy places along the coast, 3325DC, Port Elizabeth, ARCHIBALD 3400 (GRA).

Along the road to the mouth of the Van Stadens River, 3325CC, Port Elizabeth District, THERON 1650 (PRE).

CYATHOCOMA NEES 0494010

*C. hexandra* (Nees) J.Browning 300

Witelsbos SAFCOL forest, on the slopes of the Tsitsikammaberg, on the grassy road verge, in Pine forest, 3424AA, Humansdorp District, SONNENBERG 477 (GRA, UN).

Witelsbos SAFCOL forest, Indigenous forest, on rocky stream banks, in an area just cleared of forest, 3424AA, Humansdorp District, SONNENBERG 483 & 484 (GRA, UN).

Witte Els Bosch, on the flats, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 1007A (GRA).

Van Stadensberg Mountains, 3325CC, BAKER 2090 (GRA).

CYPERUS L. 0459000

*C. albostriatus* Schrad. 100

Brooklands near Grahamstown, on a south-east facing grassland slope, 280 m above sea level, 3326BC, Albany District, PENNEFATHER & PARSONS 39 (GRA).
Cradock road, on the flats near Grahamstown, 3326AB/AD, Albany District, SCHÖNLAND, S. 4401 (GRA).

Block Drift, University of Fort Hare, 516 m above sea level, 3226DD, Alice, GIFFEN 650 (PRE).

Fort Hare Farm, at the end of the road, past the irrigation dam, in the Riverine thicket of the Tyumie River, in the light shade under a *Acacia caffra*, in loose sand soil, on top of a steep sandy bank, 1600ft above sea level, 3226DD, Alice, GIBBS-RUSSEL 3383 (GRA, PRE).

Cathcart to Stutterheim road, 13 kilometre's from Stutterheim, in a disturbed area, 1006 m above sea level, 3227AD, Amatole Mountains, PHILLIPSON 259 (PRE).

Wolfsridge Forest Reserve, 7 miles from Hogsback Village, in the undergrowth of a Pine forest, 5000ft above sea level, 3226DB, Amatole Mountains, LUBKE 355 (GRA).

Wolfsridge Forest Reserve, on a steep Southern facing slope, in the high forest, 3500ft above sea level, 3226DB, Amatole Mountains, STORY 3445 (GRA).

Round Hill (Oribi Reserve), in the damp soil of a river bank, 375 m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 175 (GRA).

Trappes Valley, 3326BD, Bathurst District, DALY 703 (GRA, PRE).

Waters Meeting Nature Reserve, in forested valleys, on the Bathurst stream, in undisturbed vegetation, in a steep sided valley, also near the forest roadway, in short vegetation, in semi-shade, 100m above sea level, 3326DB, Bathurst District, JACOT-GUILLARMOD & BRINK 26 (GRA).

Andries Vosloo Kudu Reserve, in a area cleared of shrub, 425m above sea level, 3326BA, Fort Brown, GIBBS-RUSSEL 3588 (PRE).

Andries Vosloo Kudu Reserve, in Fish River Scrub, near a small river, in a damp shady area, 1000ft above sea level, 3326BA, Fort Brown, DIFFORD & MATTISSON 459 (GRA).

3327BB, East London, BREYER 16547 (PRE).

The Mill near the Airport, in sandy soils near the coast, 3327BB, East London, WOOD 6 (GRA).

Blind River Valley, in the Southern wood, in a cleared area, 15m above sea level, 3327BB, East London District, SMITH 3647 (PRE).

Fort Grey Nature Reserve, in the forest, 150m above sea level, 3327BB, East London District, GELDENHUYS 752 (PRE).

2200ft above sea level, 3326BC, Grahamstown, BAYLISS 8606, 8606A (GRA).

Beggars Bush near Grahamstown, in stream bed and in forest, in moist shady places, 3326BC, Grahamstown District, SEAGRIEF 160 (GRA).

Faraway, Portion 3 of Coldsprings, on the forest floor, 700m above sea level, 3326AD, Grahamstown District, JACOT-GUILLARMOD 8441 (GRA).

Fernkloof, on the Common, 2000ft above sea level, 3326BC, Grahamstown, ABRAHAM sn. (GRA No. 21923).

Grahamstown Nature Reserve, on the temperate forest floor, 2000ft above sea level, 3326BC, Grahamstown, WEEKS 108 (GRA).

Rhodes University, in the stream near the Athletes track, 3326BC, Grahamstown, BELL 3 (GRA).

Near Settlers Dam, in the sandy soil near the dam, amongst the grass, 3326BC, Grahamstown District, RICHARDSON 42 (GRA).

Woest Hill, on the rocky slopes of the grassy fynbos, in damp places, 560m above sea level, 3326BC, Grahamstown, SONNENBERG 187 (GRA).

3226DB, Hogsback, BRADFORD sn. (GRA No. 1673).

Auckland Trust Forest, above the forest, in stony soil, 230m above sea level, 3226DB, Hogsback District, DAHLSTRAND 2677 (GRA, PRE).

Indigenous forest around the Big tree, 3800ft above sea level, 3226DB, Hogsback, JACOT-GUILLARMOD 5506 (GRA).

Near Oak Avenue, in the forest, 3226DB, Hogsback, M'DOWALL sn. (GRA No. 17779).

In a cleared woodland, 3227CA, Keiskammahoek District, KOTSOKOANE 180 (PRE).

Keiskammahoek Commonage, in a dry rocky watercourse, 2000ft above sea level, 3227CA, Keiskammahoek District, DYER 3204 (GRA).

Somerset Str., near No. 5, in an area cleared of bush, 3326DA, Kenton-on-Sea, ABRAHAMS 58165 (GRA, PRE).

3227CD, King William’s Town, LEIGHTON 3 (GRA).

In woods near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 986 (GRA, PRE).

3226DB, Port Alfred, SALISBURY 56 (GRA); HUTTON 60 (GRA).

Fish Picnic Place, on the Kowie River, in the shady parts of the bush, 3326BD, Port Alfred District, BRITTEN 426 (GRA).

Van Staden's Nature Reserve, on the forest floor, 500ft above sea level, 3325CC, Port Elizabeth District, WELLS 3377 (GRA).

Suurberg, 3225BD, Port Elizabeth District, HOLLAND 140 (GRA).

Suurberg, at the Melkhoutsboom Archaeological Site, in the forest opposite the cave, 3325BD, Port Elizabeth District, JESSOP 916 (GRA).

Auckland Forest, 1275m, 3226DB, Seymour District, GIFFEN 1589 (PRE).

Hogsback road, on the big tree path, in the forest, 3226DB, Seymour District, DOWALL 459 (GRA).

3225DA, Somerset-East, ROGERS 162 (GRA).

Boschberg Mountains, 2500ft above sea level, 3225DA, Somerset-East District, SONDER 1690 (GRA).

3 Miles from Amabele, along the river, 2600ft above sea level, 3227DA, Stutterheim District, DE VRIES 1 (GRA).

Fort Cunyghame, 1 mile from the Foresters Cottage, in sandy soil, 3000ft above sea level, 3227AD, Stutterheim District, SCHÖNLAND, R. 20 (GRA), 27 (GRA, PRE), 105 (GRA).

Kologha Forest, 3227CB, Stutterheim District, ACOCKS 9048 (PRE).

400ft above sea level, 3235CB, Uitenhage District, SCHLECHTER 2569 (GRA).

Elandsrivier Catchment Area, Groendal Wilderness Reserve, in the forest, on humus soil, 230m above sea level, 3325CC, Uitenhage District, SCHARF 1284 (PRE).

**C. denudatus** L.f. 1200

At the top of Blaauwkrantz, in a shallow pan on the left hand side of the road to Grahamstown, 35 kilometres from Grahamstown, SONNENBERG 263 (GRA, UN).
Faraway, near Grahamstown, 3326AD, Albany District, BURTT-DAVY 11648 (PRE).

40 Kilometre's from Grahamstown on the Port Alfred road, 100m from the road, at the edge of a small vlei, 3326BC, Albany District, SONNENBERG 261 (GRA).

Trappes Valley, 3326BD, Bathurst District, DALY 668 (GRA), 12930 (PRE).


Dogs Dam, on a shady river bank, amongst Kikuyu grass and brambles, 3326BC, Grahamstown, LUBKE 98 (GRA).

Featherstone Kloof, above the wet river bank, amongst the grasses, 1350ft above sea level, 3326BC, Grahamstown, LUBKE 71 (GRA).

Howieson's Poort, in a swamp, 3326AD, Grahamstown District, BRITTEN 973 (GRA).

Kei Mouth Air Field, in the marsh opposite the field, in grassland, wet soil, 3228CB, Kei Mouth District, SONNENBERG 433 (GRA, UN).

In marshes and vleis, 1000ft above sea level, 3228AB/CB, Kentani District, PEGLER 1082 (GRA).

Rooikrans/Maden Dam, in the grassland, on sandy soil, at the margin of the dam, 580m above sea level, 3226DB, King William’s Town District, GIBBS-RUSSEL 4048 (GRA, PRE).

3227DB, Komga, FLANAGAN 668 (GRA), 976 (PRE).

Dohne Pasture Research Station, in a marsh, 3227CB, Stutterheim District, ACOCKS 8907 (PRE).

**C. difformis L. 1400**

40 Kilometres from Grahamstown on the road to Port Alfred, on the banks of a small marsh, in clay soil, 3326BC, Albany District, SONNENBERG 260 (GRA).

Fish River Valley, 15 miles from Grahamstown, in Fish River Scrub, near a pool of water, in a shady area, 950ft above sea level, 3326BA, Albany District, LUBKE 105 (GRA).

Near the top of Koonap Heights, in a small pool of water by the roadside, 3226DC, Albany District, SCHÖNLAND, S. 3695 (GRA, PRE).

2 Miles from Alice, on a river bank, 3226DD, Alice District, THERON 1656 (PRE).

The pond 1 kilometre along Calderwood road, travelling from the Peddie road, on the waters edge, 579m above sea level, 3226DD, Alice District, PHILLIPSON 230 (PRE).

On the road to Peddie, in pond below the Commonage, on the left side of the road, at the waters edge, 594m above sea level, 3226DD, Alice District, PHILLIPSON 180 (PRE).

Sandiles Kop, University of Fort Hare, 646m above sea level, 3226DD, Alice, GIFFEN 1592 (PRE).

Tortoise Pond, on the Grahamstown road, 516m above sea level, 3226DD, Alice, GIFFEN 933 (PRE).

Weltevreden, near Calderwood, on the river bank, 395m above sea level, 3226DC, Amatole Mountains, ACOCKS 15978 (PRE).

Bathurst Commonage, on the road side, 5 kilometre's from Bathurst, on the Southwell road, at the edge of grassland, in a water furrow, on clay soil, 3326DB, Bathurst District, SONNENBERG 223 (GRA).

On the roadside near Glentillan, semi-aquatic, 3326DB, Bathurst District, MARTIN sn. (GRA No. 8875).

Andries Vosloo Kudu Reserve, in wood clearing, 425m above sea level, 3326BA, Fort Brown, GIBBS-RUSSEL 3559 (PRE).
2000ft above sea level, 3326BC, Grahamstown, SONDER 1347 (GRA).

Stowan Farm Dam, near Grahamstown, 3326AD, Grahamstown District, BRITTEN 5974 (PRE).

Marshy and grassy spots near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 1262 (GRA, PRE).

Double Mouth Reserve, in the grasslands, 2 kilometres from the camp site, on the Morgan's Bay side of the reserve, at the edge of a small pool of water, 3228CB, Morgan's Bay District, SONNENBERG 431 (GRA, UN).

Addo Elephant Nature Reserve, at the Rhino Camp, opposite the forest, 100m above sea level, 3325BC, Port Elizabeth District, HALL-MARTIN 5985 (PRE).

On a mountain near Kommadagga, 3325BB, Somerset-East District, BURCHELL 3350 (PRE).

\textbf{C. distans \textit{L.f. 1700}}

7 Kilometre's from the turn-off to Committees Drift, on the road that turns near Fort Brown, bordering the Andries Vosloo Nature Reserve, in a rocky stream bed, under the rocks, in the middle of the stream bed, 150m from a shale outcrop and 100m from the road, 500m above sea level, 3326BA, Albany District, SONNENBERG 200 (GRA).

Trumpeters Drift Fort, in the shale river bed of the Blé River, in \textit{Acaia karoo} Riverine thicket, 400m above sea level, 3326BB, Albany District, SONNENBERG 203 & 204 (GRA).

At the pond 5 kilometre's along the Calderwood road, travelling from the Peddie road, 502m above sea level, 3226DD, Alice District, PHILLIPSON 228 (PRE).

Cintsa River Mouth, 3228CC, East London District, VORSTER 2741 (PRE).

1 Kilometre from the turnoff to Hagga Hagga on the road to Hagga Hagga, on the clay banks of a small dam, 100m from the road, on the left hands side of the road, 3228CB, Hagga Hagga District, SONNENBERG 441 (GRA, UN).

Rooikrans/Maden Dam, near the lake, in grassland, 580m above sea level, 3227CB, King William’s Town District, GIBBS-RUSSEL 4039 (PRE).

Grassy valleys near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 1264 (GRA, PRE).

Port Alfred road, 2300ft above sea level, 3326DB, Port Alfred District, ROGERS 3219 (GRA).

\textbf{C. esculentus \textit{L. 1900}}

Oakwell Farm, in the valley beneath house, in damp seepage patches below the kraal, in the "alluvial plain" at big dam, 33° 17' 33" S, 26° 20' 21" E, 3326AB, Albany District, HOBSON, S. 1318 (GRA).

Fort Hare Farm, 485m above sea level, 3226DD, Alice, GIBBS-RUSSEL 3399 (PRE).

Marsh Sands, in the marsh alongside a small river, 3228CB, Hagga Hagga District, SONNENBERG 451 (GRA, UN).

Marsh Sands, in the building site, 700m from a small river, in sandy soil, 3228CB, Hagga Hagga District, SONNENBERG 452 (GRA).

in the gravel at the side of the road, in front of the Mitford Holiday Flats, 50m from the beach, 3228CB, Morgan's Bay, SONNENBERG 439 (GRA, UN).

Theesecombe, on a damp river bank, 230m above sea level, 3325AD, Port Elizabeth District, RAUTENBACH 16 (GRA).

Dohnne, 3227CB, Stutterheim District, ACOCKS 658 (PRE).
**C. fastigiatus** Rotb. 2000

Oakwell Farm, in the valley beneath house, in seepage patches, below the kraal, on the “alluvial plain” below the big dam, 33° 17’ 33” S, 26° 20’ 21” E, 3326AB, Albany District, HOBSON, S. 1317 (GRA).

Near the Ghio Bridge, 30m above sea level, 3326DA, Alexandria District, ARCHIBALD 4865 (PRE).

On the road to Peddie, near the pond below Commonage, on the right side of the road, on dry ground, 3326DB, Alice District, PHILLIPSON 187 (PRE).

3226DC, Fort Beaufort, GIFFEN 57818 (PRE).

Mosslands, 3326AD, Grahamstown District, GILLESSON 809 (GRA), 820 (GRA, PRE).

On the banks of the Kei River, near Komga, 1500m above sea level, 3227DB, Komga District, FLANAGAN 2312 (GRA, PRE).

Suurberg, Upper Coerney River, on a river bank, 395m above sea level, 3325AD, Port Elizabeth District, ARCHIBALD 4939 (PRE).

**C. immensis** C.B.Clarke 2900

Bathurst Commonage, along the banks of the Lushington River, 11 kilometre’s from Bathurst, 3326BD, Bathurst District, SONNENBERG 222 (GRA).

Shaw Bridge, 6 miles from Kidds Beach, on the road to East London, at the edge of the water, 3327BA, East London District, COMINS 1601 (PRE).

Buffalo River, on the river banks, 3227CD, King William's Town, GALPIN 2791 (GRA); RANDALL 2791 (PRE).

William's Farm, 4 miles West of King William's Town, on a river bank, 3227DA, King William's Town District, HILNER 132 (GRA, PRE).

Near Komga, along the streams, on the stream banks, 610m above sea level, 3227DB, Komga District, FLANAGAN 1784 (PRE).

Sunridge Park, in a marsh, 50m above sea level, 3325DC, Port Elizabeth, DAHLSTRAND 588 (GRA, PRE).

**C. laevigatus** L. 3200

Double Drift, in the Fish River Valley, on the banks of the river, 167m above sea level, 3326BB, Albany District, PHILLIPSON 214 (PRE).

Near the summit of Koonap Height, 3226DC, Albany District, SCHÖNLAND, S. 3701 (PRE).

Riet River Mouth, amongst the 6 inch high grasses, in the salt marsh, 3326DB, Bathurst District, LUBKE 91 (GRA).

Christmasvale, on the margin of the stream, 3227AA, Cathcart District, LUBKE 2762 (GRA).

Cintsa River Mouth, in the rock crevices of a small tributary stream to the Cintsa river, near a bridge, below Buccaneers Retreat, 3228CC, Cintsa West, SONNENBERG 241 (GRA).

Cintsa River Mouth, 250m from the sea, on the sandy river bank, next to a steep sand dune, 3228CC, Cintsa West, SONNENBERG 240 (GRA, UN).

The bridge at Committees Drift, in the river bed, 3326BB, Committees Drift, ARNOLD 629 (PRE).
Buluga Mouth, at the edge of the beach, in a stony seepage area, 5m above sea level, 3228CC, East London District, ACOCKS 15758 (PRE).

Van Ryneveld Pass Dam, 3224BA, Graaff-Reinet District, SMOOK 3920 (PRE).

Sea Vista, on the main beach, 34° 10' S, 24° 50' E, 3424BB, Humansdorp, LUBKE 1823 (GRA).

Kei River Mouth, 20 yards from the sea, between the rocks, in a seepage area, 3228CB, Komga District, ARNOLD 558 (PRE).

Salt vlei, at the waters edge, 3326DB, Port Alfred, BRITTEN 1917 (GRA, PRE).

Swartkops River, in a *Sporobolus* community, in the Estuary, 3325DC, Port Elizabeth, ARCHIBALD 5016 (GRA, PRE).

Soastoubosstrand, Aasvoelkrans, East of Oubosstrand, in a stony grassland, 3m above sea level, 3424AB, East Tstsikamma, TAYLOR 9967 (PRE).

**C. longus** L. **Var. longus** 3500

Cathcart to Stutterheim road, 22 kilometre's from Cathcart, North of the road, along the river, 1006m above sea level, 3227AD, Amatole Mountains, PHILLIPSON 246 (PRE).

Committees Drift, next to a river, on a sandy river bank, 3326BB, Albany District, VORSTER 2314 (PRE).

Double Drift, in the Fish River Valley, on the banks of the river, 3326BB, Albany District, PHILLIPSON 213 (PRE).

Common in grass, in fairly damp spots, on the roadside, on the road leading to East London West, 3327BB, East London District, HILNER 250 (GRA, PRE).

Breakfast Vlei, between Fort Beaufort and Grahamstown, in a shrub clearing, 212m above sea level, 3326BA, Fort Brown, GIBBS-RUSSEL 4023 (GRA, PRE).

Karoo Nature Reserve, in the grass at Gaanalaagte, 3224AB, Graaff-Reinet District, PALMER, A. 1109 (PRE).

Van Ryneveld Pass Dam, 3224BA, Graaff-Reinet District, SMOOK 3919 (PRE).

Near Kei Mouth, in a marsh, 15m above sea level, 3228CB, Komga District, FLANAGAN 1788 (GRA, PRE).

**C. longus** L. **Var. tenuiflorus** (Rottb.) Boeck. 3600

Centenary Dam, on the dam banks, 3228CB, Kei Mouth District, SONNENBERG 435 (GRA, UN).

Dohne Research Station, 915m above sea level, 3227CB, Stutterheim District, ACOCKS 9507 (PRE).

**C. marginatus** Thunb. 4000

Victoria Girls High School, next to the wall of the lower hockey field, 3326BC, Grahamstown, TASMER 1 (GRA).


**C. natalensis** Hochst. 4300

Bushman's River Mouth, near the Estuary Mouth, 3326DA, Alexandria District, DYER 3359 (PRE).
Bushman's River Mouth, on the Southern Shore, behind the dunes, 0m above sea level, 3326DA, Alexandria District, VORSTER 2281 (PRE).

Sandflats, on the sand dunes, 305m above sea level, 3325DB, Alexandria District, ARCHIBALD 3882 (PRE).

Fish River Mouth, South of river, in the dunes, 10m above sea level, 3327AC, Bathurst District, PHILLIPSON 173 (PRE).

Roundhill (Oribi Reserve), grassland, 3326DB, Bathurst District, SONNENBERG 271 (GRA, UN).

Near the freshwater springs, at the base of the cliff, 5m above sea level, 3326CD, Cape Padrope, JACOT-GUILLARMOD & BRINK 33 (GRA, PRE).

Between the Cintsa and Kefane River Mouths, in the grasslands behind the dunes, 3228CC, East London District, VORSTER 2753 (PRE).

Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth, SONNENBERG 406 (GRA, UN).

Kowie River Mouth, 0.5 kilometre's North of the river mouth, on the sand dunes, in estuary sand, 3326DB, Port Alfred, ARNOLD 825 (PRE).

Rufanes River Mouth, in a dune slack, 2 kilometres to the North of the mouth, 3326DB, Port Alfred District, SONNENBERG 270 (GRA, UN).

On the flat areas near the Pier, on the Eastern Beach, near the bush, 3326DB, Port Alfred West, BRITTEN 5212 (PRE).

Coeega River area, near Blue Water Bay, on the dunes, 3325DC, Port Elizabeth District, OLIIVIER 2020 (PRE).

Markman Indian Area, along the coastal sand dunes, 10m above sea level, 3325DC, Port Elizabeth, DAHLSTRAND 3007 (GRA, PRE).

At the Tennis Courts, on Conyngham road, in the area around the courts, 3325DC, Port Elizabeth District, TROUGHTON 489 (PRE).

_C. obtusiflorus Vahl._

Highlands/Coldsprings area, in the grassland, 2000ft above sea level, 3326AD, Albany District JACOT-GUILLARMOD 6849 (GRA).

Hayes Siding, in sandy soil, on the road side, in the fields and railroad enclosure, 300ft above sea level, 33° 34' S, 26° 54' E, 3326DB, Bathurst District, JACOT-GUILLARMOD 5598 (GRA).

Gunfire Hill, on an exposed hill, 2000ft above sea level, 3326BC, Grahamstown, HOSKING 48 (GRA).

Kei Moth Golf Course, sandy soil, 3228CB, Kei Mouth, SONNENBERG GRA, UN).

3228CB, Kentani District, PEGLER 224 (PRE).

In the pastures near Kei Mouth, in grassland, 91m above sea level, 3228CB, Komga District, FLANAGAN 966 (GRA, PRE).

Suurberg Mountains, in *Themeda tristachya* veld, 3325BC, Port Elizabeth District, LUBKE 459 (GRA).

_C. pulcher Thunb. 5700_

Oakwell Farm, in the valley beneath the house, on an alluvial plain, in the seepage, at the big dam outlet, 33° 17' 33" S, 26° 20' 21" E, 3326AB, Albany District, HOBSON, S. 1335 (GRA).

3226DD, Alice, PAHL 108 (GRA).
Gqumashe, 3226DD, Alice District, GIFFEN 58035 (PRE).

On the road to Peddie, near the pond below the Commonage, on the right hand side of the road, near the water, in the grassland, 594m above sea level, 3226DD, Alice District, PHILLIPSON 186 (PRE).

Near the pond, 1 kilometre along the road to Hogsback, 563m above sea level, 3226DD, Alice District, PHILLIPSON 308 (PRE).

Sandiles Kop, University of Fort Hare, 646m above sea level, 3226DB, Alice, GIFFEN 702, 1598 (PRE).

Town Water Supply Dam, behind Lovedale, on the waters edge, 579m, 3226DD, Alice, PHILLIPSON 266 (PRE).

University of Fort Hare Research Farm, in the weeds at the roadside, 516m, 3226DD, Alice, GIBBS-RUSSEL 3940 (GRA, PRE).

Garfield, in the river, 460m above sea level, 3226DD, Amatole Mountains, ACOCKS 23278 (PRE).

Turpin Dam, above the dam, in the forest, 915m above sea level, 3226CA, Bedford District, ACOCKS 16264.

Toise River, on a muddy river bank, 3227DA, Cathcart District, HILNER 520 (GRA, PRE).

3327BB, East London, HILNER 295 (PRE).

Overton Farm, 11 miles East of East London, in marshy soil, on the stream bed, 3327BB, East London District, HILNER 211 (GRA, PRE).

Overton Farm, 11 miles East of East London, at the edge of the dam, 3327BB, East London District, HILNER 295 (GRA).

Andries Vosloo Nature Reserve, in a shrub clearing, 425m above sea level, 3326BA, Fort Brown, GIBBS-RUSSEL 3555 (PRE).

3326BC, Grahamstown, BAKER 652 (GRA); DALY & SOLE 34 (GRA); ROGERS 27429 (GRA).

In damp and marshy soil, 2130ft above sea level, 3326BC, Grahamstown, PAINE 4 (GRA).

Blaauwkrantz, in a river bed, 3326BC, Grahamstown District, BRITTEN 867 (PRE).

Below Brickhill’s, aquatic, 1800ft above sea level, 3326BC, Grahamstown, BENNIE 360 (GRA).

Gowies Kloof, at the pond below the dam, on dry land, 3326BC, Grahamstown District, MARTIN sn. (GRA No. 8017).

Hamilton Reservoir, in the shade of a Port Jackson Willow, Grahamstown District, LUBKE 63 (GRA).

In the hills near Grahamstown, 3326BC, Grahamstown District, DALY & SOLE 34 (PRE).

At the Pottery Works, 3326BC, Grahamstown, SWIFT sn. (GRA No. 6228).

2.2 Kilometre's from Hamburg, in a marsh, on clay soil, 3327AD, Hamburg District, ARNOLD 577 (PRE).

In a vlei East of the road, at the entrance to Hamburg, in a marsh, 3327AD, Hamburg, VORSTER 2258 (PRE).

Centenary Dam, on the dam banks, at the waters edge, wet soil, in the full sunlight, 3228CB, Kei Moth District, SONNENBERG 437 (GRA, UN).

3227DB, King William’s Town, LEIGHTON 4 (GRA); SIM 2856 (GRA).

Orange Grove Farm, 4 kilometre's West of King William’s Town, on the river banks, 3327CD, King William’s Town District, HILNER 125 (GRA, PRE).
Rooikrans/Maden Dam, in wet soil, at the water's margin, in the grassland, 580m above sea level, 3227CB, King William’s Town, GIBBS-RUSSEL 4043 (GRA, PRE).

Stockton Farm, Kei road, in the damp soil next to a vlei, 3227DC, King William’s Town District, COMINS 1782 (GRA).

Suurberg, Upper Coerney River, on the river banks, 395m above sea level, 3325AD, Kirkwood District, ARCHIBALD 4942 (PRE).

Near Komga, in a marsh, 610m above sea level, 3227DB, Komga District, FLANAGAN 2223 (PRE).

Swamps near Komga, in a marsh, 2000ft above sea level, 3227DB, Komga District, FLANAGAN 901 (GRA).

Springs Reserve, near the earth dam, 3325CD, Port Elizabeth District, OLIVIER 2255 (GRA).

Near Somerset-East, 3225DB, Somerset-East District, MACOWAN 652 (PRE).
3227BC, Stutterheim District, ROGERS 12717 (GRA).

Dohne Research Station, in a marsh, 3227CB, Stutterheim District, ACOCKS 9377 (PRE).

15 Miles North North-east of the Dohne Research Station, 1065m, 3227BC, Stutterheim District, ACOCKS 20265 (PRE).

Kamachs, 3325CB, Uitenhage District, PATERSON 25835 (TM).

**C. rotundus** Linn. **Subsp. rotundus** Var. **rotundus** 6300

Heatherton Towers Farm, in the Fish River Valley, on a stream bed, 950ft above sea level, 3326BB, Albany District, LUBKE 155 (GRA).

Fort Hare Campus, in the old Botany quadrangle, 518m above sea level, 3226DD, Alice, PHILLIPSON 179 (PRE).

3327BB, East London District, MEYER 39258 (PRE).

Gletwyn, 3326BC, Grahamstown District, BURTT-DAVY 7828 (PRE).

**C. rubicundus** Vahl. 6350

3226CB, Adelaide, DYKE 3520 (PRE).

Botha's Hill, 10 miles from Grahamstown, at the junction between the grassveld and Karoid shrub, 546m above sea level, 3326BA, Albany District, DYER 1477 (GRA, PRE).

Carlisle Bridge, in the Karoid vegetation, on sandy clay soil, 425m above sea level, 3326AA, Albany District, BAYLISS 8603 (GRA, PRE); BOWKER 5 (GRA).

Near the bridge at Committees Drift, near the turn-off to Trumpeter’s Drift Fort, on a shaley river bed, 3326BB, Albany District, SONNENBERG 188 (GRA).

On the banks of the Mooi River, 2.5 kilometre's from Committees Drift on the Fort Brown road, 3326BA, Albany District, SONNENBERG 202 (GRA, UN).

Fish River Valley, 15 miles from Grahamstown, in the shale, near the road, 3326BA, Albany District, LUBKE 104 (GRA).

At the foot of the Suurberg Pass, 1 mile from the Sandflats turn-off, 303m above sea level, 3325BC, Alexandria District, ARCHIBALD 5462 (PRE).

On the rocky slopes behind the Alice Hospital, 546m above sea level, 3226DD, Alice, ACOCKS 15747 (PRE).
On road to Peddie, near the pond below Commonage, on the left hand side of the road, 594m above sea level, 3226DD, Alice District, PHILLIPSON 181 (PRE).

Sandiles Kop, University of Fort Hare, 3226DD, Alice, GIFFEN 1590 (PRE).

Amherst Siding, between Seymour and Fort Beaufort, 3226DA, Fort Beaufort District, ROBBERTSE 956 (PRE).

Near Fort Beaufort, on the dry hills, South of the town, also in damp localities to the North of the town, 2000ft above sea level, 3226DA/DC, Fort Beaufort District, DYER 236 (GRA).

Near the top of Koonap Heights, in and about a small pool, 3226DC, Fort Beaufort District, SCHÖNLAND, S. 3708 (PRE), 4704 (GRA).

Andries Vosloo Nature Reserve, in sandy soil and Fish River Scrub, 1350ft above sea level, 3326BA, Fort Brown, DIFFORD & MATTISON 1 (GRA).

Andries Vosloo Kudu Reserve, in a shrub clearing, 425m above sea level, 3326BA, Fort Brown, GIBBS-RUSSEL 3575A (PRE).

Bloukrantz Nature Reserve, in valley bushveld, 250m above sea level, 33° 23’ S, 26° 43’ E, 3326BC, Grahamstown District, LLOYD 140 (GRA).

Grasslands Farm, in grassland, 2100ft above sea level, Grahamstown District, EVANS 46 (GRA).

Nquama Ridge, 3.2 miles from Keiskammahoek, near the bridge, on the road to Debe Nek, in a shrub clearing, 759m above sea level, 3227CA, Keiskammahoek District, STORY 3392 (PRE).

In the rocks near Kei Mouth, 546m above sea level, 3227DB, Komga District, FLANAGAN 1013 (GRA, PRE).

3326DB, Port Alfred, TYSON 123 (GRA).

On a river embankment, 3326DB, Port Alfred, TYSON 589 (PRE).

On the Eastern bank, near the river, 3326DB, Port Alfred, BRITTEN 481 (PRE).

Addo Elephant Nature Reserve, in a shallow pan, in the middle of a Buck camp, 3325BD, Port Elizabeth District, LIEBENBERG 7756 (PRE).

Sonop Farm, Coega, on rocky ground, 3325DC, Port Elizabeth, District, OLIVIER 1574 (PRE).

Cradock road, near the Riebeek-East turn-off, in the shale at the roadside, 3326AA, Riebeek-East District, HEEG 69 (GRA).

300ft above sea level, 3325CB, Uitenhage, SCHLECHTER 2485 (GRA).

**C. rupestris** Kunth. var. *rupestris* 6400

On the Summit of Gaika's Kop, 6000ft above sea level, 3226DB, Amatole Mountains, RATTRAY 68 (GRA).

Bathurst Commonage, 3 kilometre's from Bathurst on the Bathurst-Southwell road, approximately 400m from the road, on the right hand side of the road, in grassy spots, between the bushclumps, 370m above sea level, 3326BD, Bathurst District, SONNENBERG 227 (GRA).

Rockford, on the banks of the Tay river, 40 kilometres from Cathcart, near a small bridge, 3226DA, Cathcart District, SONNENBERG 383 (GRA, UN).

Oribi Gorge, on the West Bank, on the Kranz tops, 3227DD, East London, GLEN 265 (GRA).

3224BC, Graaff-Reinet, BOLUS 760 (PRE).
Near Grahamstown, off the Cradock road, beyond the Golf course, in the dry grassflats, 2000ft above sea level, 3326BC, Grahamstown District, DYER 235 (GRA).

In grassy places, 364m above sea level, 3227CD, King William’s Town, FLANAGAN 2203 (GRA, PRE).

Boschberg, 1465m above sea level, 3225DA, Somerset-East District, MACOWAN 1993 (PRE).

On a hill side at St. Johns, 3227DA, Stutterheim District, ACOCKS 9423 (PRE).

*C. schlechteri* C.B.Clarke 6500

Menziesberg, on the hill East of the main Peak, on dry bare ground, 1463m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1165 (PRE).

Katberg, on a stony grassland area, 2060m above sea level, 3226BC, Stokenstroom District, DYER 363 (GRA, PRE).

*C. semitrifidus* Schrad. var. *semitrifidus* 6600

Highlands, 3326AD, Albany District, PATERSON 3401 (GRA).

Highlands road, 3326AD, Albany District, WITKOP *sn.* (GRA).

Between the Skietrug and Waaieheuvel turn-off, on the Salem-Alexandria road, 155m above sea level, 3326CB, Alexandria District, JOHNSON 811 (PRE).

Honeydale Farm, in the Trollops burn-browse plots, 516m above sea level, 3226DD, Alice, GIBBS-RUSSEL 3153 (GRA, PRE).

Menziesberg, on the hill East of the main Peak, on dry bare ground, 1463m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1164, 1165 (PRE).

Round Hill (Oribi Reserve), in open grassland, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 102 (GRA).

Round Hill (Oribi Reserve), in open grassland, 200m from a thickly wooded area and 50m from a small reservoir, 375m above sea level, 3326BD, Bathurst District, SONNENBERG 280 (GRA, UN).

Trappes Valley, 3326BD, Bathurst District, DALY 683 (GRA), 12931 (TM).

On a south-east facing slope, at the Eastern end of the mountain, on the bottom edge of the rock sheets, on the slope, 1524m above sea level, 3226DD, Elandsberg, PHILLIPSON 165 (PRE).

Blaauwkrantz River, 3700ft above sea level, 3326BC, Grahamstown District, SCHLECHTER 6876 (GRA).

Bloukrantz Nature Reserve, in valley bushveld, 250m above sea level, 3326BC, Grahamstown District, LLOYD 53 (GRA).

At the Quarry, in the bare veld, 2000ft above sea level, 3326BC, Grahamstown, KEMGON 16 (GRA); LUBKE 65 (GRA).

In the rocks near Komga, 550m above sea level, 3227DB, Komga District, FLANAGAN 1016 (PRE).

At the Show grounds, 3325DC, Port Elizabeth, DREGE 392 (GRA).

Boschberg Mountains, 2000ft above sea level, 3225DA, Somerset-East District, SONDER 1505 (GRA).

"Die Toekomst", 3225DA, Somerset-East District, DREGE 457 (GRA).

250ft above sea level, 3325CB, Uitenhage District, SCHLECHTER 2513 (GRA).
**C. sexangularis Nees. 6700**

Mooi River, 2.5 kilometre's from Committees Drift, next to the bridge, on the road between Committees Drift and Trumpeters Drift Fort, in a river bed, in shale fragments, 400m above sea level, 3326BB, Albany District, SONNENBERG 203 (GRA).  
In the Vlei, East of the main coastal road, in a marsh, on clay soil, 3327AD, Hamburg, VORSTER 2261 (PRE).  
3227CD, King William’s Town, LEIGHTON 5 (GRA).  
5 Miles out of King William’s Town, in a small damp water course, 4000ft above sea level, King William’s Town District, DYER 811 (GRA).  
Near Komga, 610m, 3227DB, Komga District, FLANAGAN 995 (GRA, PRE), 1004 (GRA).

**C. sphaerocephalus Vahl**

3 Miles from Amabele, in grassland, 795m above sea level, 3227DA, Amabele District, DE VRIES 16 (PRE).  
On the North-eastern side of Gaika's Kop, along the fire break, near the bottom of the slope, in grassland, 1508m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1298 (PRE).  
Dixon’s Bush, 2500ft above sea level, 3326DB, Bathurst District, BENNIE 149 (GRA).  
Hayes Siding, 90m above sea level, 3326DB, Bathurst District, JACOT-GUILLARMOD 5598 (PRE).  
Martindale, in grassland, 30m above sea level, 3326BD, Bathurst District, LONG 152 (PRE).  
Martindale, 3326BD, Bathurst District, LONG 152 (GRA).  
On the road to Martindale, approximately 6 kilometre's from the Port Alfred road, in the drainage area, on the roadside, 3326BD, Bathurst District, BURROWS 3181 (GRA).  
8 Kilometre's North of Port Alfred, on the road to the Fish River Mouth, in grassland, 3326DB, Bathurst District, VORSTER 2279 (PRE).  
Fairford, 3227AA, Cathcart District, COTTERRELL 93 (GRA).  
3227DD, East London, RATTRAY 814 (GRA).  
5 To 12 miles from East London, on the Transkei road, in grassveld, 3227DD, East London District, COMINS 1353 (GRA).  
Bay road Quarry, 3326BC, Grahamstown, BRITTEN 603 (GRA).  
Coldspring, 3326AD, Grahamstown District, BRITTEN 58033 (PRE).  
Grahamstown Flats, in wet places, near the Peddie road, 3326BC, Grahamstown District, SCHÖNLAND, S. 221 (GRA).  
At the head of the Kap River, on damp slopes, 3000ft above sea level, 3326BC, Grahamstown District, GALPIN 166 (GRA).  
On the Commonage, 395m above sea level, 3227CD, King William’s Town District, LEVY 5831 (PRE).  
Mount Coke, 3227CD, King William’s Town District, SIM 1387 (GRA, PRE).  
In the grasslands near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 1012 (PRE).
8 Kilometre's from Port Alfred, in the Fish River Mountains, in grassland, 3326DB, Port Alfred District, ARNOLD 590 (PRE).

On a slope near the Suurberg Inn, in grassland, 610m above sea level, 3325DC, Port Elizabeth District, ARCHIBALD 5282 (PRE).

On the summit of the Mountains near Boschberg, 4500ft above sea level, 3225DA, Somerset-East District, SONDER 1205 (GRA).

3326DA, Southwell, SCHÖNLAND, S. 3326 (GRA).

Fort Cunynghame, 3000ft above sea level, 3227CB, Stutterheim District, SCHÖNLAND, R. 61 (GRA).

*C. sphaerospermus* Schrad. 7000

Faraway, Portion 3 of Coldsprings, on a south-western facing slope, 700m above sea level, 3326AD, Albany District, JACOT-GUILLARMOD 8600 (PRE).

Camtarha River, at the margin of the river, on the river bank, 120m above sea level, 3326CB, Alexandria District, ARCHIBALD 5675 (PRE).

Sandflats, 3325BD, Alexandria District, ROGERS 3247, 3257 (GRA).

Zwartvlei Farm, on the Kop Aleen road, in a marsh, 120m above sea level, 3326CA, Alexandria District, ARCHIBALD 5469 (PRE).

Round Hill (Oribi Reserve), 200m up the hill from the Conservation house, near a thickly wooded area, 50m from a small reservoir, 375m above sea level, 3326BD, Bathurst District, SONNENBERG 278 (GRA, UN).

Round Hill (Oribi Reserve), on the stream banks, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 120 (GRA).

Trappes Valley, 3326BD, Bathurst District, DALY 662 (GRA, PRE).

Marshy slopes near the Convict Station, 15m above sea level, 3327BB, East London West, GALPIN 5848 (PRE).

Overton Farm, 11 miles West of East London, in an old vlei, near the cottage, on the hillside, 3327BB, East London District, HILNER 153 (PRE).

Selbourne, at the Museum, 45m above sea level, 3227DD, East London District, SMITH 3688 (PRE).

Cochin Farm, on the banks of a small river, in Riverine thicket, near Marsh sands, sandy soil, 3228CB, Hagga Hagga District, SONNENBERG 448 (GRA).

Krom River, West of Humansdorp, on the river bank, 120m above sea level, 3424BA, Humansdorp District, ACOCKS 21708 (PRE).

3227CD, King William’s Town, SIM 2859 (GRA).

Near Kei Mouth, in a marsh, 5m above sea level, 3228CB, Komga District, FLANAGAN 1785 (PRE).

Double Mouth, on a slope overlooking the mouth, 3228CB, Morgan's Bay District, SONNENBERG 424 (GRA, UN).

Port Alfred West Bank, at the Grahamstown road vlei, 3326DB, Port Alfred District, BRITTEN 752 (GRA, PRE).

Near the vlei on the Grahamstown road, about 1 mile from Port Alfred, 3326DB, Port Alfred West, BRITTEN 543.

Bethelsdorp, 3325DC, Port Elizabeth District, PATERSON 346 (GRA).

Schoenmakers Kop, 3325DC, Port Elizabeth District, PATERSON 549 (GRA).
C. tenellus L.f. var. tenellus 7700

Coombs Dam, near the Coombsvale Farm, near the water, 3326BD, Albany District, ARNOLD 634 (PRE).

On the Forest track below the Wolf Ridge Lookout, 3226DB, Amatole Mountains, PHILLIPSON 344 (PRE).

Featherstone Kloof, in the alluvium of the stream, 3326BC, Grahamstown, LUBKE 161 (GRA).


Near Grahamstown, ½ a mile beyond the Hamilton Dam, amongst Scirpus ludwigii and S. cernius, on a stream bank, 1800ft above sea level, 3326BC, Grahamstown District, DYER 232 (GRA).

On the upper part of Howieson's Poort, in damp and swampy places along the river, 1500ft above sea level, 3326AD, Grahamstown District, SCHÖNLAND, S. 582 (GRA).

Shaw’s Farm, Governors Kop (the highest point in District), 10 miles from Grahamstown, on a stream bank, 3326BC, Grahamstown District, HILNER 255 (GRA, PRE).

In a marsh, 3226DB, Hogsback, RATTRAY 392 (GRA).

In the Pine forest and behind the Hogsback Dam, 4000ft above sea level, 3226DB, Hogsback, LUBKE 359 (GRA).

In the swamp below the State Forest, 3226DB, Hogsback, NOEL sn. (GRA No. 8707).

Madonna and Child Falls, on the rocky slope at the foot of the falls and in the river leading away from the falls, wet soil, in shade, 3226DB, Hogsback District, SONNENBERG 341 (GRA, UN).

700m Uphill from the Robertson Falls Dam, on the banks of a small stream, 3226DB, Hogsback District, SONNENBERG 385 (GRA, UN).

1.1 Kilometres uphill from the Robertson Falls Dam, on the banks of a small stream, 3226DB, Hogsback District, SONNENBERG 388 (GRA, UN).

On the main road, just West of the Humansdorp turn-off, on the right hand side, in a marshy place on the roadside, 3424BB, Humansdorp District, IMMELMAN 305 (PRE).

Witte Els Bosch, on the flats, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 893 (GRA).

Witelsbos SAFCOL forest, on the slopes of the Tsitsikammaberg, below the radio tower, in a newly cleared area, rocky soil, 3424AA, Humansdorp District, SONNENBERG 489 (GRA, UN).

Van Stadensberg, 3325CC, Port Elizabeth District, MACOWAN 2175 (GRA).

Auckland Forest, on a river bank, 1275m above sea level, 3226DB, Seymour District, GIFFEN 1596 (PRE).

C. textilis Thunb. 8100

Bucklands, opposite the wood, on a river bank, 455m above sea level, 3326BA, Albany District, ACOCKS 23792 (PRE).
Highlands road, 10 kilometre's from Grahamstown, at the edge of a stream, near a small dam, 3326AD, Albany District, LUBKE 168 (GRA).

Oakwell Farm, in the valley beneath the house, on an alluvial plain, in a seepage of the outlet of the big dam, 33° 17' 33" S, 26° 20' 21" E, 3326AB, Albany District, HOBSON, S. 1314 (GRA).

T.C. Whitesfarm, Cradock road, at the river's edge, 3326AD, Albany District, WOOD 5 (GRA).

Boknesstrand, in the river, 1m above sea level, 3326DA, Alexandria District, BURROWS 3092 (GRA).

Camtarha River, on the river bank, 120m above sea level, 3326CB, Alexandria District, ARCHIBALD 5686 (PRE).

Kasouga Mouth, on the river bank, 3326DA, Alexandria District, BRITTEN 2317 (PRE).

Kasouga River Mouth, North of the lagoon, 6m above sea level, 3326DA, Alexandria District, PHILLIPSON 347 (PRE).

In a dry vlei, in a grassy area, 3326DB, Bathurst District, DYER 623 (GRA).

Horse Shoe, 3326BD, Bathurst, VON GADOW 300 (GRA).

Kap River, 3327AC, Bathurst District, PALMER 1591, 1600 (GRA).

Round Hill (Oribi Reserve), on a stream bed, 375m above sea level, 3326DB, Bathurst District, WIRMINGHAUS 108 (GRA).

Rufanes River Mouth, on the river's edge, 0m above sea level, 3326DB, Bathurst District, MARTIN sn. (GRA No. 3382).

On the road to Three Sisters, 3326DB, Bathurst District, BRITTEN 732 (GRA), 732A (PRE).


Newlands, 3327BB, East London, LEVY 3119 (PRE).

Igoda Mouth, in the wet places along the river bank, 0-10m above sea level, 3327BB, East London District, LUZZI 58 (GRA).

Shaw Bridge, 6 miles from Kidds Beach, on the road to East London, on the alluvial flats above the bridge, next to the stream and in the stream, 3227DD, East London District, COMINS 1600 (GRA).

Beggars Bush, in a stream bed, 3326BC, Grahamstown District, NOEL 1110 (GRA).

Belmont Valley, 3326BC, Grahamstown District, BRITTEN sn. (GRA un-numbered).

Blaauwkrantz, in the gorge, 3326BC, Grahamstown District, BRITTEN 849 (PRE).

Blaauwkrantz, 16 miles from Grahamstown, 3326BC, Grahamstown District, HILNER 74 (GRA, PRE).

Blaauwkrantz, area 8, on the Riverine flats of a narrow flood plain and on the steeply sloping sides of the valley, towards the river, 3326BC, Grahamstown District, JACOT-GUILLARMOD & BRINK 34 (GRA).

Featherstone Kloof, 3326BC, Grahamstown, SWIFT sn. (GRA No. 6217).

New Year's River, below the Kaolin Mine, on the stream banks, 600m above sea level, 3326AD, Grahamstown District, BETHUNE 5 (GRA); COETZEE 14 (GRA).

Stowan Farm Dam, 600m, 3326AD, Grahamstown District, ANON sn. (GRA No. 6213); BETHUNE 16 (GRA).

Thomas Baines Nature Reserve, Palmiet River, 3326AD/BC, Grahamstown District, PALMER 1030 (GRA).

Kareedouw, 3424AB, Humansdorp District, HORN 2460 (SKF).
Krom River, were the stream enters the river, in shady places, 3424BB, Humansdorp, MORRISON 84 (GRA).
Along the streams, 1000ft above sea level, 3228AD/CB, Kentani District, PEGLER 1152 (GRA).
Sundays River, on the river's edge, 3325DB, Kirkwood District, TIBSCHRAENY 19 (GRA).
3225DC, Port Elizabeth, KEMSLEY 244 (GRA).
Perseverance, at the Old Drift, in the sea water, 3225 DC, Port Elizabeth District, OLIVIER 492 (GRA).
Redhouse, 3225DC, Port Elizabeth, PATerson 253 (GRA).
Mitford Park, MJ.Hoole's Farm, near Riebeek-East, in the sandy soil near the stream, 3326AA, Riebeek-East District, BRINK 112 (GRA).
2300ft above sea level, 3225DA, Somerset-East, SONDER sn. (GRA No. 1870).
Kubusie, 3227DA, Stutterheim District, WEHMEYER 1 (PRE).
Swartkops River, 3325CD, Uitenhage District, ECKLON & ZEYHER 170 (PRE).
In the Southern facing forestry land, on a flood plain, in clay soil, 15m above sea level, 3325CD, Uitenhage District, DAHLSTRAND 387 (PRE).
Zunga Catchment Basin, Groendal Wilderness Reserve, at the dam, on the bank, in humus soil, 140m above sea level, 3325CB, Uitenhage District, SCHARF 1514 (PRE).

C. usitatus Burch. var. macrobulbus Kukenth. 8380

Botha's Ridge, in the Fish River Valley, 10 kilometre's from Grahamstown, in succulent scrub, 3326BC, Albany District, LUBKE 101 (GRA).
Oakwell Farm, the valley beneath the house, on an alluvial plain, 33° 17' 33" S, 26° 20' 21" E, 3326AB, Albany District, HOBSON, S. 1315 (GRA).
Brakfontein, on the slope across the road from the huts, below the quarry, in an Acacia dominated, grassy, depauperate mid-slope, in the shale at the top of the slope, 715m above sea level, 32° 43' 13" S, 26° 01' 46" E, 3226CA, Bedford Catchment, HOBSON, S. 906 (GRA).
Swartkops Riverside area, in a marsh, on the river bank, 3325CB, Uitenhage District, RANNASAMMY-COOK 73 (GRA).

C. usitatus Burch. var. usitatus 8400

Commando Drift Dam Nature Reserve, 40 kilometre's East of the Cradock Management Survey, in false Karoid broken veld, 1000m above sea level, 3225BB, Cradock District, PALMER 1007 (GRA).
Oatlands, 3326BC, Grahamstown District, DALY & SOLE 149, 176 (GRA).
Rhodes University, in the waste land behind the Botany Department, 3326BC, Grahamstown, BRITTEN 5220 (GRA).
Katberg, in the grassy plains, 5000-5300ft above sea level, 3226DA, Queenstown District, GALPIN 1697 (GRA).
Coega, 15 miles East-North-East of Port Elizabeth, between the road to Grahamstown and the sea, 3325DC, Port Elizabeth District, DAHLSTRAND 669 (GRA).
Coega Station, 3325DC, Port Elizabeth District, BEITCH A2068 (GRA).
Cradock Place, 1000ft above sea level, 3325DC, Port Elizabeth, GALPIN 6410 (GRA).
Redhouse, 3325DC, Port Elizabeth, PATERSON 492, 619 (GRA).

Swartkops, on the roadside around the salt pans, 3325DC, Port Elizabeth District, THONGHLIN 430 (GRA).

**ELEOCHARIS R.Br. 0469010**

*E. dregeana* Steud. 600

Waldon Farm turnoff, 40 kilometres from Grahamstown on the Port Alfred road, at the edge of a small marsh, clay soil, 3326BC, Albany District, SONNENBERG 262 (GRA, UN).

Robertson Falls, overlooking the Tyumie Basin, on the rocky river banks of the river that feeds the falls, 3226DB, Hogsback District, SONNENBERG 384 (GRA, UN).

Siberia marsh, on the way to Gaika's Kop, clay soil, 3226DB, Hogsback District, SONNENBERG 394 (GRA, UN).

Kei Mouth dump Site, in the grassland surrounding the site, sandy soil, 3228CB, Kei Mouth, SONNENBERG 434 (GRA, UN).

1 Kilometre before Port Alfred, travelling from Alexandria, at the lake, 3326DB, Port Alfred District, ARNOLD 607 (PRE).

*E. limosa* (Schrad.) Schult. 1000

The New Year Rivers Dam, in mud, 3326BC, Alicedale District, JACOT-GUILLARMOD 7460 (GRA).

At the bottom of Botha's River Valley, 3326BC, Albany District, SCHÖNLAND, S. 4426 (GRA).

On the Cradock road, 7 miles from Grahamstown, 3326BC, Albany District, HILL, A. sn. (GRA No. 6208).

On the Highlands road, 10 miles from Grahamstown, around the stream leading up to the dam, 3326AD, Albany District, LUBKE 169 (GRA).

On the Kowie road, 8 miles from Grahamstown, in 6 inches of water, in the "Isoetes" pool, 3326BC, Albany District, LUBKE 85 (GRA).

8 Kilometres from Riebeek-East, in a dry dam, 100m from the Riebeek-East road to Hells Poort, 3326AA, Albany District, SONNENBERG 218 (GRA).

Suurberg, Melkhoutboom Archaeological Site, 3325BC, Alexandria District, JESSOP 908 (GRA).

8 Miles East of Charlgrove Store, 185m above sea level, 3326DB, Bathurst District, ACOCKS 18353 (PRE).

Mjilo, in the Tortoise pools near Alice, 3226DD, Fort Beaufort District, GIFFEN 57543 (PRE).

200ft above sea level, 3326BC, Grahamstown, SONDER 1543 (GRA).

New Years River, along the moist river banks, 3326AD, Grahamstown District, SILBERBAUER 12 (GRA).

New Years River, near the pool, 3326AD, Grahamstown District, TAYLOR 20 (GRA).

New Years River Origin, at the river margin, 600m above sea level, 3326AD, Grahamstown District, BETHUNE 19 (GRA); COETZEE 36 (GRA).

Oatlands, 3326BC, Grahamstown District, BENNIE 371 (GRA).

Eerste River, in the marshy watercourse, 350ft above sea level, 3424BB, Humansdorp District, FOURCADE 2447 (GRA).
9.3 Miles North-west of Kareedouw, in a wooded Kloof, fynbos, 275m above sea level, 3324CD, Humansdorp District, ACOCKS 20037 (PRE).

Cape Morgan Nature Reserve, in the grassland near the gate to the reserve, in and old marsh, sandy soil, 3228CB, Kei Moth District, SONNENBERG 413 (GRA, UN).

Marsh, 365m above sea level, 3228CB, Kentani District, PEGLER 2094 (PRE).

0.5 Kilometre West of Qolora Mouth, next to the Qolora River, opposite the forest, river bank, 3228CB, Kentani District, VAN WYK 3251 (PRE).

Mount Coke, 3227CD, King William’s Town District, SIM 1371 (GRA, PRE).

In the swamps near Komga, 2000ft above sea level, 3227DB, Komga District, FLANAGAN 903 (GRA, PRE).

Port Alfred West Bank, the vlei on the Grahamstown road, 3326DB, Port Alfred, BRITTEN 749 (GRA).

Baakens River Valley, 3325DC, Port Elizabeth, DREGE 347 (GRA); PATERSON 856 (GRA).

Redhouse, 3225DC, Port Elizabeth, RATTRAY 627 (GRA).

Swartkops, Riverside Area, in the river, marsh, 3325DC, Port Elizabeth, RAMMASAMMY-COOK 73 (PRE).

Swartkops River, moist spots in the channel, 3325DC, Uitenhage District, ECKLON & ZEYHER 438 (PRE).

Villa Paul Mare, Swartkops River Valley, 85m above sea level, 3325CD, Uitenhage District, ZEYHER 4423 (PRE).
**E. palustris** R.Br. 1150

Palmiet River, Howieson's Poort, 33° 22' S, 26° 29' E, 3326BC, Albany District, RAMMASAMMY-COOK 76 (GRA).

Kasouga River Mouth, in the salt marsh flood plain, 750m from the sea, directly across from the holiday shacks, 3326DA, Bathurst District, SONNENBERG 215 (GRA).

Between Fort Beaufort and Grahamstown, in vicinity of Fort Brown and Breakfast Vlei, 213m above sea level, 3326BA, Fort Brown, GIBBS-RUSSEL 4013 (PRE).

4 Miles from Grahamstown, on the King William’s Town road, in the water, 3326BC, Grahamstown District, BRITTEN 588 (PRE).

In a marsh, 365m above sea level, 3228CB, Kentani District, PEGLER 2095 (PRE).

Near Komga, marsh, 610m above sea level, 3227DB, Komga District, FLANAGAN 903 (PRE).

2.6 Kilometre from the turn-off to Kei Mouth, on the river bank, 3228CA, Komga District, ARNOLD 549 (PRE).

Dohne Research Station, in the clear pools, grassland, 3227CB, Stutterheim District, ACOCKS 9263 (PRE).

Mount Boschberg, 4500ft above sea level, 3225DA/DC, Somerset-East District, BARKER 1741 (GRA).

**EPISCHOENUS** C.B.Clarke 0477010

**E. quadrangularis** (Boeck.) C.B.Clarke 600

Paradise Kloof, in a dry stream near the cattle path, 3326BC, Grahamstown District, MARTIN sn. (GRA No. 2910).

Osmunda Kloof, in the marshy area near the top of the Kloof, on the South-western slopes, 3326BC, Grahamstown District, MARTIN sn. (GRA No. 3102).

Cockscomb, Groot Winterhoek Mountains, 1600m above sea level, 3324DB, Uitenhage District, ESTERHUYSEN 27538 (PRE).

Kouga Peak, near Joubertina, on a river bank, 3324CA, Uniondale District, ESTERHUYSEN 16286 (PRE).

**FICINIA** Schrad. 0465000

**F. acuminata** (Nees) Nees 200

Suurberg Mountains, in the tussock grassland, 3325BC, Alexandria District, LUBKE 23 (GRA).

Driefontein Farm, Suurberg State Forest, in the mountain grassland, 33° 18' S, 25° 35' E, 790m above sea level, 3325BC, Alexandria District, LUBKE 2065 (GRA).

Howieson's Poort, between Featherstone Kloof and Osmunda Kloof, in pines, on a shoulder of rock, at the end of the ridge, 3326AD, Grahamstown District, MARTIN sn. (GRA No. 3106).

Paradise Kloof near Grahamstown, on the cliff face, 2200ft above sea level, 3326BC, Grahamstown District, LUBKE 82 (GRA).

Below the Forest Station, swamp, 3226DB, Hogsback, NOEL sn. (GRA No. 10513).
Near the Perry Bar, 4000ft above sea level, 3226DB, Hogsback, SEAGRIEF 1561 (GRA).

In the Pine forest, on the forest floor, 4000ft above sea level, 3226DB, Hogsback, LUBKE 110 (GRA).

Buffelsbos, in derived sourveld (*Thamnochotus glaber-Digitaria mono*stactyla), 90m above sea level, 3242AB, Humansdorp District, COWLING 1468 (GRA).


Cockscomb, Great Winterhoek Mountain, 1740m above sea level, 3324DB, Uitenhage District, ESTERHUYSSEN 27526 (PRE).

**F. albicans Nees 300**

Trappes Valley, 3326BD, Bathurst District, DALY 664 (GRA).

Near Kwenxura Mouth, 3227CC, East London District, GALPIN 5816 (GRA).

In mature *Protea neriifolia* fynbos, on Enon sandstone, a few kilometres from Hankey, on the Loerie road, 160m above sea level, 3324DD, Hankey District, COWLING 1193 (GRA).

Below a kopie, grassland, 3424BB, Humansdorp District, BRITTEN 1153 (PRE).

Buffelsbos, in derived grazed sourveld, on *Thamnochotus glaber, Digitaria monodactyla, Tristachya*, 90m above sea level, 32424AB, Humansdorp District, COWLING 1465 (GRA).

In dune fynbos near Cape St. Francis Bay, 10m above sea level, 3424BB, Humansdorp District, COWLING 55 (GRA).

4 Kilometre South of Humansdorp on road to Cape St. Francis, fynbos, 80m above sea level, 3424BB, Humansdorp District, DAVIDSE 33616 (PRE).

Van Stadens Nature Reserve, on the sand flats, on shales, 100m above sea level, 3325CC, Port Elizabeth District, DAHLSTRAND 2530 (GRA, PRE).

**F. arenicola Arnold & Gordon-Gray var. arenicola 550**

Bushman's River Mouth, at the turn-off to Southwell, on the Kenton-on-Sea-Port Alfred road, in grassland, 3326DA, Alexandria District, ARNOLD 602 (PRE).

Cannon Rocks, behind the dunes, 15m above sea level, 3326CD, Alexandria District, ACOCKS 23902 (PRE).

Coast road at Cape Padrone, grassland, 90m above sea level, 3326DC, Alexandria District, ARCHIBALD 5531 (PRE).

2 Kilometre South-west of Fish River Mouth, on the road to Port Alfred, against a hill, 3327AC, Bathurst District, VORSTER 2277 (PRE).

Kasouga, Mr L.Sandains house, on sandy soil overlooking ocean, 50m above sea level, 3326DB, Bathurst District, DAHLSTRAND 2869 (GRA, PRE).

Tharfield Private Nature Reserve, on the verge of the coastal thicket, three dune ridges from the sea, 3327CA, Bathurst District, SONNENBERG 209 (GRA).

Coldstream, 3326BC, Grahamstown District, SCHÖNLAND, S. 1554 (PRE).

Cape St. Francis, behind the dunes, 2m above sea level, 3424BB, Humansdorp District, DAVIDSE 33631 (PRE).

3326DB, Port Alfred West, TYSON 604 (PRE).
Near the river mouth, grassland, 3326DB, Port Alfred, TYSON 154, 605, 57236 (PRE).

Grassland, 3326DB, Port Alfred, TYSON 17543 (TM).

Port Alfred West Bank, near the Bay of Biscay, 3326DB, Port Alfred District, BRITTEN 1901 (GRA).

3325DC, Port Elizabeth, KEMSLEY 24 (GRA); PATerson 2302 (GRA).

5 Kilometre before the Van Stadens River Mouth, grassland, 3325CC, Port Elizabeth District, ARNOLD 648 (PRE).

**F. bulbosa** (L.) Nees 1000

Bushman's River Mouth, grassland, 45m above sea level, 3326DA, Alexandria District, ARCHIBALD 4877 (PRE).

Kenton-on-Sea, the dune slacks behind the first set of coastal dunes, near the Joan Muirhead Nature Reserve, 3326DA, Alexandria District, BARKER 612 (PRE).

Sunday's River, in coastal scrub, 3325DB, Alexandria District, LUBKE 2625 (GRA).

Leggs Farm, Rufanes River, in the grassveld, 3326DB, Bathurst District, LUBKE 107 (GRA).

Tharfield Private Nature Reserve, West-Kleinemonde, in the dune thicket, near the FM tower, three dune ridges from the sea, 3326CA, Bathurst District, SONNENBERG 208 (GRA).

Pine forest, on a moist slope, at the edge of the pines, 3226DB, Hogsback, DEWEY 1 (GRA).

Aston Bay, near the Sea, 3424BB, Humansdorp District, ARNOLD 660 (PRE).

Near Cape St. Francis, in derived dune grassland (*Stenotaphrum-Sporobolus africanus-Themeda*), 20m above sea level, 3424BB, Humansdorp District, COWLING 128, 467 (GRA).

Cape Recieff, in a burnt area, 3425BA, Port Elizabeth, OLIVIER 2380 (GRA).

Humewood, behind the dunes, 10m above sea level, 3325DC, Port Elizabeth, DAHLSTRAND 151 (PRE).

King Neptune Beach, 12 kilometre's East of Port Elizabeth, behind the dunes, 3325DC, Port Elizabeth District, ARNOLD 1069 (PRE).

57 Kilometre South-west of Paterson, on the road to Port Elizabeth, on a limestone outcrop, 50m above sea level, 3325DC, Port Elizabeth District, DAVIDSE 33566 (PRE).

Port Elizabeth Campus, in the drift sands, 3325DC, Port Elizabeth, ANon sn. (GRA No. 155).

Redhouse, 3325DC, Port Elizabeth, PATerson 776 (GRA), 2126 (GRA, PRE), 2500 (GRA); ROGERS 4074 (GRA).

2 Kilometre from the Sunday's River Mouth, behind the dunes, 3325DB, Port Elizabeth District, ARNOLD 640 (PRE).

Swartkops River Estuary, in the stable sand on the west bank, 10-15m above sea level, 3325DC, Port Elizabeth District, ARCHIBALD 4909 (GRA).

**F. capillifolia** (Schrad.) C.B.Clarke 1250

Featherstone Kloof, amongst ferns, in a damp area, 1350ft above sea level, 3326BC, Grahamstown, LUBKE 164 (GRA).

The Kloof Entering Howieson's Poort from the south-east, 4 miles from Grahamstown, on the stream bank, 3326BC, Grahamstown District, MARTIN sn. (GRA No. 3097, GRA No. 3097).
**F. cinnamomea C.B.Clarke 1500**

On the top of the Hogsback Pass, near the top of the Big-Tree path, in a forest clearing, 1158m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 944 (PRE).

Blaauwkrantz, in the crevices of rocks, in the gorge, 3326BC, Grahamstown District, HILNER 64 (GRA).

In crevices of rocks and between boulders, near one or two trees on Featherstone Kloof, 4 miles from Grahamstown, 2000ft above sea level, 3326BC, Grahamstown District, DYER 1404 (GRA, KEW).

Howieson's Poort, among rocks at the margin of the Kloof bush, 3326AD, Grahamstown District, DYER 1576 (GRA).

Robertson Falls, on the rocky river banks of the river that feeds the falls, 3226DB, Hogsback District, SONNENBERG 339 (GRA, UN).

3325DC, Port Elizabeth, PATERSON 684 (GRA).

Baakens River Valley, 3325DC, Port Elizabeth District, DREGE 684 (GRA).

**F. compasbergensis Drege 1600**

1478m above sea level, 3224BC, Graaff-Reneit, BOLUS 704 (GRA, PRE).

**F. dasystachys C.B.Clarke 1800**

Ellersvlei, not far from the river bank, also on the mountain sides, 3227AA/AC, Cathcart District, COTTERELL 68 (GRA).

Common on sandy soil, on hill above the Cemetery, Eastern slopes of King William’s Town, 3000ft above sea level, 3227CD, King William’s Town, HILNER 104 (GRA).

Pastures near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 922 (PRE).

**F. dunensis Levyns 2100**

Cape St. Francis, behind the dunes, 2m above sea level, 3424BB, Humansdorp District, DAVIDSE 33633 (PRE).

Walmer, 3325DC, Port Elizabeth, PATERSON 1071 (GRA).

**F. dura Turrill 2150**

Near Gaika's Kop, where to river marshes converge, at the base of a small hillock, 3226DB, Hogsback District, SONNENBERG 395 (GRA, UN).

Gaika's Kop, in the marsh below the old forestry tower, at the margin of the Pine forest, sandy soil, 3226DB, Hogsback District, SONNENBERG 397 (GRA, UN).

**F. fascicularis Nees 2500**

Elandsberg, among the grasses, 1524m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 426 (PRE).

Eastern Slopes of Dassie Kranz, in the damp areas under the trees, 2000ft above sea level, 3326AD/BC, Grahamstown, DYER 141 (GRA, KEW).

Nature Reserve at Grahamstown, at the foot of Dassie Kloof, fynbos, in humus soil, 3326BC, Grahamstown, ARNOLD 619 (PRE).

3227CD, King William’s Town, SIM 887 (PRE).

Kettle Spout Falls, in the small stream, at the margin of the Pine forest and fynbos, 3226DB, Hogsback District, SONNENBERG 298 (GRA, UN).

Assegaai Bosch, 900-1000ft above sea level, 3324CD, Humansdorp District, ROGERS 2016 (GRA).

Witelsbos SAFCOL forest, in an area cleared of Eucalyptus trees, 700m from the N2 to Storms River, 1 kilometre from the SAFCOL Offices, wet clay soil, 3424AA, Humansdorp District, SONNENBERG 463, 464, 466 (GRA, UN).

Witelsbos SAFCOL forest,1.1 kilometres up the Tsitsikammaberg, on a rocky slope in Pine forest, 3424AA, Humansdorp District, SONNENBERG 476 (GRA, UN).

Cata Peak Ridge, near a mountain stream and in the thick bracken growth, 5000-5500ft above sea level, 3227CB, King William’s Town District, DYER 343 (GRA).

Ghulu Kop, sheltered by rocks, 1370m above sea level, 3227CA, King William’s Town District, DYER 652 (GRA, PRE).

Otterford Forestry Reserve, 800m above sea level, 3324DB, Seymour District, DAHLSTRAND 768 (PRE).

Boschberg, on a stony river bank, 3225DA, Somerset-East District, HILLIARD & BURTT-DAVY 13223 (PRE).

Boschberg Mountains, 3000-4000ft above sea level, 3225DA, Somerset-East District, BAKER 1975 (GRA).

West end of Kabaku Hills, in the forest, 3227CB, Stutterheim District, ACOCKS 9090 (PRE).

Chase's Kloof, Groendal Wilderness Reserve Catchment Basin, in the forest, on a stony river bank, 185m above sea level, 3325CA, Uitenhage District, SCHARF 1484 (PRE).

**F. filiculmea B.L.Burtt 2650**

Witelsbos SAFCOL forest,700m up the Tsitsikammaberg, on a rocky slope in Pine forest, 3424AA, Humansdorp District, SONNENBERG 474 & 475 (GRA, UN).

Witelsbos SAFCOL forest, in the understorey of indigenous forest on the Tsitsikammaberg side of the N2 to Storms River, 3424AA, Humansdorp District, SONNENBERG 481 (GRA, UN).

**F. filiformis (Lam.) Schrad. 2700**

Driefontein Farm, Suurberg State Forest, mountain grassland, 790m above sea level, 33° 18’ S, 25° 35’ E, 3325BC, Alexandria District, LUBKE 2067 (GRA).

Kasouga River Mouth, edge of Juncus sp. sward, on the river bank, 3326DA, Bathurst District, SONNENBERG 216 (GRA).

Bathurst Commonage, 6 Kilometre’s from Bathurst, 1 Kilometre’s from the Bathurst-Southwell road, on the banks of the Lushington river, amongst the grasses and Cyperus textilis, 3326BD, Bathurst District, SONNENBERG 221 (GRA).

Round Hill, edge of the river, in shallow water, 3326BD, Bathurst District, McLAREN 14 (GRA).
Hamilton Dam, 3326BC Grahamstown, GORDON-GRAY *sn.* (GRA No. 2046).

Thomas Baines Nature Reserve, 3326BC, Grahamstown District, ANON *sn.* (GRA No. 19713).

Dune fynbos near Cape St. Francis, 10m above sea level, 3424BB, Humansdorp District, COWLING 38A (GRA).

**F. gracilis** (Poir.) Schrad. 2800

Lockerbie, 12 miles south-west of Grahamstown, 395m above sea level, 3326AD, Albany District, ACOCKS 23904 (PRE).

Spadona Halt, 155m above sea level, 3326DA, Alexandria District, JOHNSON 884 (PRE).

Summit of Gaika's Kop, 6000ft above sea level, 3226DB, Amatole Mountains, RATTRAY 70 (GRA).

Round Hill (Oribi Reserve), open grassland, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 235 (GRA).

3327CB, East London, RATTRAY 855 (GRA).

3326BC, Grahamstown, BARKER 1973 (GRA); BRITTEN *sn.* (GRA un-numbered); DALY & SOLE 74 (GRA), 104A (GRA), 220 (GRA, PRE); ROGERS 3050 (GRA); SONDER 156 (GRA).

2 Kilometre’s East of Grahamstown, 3326BC, Grahamstown District, LIPSKEY 38 (GRA).

Coldsprings, in damp places near the railway-line, near the tunnel, 3326AD, Grahamstown District, HILNER 252 (GRA).

Above Featherstone Kloof, near Woest Hill, amongst the pines, on a grassy rocky slope, 2100ft above sea level, 3326BC, Grahamstown, LUBKE 152 (GRA).

Stones Hill, 3326BC, Grahamstown District, SCHÖNLAND, S. 75 (GRA).

Woest Hill, 2100ft above sea level, 3326BC, Grahamstown District, SCHÖNLAND, S. 1892 (GRA).

In derived *Leptophyll* Shrubland (Renosterveld), on Enon clay, near Harmonie (Loerie), (Dominants-*Elytropappus, Themeda, Relhania genistaefolia, Agathosma puberula*), 100m above sea level, 3324DD, Hankey District, COWLING 829 (GRA).

In mature *Protea neriifolia* fynbos, on Enon sandstone, a few kilometres from Hankey on the Loerie road, 160m above sea level, 3324DD, Hankey District, COWLING 1194 (GRA).

Hankey Pass, in Renosterveld, on Enon conglomerate, dominated by *Elytropappus, Phylica arillaris, Themeda*, 160m above sea level, 3324DD, Hankey District, COWLING 1498 (GRA).

3226DB, Hogsback, RATTRAY 216 (GRA).

Assegaa Bosch, 900-1000ft above sea level, 3424BB, Humansdorp District, ROGERS 2007 (GRA).

Buffelsbos, in derived sourveld (Dominants-*Thamnochortus glaber, Digiaria monodactyla*), on deep sand, 90m above sea level, 3424AB, Humansdorp District, COWLING 1498 (GRA).

Krom River, in frequently burnt fynbos above Linderhof, (Dominants *Erica diaphana, Tetraria* spp., *Adropogon filifolius*), 110m, 3424BB, Humansdorp District, COWLING 1334 (GRA).

Kruisfontein Mountains, in proteoid fynbos (*Protea neriifolia*), 300m above sea level, 3424AB, Humansdorp District, COWLING 1414 (GRA).

Misgund, in mature fynbos, (Dominants-*Protea neriifolia, Agathosma unicalpellata, Passerina pendula, Restio triticeus*), 160m above sea level, 3324DD, Humansdorp District, COWLING 1118 (GRA).
Cata Peak Ridge, amongst grass, 5500ft above sea level, 3227CB, King William’s Town District, DYER 340, 346 (GRA).

Hill sides of Mount Hope, Upper Zwart Kei, 1585m above sea level, 3226BC, Queenstown District, GALPIN 5603 (PRE).

Walmer Township, old farming ground left unattended for years, 8 miles West-North-West of Port Elizabeth and 6 miles North of the coastline, on sandy soil, 100ft above sea level, 3325DC, Port Elizabeth District, DAHLSTRAND 316 (GRA).

Suurberg Mountains, in *Themeda/Tristachya* veld, 3325BC, Port Elizabeth District, LUBKE 23 (GRA).

Cumakala River Valley, grassland, 825m above sea level, 3227CB, Stutterheim District, ACOCKS 9203 (PRE).

Dohne Research Station, grassland, 915m above sea level, 3227CB, Stutterheim District, ACOCKS 9224 (PRE).

Fairfields, Great Winterberg Mountains, grassland, 1830m, 3226AD, Tarkastad District, ACOCKS 17640 (PRE).

Kouga Mountains, 3324CA, Uniondale District, ESTERHUYSEN 10805 (PRE).

Swartkops, 3325DC, Uitenhage District, ZEYHER 4413 (GRA).

**F. indica** (Lam.) Pfeiffer var. *indica* 2900

East Kleinemonde, the vlei area at the river's edge, next to *Stenotaphrum* spp., 100m from the closed river mouth, 3326CA, Bathurst District, SONNENBERG 213 (GRA).

Howieson's Poort, on the river bank, 3326AD, Grahamstown District, RAMMASAMMY-COOK 67 (GRA).

Assegaai Bosch, 900-1000ft above sea level, 3424AA, Humansdorp District, ROGERS 2012 (GRA).

Assegaai Bosch Station, on the slope towards the Krom River, 3424AA, Humansdorp District, SCHÖNLAND, S. 3060 (GRA, PRE).

Witte Els Bosch, on the flats, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 1012 (GRA).

3326DB, Port Alfred, SCHÖNLAND, S. 1554 (GRA).

Port Elizabeth Valley, 3325DC, Port Elizabeth, PATerson 2575 (GRA).

Swartkops River, 3325DC, Uitenhage District, ZEYHER 4391, 4395 (GRA).

**F. involuta** Nees 3000

3325DC, Port Elizabeth, FRIES & NORLIND 425 (PRE).

Van Staden's, 3325CC, Port Elizabeth District, PATerson 2481 (GRA).

**F. laciniata** (Thunb.) Nees 3300

Boknesstrand, 0.7 kilometre's south-west of Kenton-on-Sea, near Bakanas river, 1 kilometre from the sea, in grassland, 6m, 3326DA, Alexandria District, BURROWS 2472 (PRE).

Bushman's River Mouth, in grassland, 30m, 3326DA, Alexandria District, KILLICK 1767 (PRE).

Sandflats, 305m above sea level, 3325BD, Alexandria District, ARCHIBALD 3736 (PRE).

At the turn-off to Southwell, travelling from Bushman's River Mouth, in grassland, 3326DA, Alexandria District, ARNOLD 604 (PRE).
Overton Farm, 11 miles West of East London, amongst the tall grass, near the lands, 0m above sea level, 3327BB, East London District, HILNER 293 (GRA, PRE).

Yarrow, 3326AD, Grahamstown, BURTT-DAVY 11675 (PRE).

3325DC, Port Elizabeth, NORLIND 425 (PRE).

Redhouse, 3325DC, Port Elizabeth, PATERSON 2267 (GRA).

Walmer, 3325DC, Port Elizabeth, PATERSON 259A (GRA).

Walmer Commonage, 50m above sea level, 3325DC, Port Elizabeth, DAHLSTRAND 316 (PRE).

Swartkops River, 3325CD, Uitenhage District, ECKLON & ZEYHER 177 (PRE); ZEYHER 4415 (GRA).

_**F. lateralis** (Vahl.) Kunth. 3500_

Highlands, near the railway, in veld, 3326AD, Albany District, NOEL 1108 (GRA).

In the dunes, 3326CB, Alexandria District, OSBORNE 129 (GRA).

Alexandria Forest, in the forest behind the dunes, 3326CB, Alexandria District, OSBORNE 129 (PRE).

Bosbokstrand, Dias Cross Memorial, dunes, 3326DA, Alexandria District, RETIEF 1195 (PRE).

Bushman's River Mouth, in the dune gullies, on the West bank near the mouth, 3326DA, Alexandria District, ANON _sn._ (GRA No. 1263).

Cape Padrone, near the freshwater springs, at the foot of a cliff, in humus soil, 5m above sea level, 3326CD, Alexandria District, JACOT-GUILLARMOD & BRINK 26 (GRA, PRE).

Woody Cape, in the slack of a high dune, in the open areas, 60m above sea level, 3326CD, Alexandria District, JACOT-GUILLARMOD 9819 (GRA, PRE).

Bathurst Commonage, 5 kilometre's from Bathurst, 250m from the Bathurst-Southwell road, in the grassland between the bushclumps, on sand soil, 3326DB, Bathurst District, SONNENBERG 225 (GRA).

Near the Fish River Mouth, South of the river, 10m above sea level, 3327AC, Bathurst District, PHILLIPSON 170 (PRE).

Kasouga Mouth, on the Eastern side of the beach, 3326DA, Bathurst District, BRITTEN 2291, 2308 (GRA, PRE).

Kowie East, in the salt marsh, in sandy areas, next to *Passerina rigida, Acacia saligna* & grass, 3326DB, Bathurst District, MARTIN _sn._ (GRA No. 8235).

Middle Rock, Three Sisters, 3326DB, Bathurst District, BRITTEN 825 (GRA), 825A, 825B (PRE).

Riet River, 3327CA, Bathurst District, WHITE 50 (GRA).

Riet River Mouth, on an isolated cliff, on the edge of the sea, 3327CA, Bathurst District, GREATHEAD 7 (GRA).

Between Port Alfred and Kasouga, near Ship Rock, 3326DB, Bathurst District, GIBBS-RUSSEL 4104, 4105 (PRE).

Southwell, 3326DA, Bathurst District, BRITTEN 2291 (GRA).

Tharfield Private Nature Reserve, in dune thicket, 250m from Kleinemonde-West, under a large *Rhus crenata*, 3326CA, Bathurst District, SONNENBERG 205 (GRA).

On sandy dunes, 3227DD, East London, RATTRAY 726 (GRA).

Bosbokstrand, in a dune slack, 0m above sea level, 3228CC, East London District, STEEL 19 (GRA).
Gonubie Beach, 3228CC, East London, HILLIARD & BURTT-DAVY 12459 (PRE).

Kwelegra River Mouth, in the forest, 3228CC, East London District, HILLIARD & BURTT-DAVY 14815 (PRE).

Nahoon, 3227CC, East London District, NANNI 38840 (PRE).

Nahoon Mouth, on the rocks, in the estuary, 3227DD, East London District, TINLEY 58034 (PRE).

Overton Farm, 11 miles West of East London, 3327BB, East London District, HILNER 223 (GRA, PRE).

Assagai Bosch, 900-1000ft above sea level, 3424BB, Humansdorp District, ROGERS 2880 (GRA).

Cape St. Francis, in the coastal fynbos, 10m above sea level, 34° 11’ S, 24° 50’ E, 3424BB, Humansdorp District, LUBKE 1846 (GRA).

Cape St. Francis, 2m above sea level, 3424BB, Humansdorp District, DAVIDSE 33632 (PRE).

Jeffrey's Bay, 3424BB, Humansdorp District, WENDELBERGER 374 (PRE).

Cape Morgan Nature Reserve, near the ruins of a large old house, in the dune thicket, sandy soil, 3228CB, Kei Mouth District, SONNENBERG 420 & 421 (GRA, UN).

Kei Mouth, behind the dunes, 30m above sea level, 3228CB, Komga District, ACOCKS 13589 (PRE).

Near Kei River Mouth, in sandy spots, 50ft above sea level, 3228CB, Komga District, FLANAGAN 1781 (GRA, PRE).

3326DB, Port Alfred, POTTS 205 (GRA, PRE); TYSON 610 (PRE), 17547 (TM).

At the edge of the road passing between the sea sand and the bush, 20m above sea level, 3326DB, Port Alfred, ARCHIBALD 51 (GRA).

In damp hollows, 50ft above sea level, 3326DB, Port Alfred West, GALPIN 2949 (GRA, PRE).

In the dunes, 3326DB, Port Alfred, BURTT-DAVY 7915 (PRE); DU PREEZ 1530 (PRE); NOEL sn. (GRA No. 10108).

Eastern Shore Beach, 3326DB, Port Alfred, MARTIN sn. (GRA No. 3403).

Kowie salt vlei, on the open dunes, 3326DB, Port Alfred, BRITTEN 2116, 2117, 2119 (GRA); MARTIN sn. (GRA No. 8235A).

Sandvlei Shore, between dunes, 3326DB, Port Alfred, BRITTEN 2117 (PRE).

Gxulu River, in the dunes West of the mouth, 3327BA, Peddie District, REID 465 (GRA).

Cape Recief, in the limestone pans, 3425BA, Port Elizabeth, OLIVIER 2878 (GRA).

Cape Recief, 3425BA, Port Elizabeth, PATERSON 1952 (GRA).

Coega, 3325DC, Port Elizabeth District, OLIVIER 2092 (PRE).

Coega River, in the dunes, 3325DC, Port Elizabeth District, OLIVIER 2025 (PRE).

Emerald Hill, behind the dunes, 3325DC, Port Elizabeth, BOLUS 9805 (PRE).

Gamtoos River Mouth, behind the dunes, in the estuary sand, 3325CC, Port Elizabeth District, ARNOLD 658 (PRE).

Humewood, 3325DC, Port Elizabeth, CRUDEN 351 (PRE); DAHLSTRAND 41 (PRE); PATERSON 619 (GRA).

New Brighton, 5m above sea level, 3325DC, Port Elizabeth, GALPIN 6425 (GRA, PRE).
Springs Reserve, near the earth dam, in a damp area, 3325CD, Port Elizabeth District, OLIVIER 2627 (GRA).

Sunday's River, behind the dunes, 3325DB, Port Elizabeth District, OLIVIER 2105 (PRE).

The area between Van Stadens River Mouth and Maitland, 3325DB, Port Elizabeth District, OLIVIER 2176 (PRE).

Swartkops, in the sandy flats near Blue Pool, 3325DC, Port Elizabeth, TROUGHTON 141 (GRA).

Swartkops River, in the dunes, 3325DC, Port Elizabeth District, ZEYHER 661 (PRE).

Swartkops River Estuary, on the west bank, in the stable sand hummocks, 3325DC, Port Elizabeth District, ARCHIBALD 4912 (GRA).

Bloubaai, Shelly Beach, on the East-Tsitsikamma coast, 2m above sea level, 3424AA, Robhoeck, TAYLOR 9955 (PRE).

\[F.\textit{ leiocarpa}\] Nees 3540

Happy Valley Farm, half way down a small slope, grassland, 3227AB, Cathcart District, SONNENBERG 379 (GRA).

\[F.\textit{ nigrescens}\] (Schrad.) J.Raynal 3950

Brooklands, on a south-east facing slope, grassland, 33° 30' S, 26° 37' E, 3326BC, Albany District, PARSONS & PENNEFATHER 29 (GRA).

Bushman's River Poort, on the top of the Winterberg, 120m above sea level, 3326AC, Alexandria District, ARCHIBALD 5577 (PRE).

Nuweposkop Valley, on stony ground, 305m above sea level, 3326BC, Alexandria District, ARCHIBALD 5975 (PRE).

3326BC, Grahamstown, DALY & SOLE 219 (GRA, PRE), 223 (GRA), 224 (GRA, PRE); HARVEY 153 (GRA).

Faraway, Portion 3 of Coldsprings, on Witteberg Quartzite soil, 700m above sea level, 3326AD, Grahamstown District, JACOT-GUILLARMOD, 8537 (GRA).

Grahamstown Nature Reserve, at the base of Dassie Kranz, fynbos, 3326AD, Grahamstown, ARNOLD 616 (PRE); SCHÖNLAND, S. 3754 (GRA, PRE).

Grahamstown Nature Reserve, on the top of Dassie Kranz, open in veld, 3326BC, Grahamstown, NOEL sn. (GRA No. 8218).

Grahamstown Nature Reserve, next to the path leading from the Caretakers house, along the Southern-facing slope, 3326BC, Grahamstown, BRINK 65 (GRA).

Grahamstown Nature Reserve, Dassie Kranz, in the Kloof forest fringe, at a broken Witteberg Quartzite rock face, 800m above sea level, 3326BC, Grahamstown, CROESER 1072 (GRA).

Grahamstown Nature Reserve, on the Southern side of Mountain Drive, 3326BC, Grahamstown, MARTIN sn. (GRA No. 3108).

1 Mile past Hamilton Dam, in the shade of the small trees and rocks on Kopie with an Eastern aspect, on stony ground, 550m above sea level, 3326BC, Grahamstown District, DYER 68 (GRA, PRE), 69 (PRE).

Mountain Drive, at the Radio-Station, in rocky grassland, 2398ft above sea level, 3326BC, Grahamstown, LUBKE 162 (GRA).

The hill above Prince Alfred road, 3326BC, Grahamstown, DALY & SOLE 209 (GRA).
Assagai Bosch, 900-1000ft above sea level, 3424BB, Humansdorp District, ROGERS 2006 (GRA).

Uitvlugt, 365m above sea level, 3424BB, Humansdorp District, FOURCADE 2638 (GRA, PRE).

3325DC, Port Elizabeth, DREGE 423 (GRA); FRIES & NORLIND 198 (PRE).

Earn cliff near Port Elizabeth, on the river bank, 45m above sea level, 3325DC, Port Elizabeth District, GALPIN 6387 (GRA, PRE).

At the back of the German School, 3325DC, Port Elizabeth, DREGE 423 (GRA).

Humewood, 3325DC, Port Elizabeth, PATerson 1101, 1071 (GRA).

Springs Reserve, on the Kleinkop rocky outcrop, 3325CD, Port Elizabeth District, OLIVIER 2269 (GRA).

Vaal Vlei Estate, 3325DC, Port Elizabeth District, MOGG 4690 (PRE).

Near the summit of the Swartberg Pass, 1525m above sea level, 3225DA, Prince Albert District, STOKOE 68138 (SAM).

Suurberg, above Ann's Villa, in fynbos, 765m above sea level, 3325BD, Somerset-East District, ACOCKS 12029 (PRE).

9 Kilometre's North of Uitenhage, on the road to Klipplaat, on a rocky outcrop, 180m above sea level, 3325CB, Uitenhage District, DAVIDSE 33584 (PRE).

Swartkops River, in the valley and on a neighbouring hill of the Villa Paul Mare, close to Uitenhage, 85m above sea level, 3325DC, Uitenhage District, ZEYHER 4378B (PRE).

Zunga, Armanus Kraal 345 Catchment Basin, in a shrub clearing, on stony ground, 440m above sea level, 33325CA, Uitenhage District, SCHARF 1372 (PRE).

**F. oligantha** (Steud.) J.Raynal 3950

Hillary, 3326AC, Alexandria District, BURTT-DAVY 13408 (PRE).

Grahamstown Golf Course, next to the second tee, in grassy thicket, sandy ground, 3326BC, Grahamstown District SONNENBERG 266 (GRA, UN).

Amms Farm, 3326AD, Salem District, KILLICK 928 (PRE).

**F. pingiour** C.B.Clarke 4300

The third Hog, near a small rock pool with rapids leading to it, grassland, 3226DB, Hogsback District, SONNENBERG 319 (GRA).

**F. polystachya** Levyns 435

Eastern slopes of Witte Els Bay, 460m above sea level, 3424AA, Humansdorp District, LEVYNs 3017 (PRE).

Cockscomb, Great Winterhoek Mountains, southern slopes near the summit, 1737m above sea level, 3324DB, Uitenhage District, ESTERHUYSSEN 28036 (PRE).

**F. ramosissima** Kunth. 4850
Kenton-on-Sea, Joan Muirhead Reserve, in coastal scrub, 3326DA, Alexandria District, FANSHAWE & BRADLEY 1, 26, 32 (GRA); MARTIN *sn.* (GRA No. 9356).

Bushman's River Mouth, in the dunes, 3326DA, Alexandria District, DU TOIT & MILES *sn.* (GRA No. 1071).

Langevlakte, Woody Cape, 3326CB, Alexandria District, LUBKE 2949 (GRA).

Faraway, Coldsprings Portion 3, in heathland, in moist areas, 700m above sea level, 3326AD, Grahamstown, JACOT-GUILLARMOD 8711 (GRA), 9222 (GRA, PRE).

Penrock Farm, 8-10 miles from Grahamstown, occasionally in the Botha's River Valley, amongst the grass and rocks, 3326BC, Grahamstown District, DYER 566 (GRA).

Otterford, in moist Southern-facing fynbos, (*Dominants-Protea mundii, Cannomois virgata, Erica copiosa, Passerina falcifolia*), 500m above sea level, 3325CC, Hankey District, COWLING 1013 (GRA).

Kettle Spout Falls, 3226DB, Hogsback, JACOT-GUILLARMOD *sn.* (GRA No. 465).

3326DB, Port Alfred, SCHÖNLAND, S. 1583 (GRA).

3325DC, Port Elizabeth, WEST 464 (GRA).

Houtbosch 347 Farm, Groendal Wilderness Reserve, Great Winterhoek Mountain Range, Zunga Catchment Basin, 364m above sea level, 3325CA, Uitenhage District, SCHARF 1953 (PRE).

3327AC, Bathurst District, ARNOLD 586A (PRE).

Riet River Mouth, in the grassland at the edge of the river, 3326CA, Bathurst District, LUBKE 97 (GRA).

Tharfield Private Nature Reserve, in between the Riet and West-Kleinemonde River Mouths, in grassland, 300m from the National road between the two mouths, 3327CA, Bathurst District, SONNENBERG 211 (GRA).

Buluga Mouth, at the edge of the lagoon, 5m above sea level, 3228CC, East London District, ACOCKS 15789 (PRE).

Military Base, 3326BC, Grahamstown, PALMER 1383 (PRE).

In the camping site alongside the river, 3327AD, Hamburg, ARNOLD 577 (PRE).

Kowie West, in grassland, along the river banks, 3326DB, Port Alfred, BRITTEN 5213 (PRE); DYER 626 (GRA, PRE).

Gamtoos River Mouth, in the camping area, grassland, on flood plain sand, 3325CC, Port Elizabeth District, ARNOLD 657 (PRE).

Redhouse, 3325DC, Port Elizabeth, PATERSON 1070 (GRA).

Swartkops River, in the fields near the river, 3325CD, Uitenhage District, ECKLON & ZEYHER 660 (PRE).

Swartkops River Estuary, on the west bank, 3325CD, Uitenhage District, ARCHIBALD 4910 (GRA), *sn.* (GRA No. 6942); ZEYHER 74, 4392, 38847 (PRE).

**F. repens** (Nees) Kunth. 4900

Fish River Mouth, grassland, 3327AC, Bathurst District, ARNOLD 586A (PRE).

Riet River Mouth, in the grassland at the edge of the river, 3326CA, Bathurst District, LUBKE 97 (GRA).

Military Base, 3326BC, Grahamstown, PALMER 1383 (PRE).

In the camping site alongside the river, 3327AD, Hamburg, ARNOLD 577 (PRE).

Kowie West, in grassland, along the river banks, 3326DB, Port Alfred, BRITTEN 5213 (PRE); DYER 626 (GRA, PRE).

Gamtoos River Mouth, in the camping area, grassland, on flood plain sand, 3325CC, Port Elizabeth District, ARNOLD 657 (PRE).

Redhouse, 3325DC, Port Elizabeth, PATERSON 1070 (GRA).

Swartkops River, in the fields near the river, 3325CD, Uitenhage District, ECKLON & ZEYHER 660 (PRE).

Swartkops River Estuary, on the west bank, 3325CD, Uitenhage District, ARCHIBALD 4910 (GRA), *sn.* (GRA No. 6942); ZEYHER 74, 4392, 38847 (PRE).

**F. stolonifera** Boeck. 5300

Beggars Bush Reserve, above the natural forest, on the stony grass slopes, 2000ft above sea level, 3326BC, Albany District, MARTIN *sn.* (GRA No. 8712).
Menziesberg, on the ridge running north-east of Mountain, in a dry area, 1524m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 76 (PRE).

Round Hill (Oribi Reserve), in open grassland near the river, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 129 (GRA).

3 Miles north-north-west of Southwell, 215m above sea level, 3326DA, Bathurst District, ACOCKS 12062 (PRE).

Trappes Valley, 3326BD, Bathurst District, DALY 664 (GRA).

Near Grahamstown on the Southern hills, in short grass, 1800-2400ft above sea level, 3326BC, Grahamstown District, DYER 176 (GRA).

Botha's Hill, 3326BC, Grahamstown District, SONDER 490 (GRA).

5000-5500ft above sea level, 3226DB, Hogsback, RATTRAY 444 (GRA).

Central Hog, near a stream, 50m from the summit, grassland, 3226DB, Hogsback District, SONNENBERG 309 (GRA, UN).

Tore Doone, near a small waterfall, coming from Kettle Spout Falls, 3226DB, Hogsback, SONNENBERG 333 (GRA, UN).

Formosa State Forest Reserve, 10 kilometre's south-west of Kareedouw, just North of Oudeboschruggens, 600m above sea level, 3424AB, Kareedouw District, LUBKE 2284 (GRA).

Cata Peak Ridge, in the grass, 3227CA, King William's Town District, DYER 348 (GRA).

Near Ghulu Kop, in the grass experimental plots, 4000ft above sea level, 3227CA, King William’s Town District, DYER 288, 289, 290 (GRA).

Walmer, 3325DC, Port Elizabeth, PATERSON 619 (GRA).

Boschberg Mountains, 3225DA/DC, Somerset-East District, BAKER 1974 (GRA).

Katberg, in the grass, on the slopes near the top, 5000-5500ft above sea level, 3226BC, Stokenstroom District, DYER 372 (GRA).

Dohne Research Station, in the grassland, 915m above sea level, 3227CB, Stutterheim District, ACOCKS 9349, 9393 (PRE).

Next to river above Cambria, Great Winterberg Mountain Range, 255m above sea level, 3324DA, White River, GELDENHUYS 1259 (PRE).

F. sylvatica Kunth. 5500

In the forest, 3326CB, Grahamstown, DE KOCK 19 (PRE).

16 Miles from Blaauwkrantz, 3326BC, Grahamstown District, MILNER 64 (PRE).

Kromrivier Forest Reserve, on the Northern side of the Mountain, at the FM Tower, in the forest, 540m above sea level, 3424AB, Humansdorp District, GELDENHUYS 1096 (PRE).

Witte Els Bosch, in the forest, 3424BA, Humansdorp District, FOURCADE 916 (GRA).

Longmore Forestry Reserve, 3325CC, Port Elizabeth District, DAHLSTRAND 743 (PRE).

Van Stadens Pass, 3325CC, Port Elizabeth District, ARNOLD 653 (PRE).
**F. tenuifolia Kunth. 5600**

Roundhill (Oribi Reserve), 50m uphill from the Nature Conservation hut, bushclump grassland, 3326DB, Bathurst District, SONNENBERG 273 (GRA, UN).

Deyssels Plaat Farm, Groendal Wilderness Reserve, Great Winterhoek Mountains, Krompoort River Catchment, near a kraal, in fynbos, 985m above sea level, 3325CA, Uitenhage District, SCHARF 1899 (PRE).

Mannetjie Farm, Range Plateau, Groendal Wilderness Reserve, Great Winterhoek Mountains, Krompoort River Catchment, near a kraal, in fynbos, 728m above sea level, 3325CA, Uitenhage District, SCHARF 1979 (PRE).

**F. tribracteata Boeck.**

Faraway, Portion 3 of Coldsprings, on a Southern-facing Witteberg Quartzite slope, in moist areas, 700m above sea level, 3326AD, Grahamstown District, JACOT-GUILLARMOD 8416 (GRA).

Gaika's Kop, on the North side, at the edge of the Pine forest, in fynbos and a marsh, 3226DB, Hogsback District, SONNENBERG 365 (GRA, UN).

near Siberia marsh, on the way to Gaika's Kop, 3226DB, Hogsback District, SONNENBERG 347 (GRA, UN).

Papiesfontein, in recently burnt Renosterveld, on Enon conglomerate, 90m above sea level, 3324DD, Humansdorp District, COWLING 517 (GRA).

**F. trichodes (Schrad.) Benth. & Hook.f. 5700**

Karoo Nature Reserve, on a Southern slope of Agterkop, 1524m above sea level, 3224BC, Graaff-Reneit District, PALMER 695 (PRE).

Fern Kloof, in the Pines, 3326BC, Grahamstown, DARBYSHIRE sn. (GRA No. 6210); SEAGRIEF 216 (GRA).

Signal Hill, 3326BC, Grahamstown, DALY & SOLE 486 (GRA).

**F. tristachya (Rottb.) Nees 5800**

Driefontein Farm, Suurberg State Forest, in mountain grassland, 790m above sea level, 33° 18' S, 25° 35' E, 3325DA, Alexandria District, LUBKE 2068 (GRA).

Round Hill (Oribi Reserve), in veld with *Aristeda* and *Eragrostis*, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 103, 260 (GRA).

3326BC, Grahamstown, DALY & SOLE 212 (GRA).

Coldspring, in grassland, 3326AD, Grahamstown District, HILNER 252 (GRA).

Above Featherstone Kloof near Woest Hill, among the Pines, on a rocky grassy slope, 2000ft above sea level, 3326BC, Grahamstown, LUBKE 158 (GRA).

Gowies Kloof, 3326BC, Grahamstown, RO-KAHN sn. (GRA No. 5991).

Near Grahamstown, common in short grass, sheltered by Pine trees, with *F. gracilis*, 1800-2100ft above sea level, 3326BC, Grahamstown District, DYER 177 (GRA).


The third Hog, near a small stream, grassland, 3226DB, Hogsback District, SONNENBERG 321 (GRA).
Osbosch Farm, in derived *Themeda* grassland, on Bokkeveld shale, 30m above sea level, 3424BB, Humansdorp District, COWLING 350 (GRA).

Near Zuurbron, in degraded Renosterveld, on Bokkeveld shale, 230m above sea level, 3324DD, Humansdorp District, COWLING 605 (GRA).

Rocky Hills above Port Elizabeth, 3325DC, Port Elizabeth District, ECKLON & ZEYHER 667 (GRA).

Walmer Commonage, 3325DC, Port Elizabeth, DAHLSTRAND 181 (PRE).

Cape Recief, 3425BA, Port Elizabeth, OLIVIER 2273 (GRA).

Gamtoos Valley, near a natural road bridge, 60m above sea level, 3325CC, Port Elizabeth District, ACOCKS 16113 (PRE).

King Neptune Beach, 12 kilometre's East of Port Elizabeth, 3325DC, Port Elizabeth, ARNOLD 1070 (PRE).

Markham Industrial Area, in the coastal scrub, on sand-clay-gravel, 20m above sea level, 3325DC, Port Elizabeth, DAHLSTRAND 2847 (GRA, PRE).

Redhouse, 3325DC, Port Elizabeth, BRITTEN 5994 (PRE); DREGE 616 (GRA); FRIES & NORLIND 500 (PRE); PATERSON 331, 3645 (GRA).

Between the Coega and Sunday's Rivers, 3325DC, Uitenhage District, ECKLON & ZEYHER 161, 1038 (PRE).

At the Mouth of the Coega and Swartkops Rivers, 30m above sea level, 3325CD, Uitenhage District, ZEYHER 4418 (GRA, PRE).

*F. truncata* (Thunb.) Schrad. 5900

Bushy Park, on a Limestone hill, 3326CB/DA, Alexandria District, HOOLE 10014 (GRA).

Butts Farm, between Salem and the sea, on Limestone soil, 3326CB/DA, Bathurst District, BRITTEN 6570 (GRA).

Hillary, 3326AC, Alexandria District, BURTT-DAVY 13407, 14259 (PRE).

Kaba, on a hill opposite Frikkie Millers Farm, 120m above sea level, 3326CB, Alexandria District, ARCHIBALD 5418 (PRE).

Kolsrand, on the Northern aspect, on Limestone, 3326DA, Alexandria District, ARCHIBALD 4521 (GRA).

The Aloes, 3325DC, Port Elizabeth, BLOCKBURN 601 (PRE); DREGE 3045 (GRA, PRE).

Cape Recief, 3425BA, Port Elizabeth, OLIVIER 2273 (GRA).

Sonop Farm, Coega, 3325DC, Port Elizabeth District, OLIVIER 1653 (PRE).

Gamtoos Valley, near a natural road bridge, 60m above sea level, 3325CC, Port Elizabeth District, ACOCKS 16113 (PRE).

King Neptune Beach, 12 kilometre's East of Port Elizabeth, 3325DC, Port Elizabeth, ARNOLD 1070 (PRE).

Markham Industrial Area, in the coastal scrub, on sand-clay-gravel, 20m above sea level, 3325DC, Port Elizabeth, DAHLSTRAND 2847 (GRA, PRE).

Redhouse, 3325DC, Port Elizabeth, BRITTEN 5994 (PRE); DREGE 616 (GRA); FRIES & NORLIND 500 (PRE); PATERSON 331, 3645 (GRA).

Between the Coega and Sunday's Rivers, 3325DC, Uitenhage District, ECKLON & ZEYHER 161, 1038 (PRE).

At the Mouth of the Coega and Swartkops Rivers, 30m above sea level, 3325CD, Uitenhage District, ZEYHER 4418 (GRA, PRE).

*F. zeyheri* Boeck. 6000

Cochin Farm, on a hill opposite the main house, 4 kilometres away, on a hill facing the sea, stony ground, 3228CB, Hagga Hagga District, SONNENBERG 453 (GRA).

*FIMBRISTYLIS* Vahl. 0471000
**F. complanata** (Retz.) Link. 400

Juanasberg, East of Tyume Peak, in grassland, 1128m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 236 (PRE).

Lenye Plateau, between the bushes, 914m above sea level, 3227CA, Amatole Mountains, PHILLIPSON 1203 (PRE).

Round Hill (Oribi Reserve), above and below the Conservation house, 50-100m, from the house, in grassy areas, 3326BD, Bathurst District, SONNENBERG 279 (GRA).

Faraway, Portion 3 of Coldsprings, on Southern-facing Witteberg Quartzite slopes, in fynbos, 700m above sea level, 3326AD, Grahamstown District, JACOT-GUILLARMOD 10040 (GRA, PRE).

Grahamstown Nature Reserve, swampy places, 3326BC, Grahamstown, BRITTEN 5979 (GRA).

Grahamstown Nature Reserve, above the main path, near the gate, 3326BC, Grahamstown, MARTIN sn. (GRA No. 9643).

Grey Dam, 3326BC, Grahamstown, DALY & CHERRY 914 (GRA, PRE).

Howieson's Poort, 1800ft above sea level, 3326AD, Grahamstown District, SONDER 1352 (GRA).

Kowie road, 8 miles from Grahamstown, in mat of grasses, near the "Isoetes" pool, 1800ft above sea level, 3326BC, Grahamstown District, LUBKE 84 (GRA).

Yarrow, near Grahamstown, 3326AD, Grahamstown District, BURTT-DAVY 11608 (PRE).

Cochin Farm, on the banks of a small river, near Marsh Sands, in Riverine thicket, sandy soil, 3228CB, Hagga Hagga District, SONNENBERG 447 (GRA, UN).

Mountains near Humansdorp, in grassy fynbos, sandy soil, 3324DD, Humansdorp District, SONNENBERG 495 (GRA, UN).

Honeyville, in recently burnt fynbos, dominants are herbs (*Restio triticeus*, *Tristachya hispida*, *Bulbostylis collina*), 280m above sea level, 3324DD, Humansdorp District, COWLING 1395 (GRA).

Cape Morgan Nature Reserve, near the gate of the reserve, in an old marsh, sandy soil, 3228CB, Kei Mouth District, SONNENBERG 412 (GRA, UN).

3227CD, King William’s Town, SIM 285 (GRA).

Damp watercourses, in grassveld, 3227DB, Komga, DYER 805 (GRA).

Grassland valleys, near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 1003 (GRA, PRE).

Pastures near Komga, grassland, 610m above sea level, 3227DB, Komga District, FLANAGAN 960 (GRA, PRE).

Van Stadens Nature Reserve, 100m above sea level, 3325CC, Port Elizabeth District, DAHLSTRAND 2515 (GRA, PRE).

Katberg, grassveld below high forest region, in damp places, 3000ft above sea level, 3226DA, Stokenstroom District, DYER 359 (GRA).

Dohne Research Station, in grassland, 3227CB, Stutterheim District, ACOCKS 9356 (PRE).

Fort Cunynghame, 3000ft above sea level, 3227CB, Stutterheim District, SCHÖNLAND, R. 68 (GRA).

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**F. dichotoma** (L.) Vahl. 500

Riet River Mouth, at the edge of the water at the river end of the salt marsh, 0m above sea level, 3326CA, Bathurst District, LUBKE 94 (GRA).
1 Kilometre from the Hagga Hagga turnoff from the Kei Mouth road, on the way to Hagga Hagga, in a small marsh, to the left of the road, on the banks of the marsh, 3228CB, Hagga Hagga District, SONNENBERG 440 (GRA, UN).

Grassland, 3228AD/CB, Kentani District, PEGLER 1090 (GRA, PRE).

Nynutura, in grassland, 305m above sea level, 3228CB, Kentani District, WARD 5725 (PRE).

Rooikrans/Maden Dam, plants in wet soil, on the margin of the dam, 580m above sea level, 3227CB, King William’s Town District, GIBBS-RUSSEL 4029 (GRA, PRE).

\textit{F. ferruginea} (L.) Vahl 600

Fish River Mouth, 3327AC, Bathurst District, DYER 3387 (PRE).

Round Hill, in savannah grassland, on a slight Northern slope, 33° 23' S, 26° 55' E, 3326DB, Bathurst District, LLOYD 32 (GRA).

3228CB, East London, RATTRAY 727 (GRA).

Buluga Mouth, at the edge of the tidal flats, on a river bank, 5m above sea level, 3228CC, East London District, ACOCKS 15786 (PRE).

Above Featherstone Kloof, near Woest Hill, in Zerocline grassveld, among rocks and \textit{Bobartia} sp., 3326BC, Grahamstown, LUBKE 159 (GRA).

Kei Mouth, in marshy spots, 60m above sea level, 3228CB, Komga District, FLANAGAN 971 (GRA, PRE); SCHLECHTER 6192 (GRA).

Kei River Mouth, on a river bank, 3228CB, Komga District, ARNOLD 559 (PRE).

In a river, 365m above sea level, 3227CD, King William’s Town, SIM 212 (PRE).

Ntshala River Mouth, 700m from the sea on the banks of the estuary, near the Nature Conservation Huts, on the opposite Morgan's Bay, sandy soil, 3228CB, Morgan's Bay, SONNENBERG 428 (GRA, UN).

\textit{FUIRENA} Rottb. 0467000

\textit{F. coerulescens} Steud. 300

Mountain Zebra Park, alongside the current stream of Mount Fountain Dam at Weltevrede, on river banks, 3225AD, Cradock District, LIEBENBERG 7627 (PRE).

Industrial Site, moist areas in grassland, being used as a dump site, 600m above sea level, 3326BC, Grahamstown, JACOT-GUILLARMOD 9256 (GRA).

Third Hog, near a small stream, grasslands, 3226DB, Hogsback District, SONNENBERG 320 (GRA).

Gaika's Kop, in a small marsh, just off the Siberia marsh, 3226DB, Hogsback District, SONNENBERG 363 (GRA, UN).

Marsh, 607m above sea level, 3227DB, Komga, FLANAGAN 931 (GRA, PRE).

Kei River Mouth, behind the first dunes, in grassland, 3228CB, Komga District, ARNOLD 551 (PRE).

5 Miles out of Komga, on the King William’s Town road, in a watercourse, amongst \textit{Mariscus congestus}, 4000ft above sea level, 3227DB, Komga District, DYER 801 (GRA).

3325DC, Port Elizabeth, FRIES & NORLIND 184 (PRE).
Bethelsdorp, 3325DC, Port Elizabeth, PATERSON 347 (GRA).  
850m above sea level, 3227CB, Stutterheim District, ACOCKS 9158 (PRE).

**F. ecklonii** Nees 400

Forest of Oliphantshoek, between the mouths of the Bushman's and Sunday's Rivers, 91m above sea level, 3326CB, Alexandria District, ZEYHER 36, 39018 (PRE).

Top of the Suurberg Range, in a marsh, 698m above sea level, 3325BD, Alexandria District, JOHNSON 859 (PRE).

Marsh, 3326BC, Grahamstown, BRITTEN 5851 (PRE).

Yarrow, 3326AD, Grahamstown District, BURTT-DAVY 11643 (PRE).

**F. hirsuta** (Berg.) P.L. Forbes 800

Menziesberg, the hill to the East of the Main Peak, at the base of a vertical rock face, in moist ground, 1341m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1498 (PRE).

Trappes Valley, 3326BD, Bathurst District, DALY 697 (GRA).

3327CB, East London, RATTRAY 811 (GRA).

Bonza Bay, 15m above sea level, 3227DD, East London District, ACOCKS 9556 (PRE).

Overton Farm, 11 miles West of East London, 100 yards from the sea, 3327BB, East London District, HILNER 186 (GRA, PRE).

Featherstone Kloof, in the slow flowing waters of the stream, 1300ft above sea level, 3326BC, Grahamstown, LUBKE 68 (GRA).

Featherstone Kloof, 3326BC, Grahamstown, SWIFT sn. (GRA No. 6227).

Grey Dam, 3326BC, Grahamstown, CORNELIUS & SMYTH 2045 (GRA); GANE 67 (GRA).

Edge of Hamilton Reservoir, swamp, 3326BC, Grahamstown District, BRITTEN 1949 (GRA), 1950 (GRA); SONNENBERG 249 (GRA), 256 (GRA, UN), 257 (GRA).

Howieson's Poort, 3326AD, Grahamstown District, BRITTEN 976 (GRA).

Howieson's Poort, Palmiet River, 3326AD, Grahamstown District, SONNENBERG 231 (GRA).

Stowan Dam, hydrophyte colony, 3326BC, Grahamstown District, HAMPSON & MORGAN sn. (GRA No. 6212).

500ft, 3424BB, Humansdorp District, ROGERS 2912 (GRA); THODE 1067 (PRE).

Assagai Bosch Station, on the slope towards the Krom River, 3424BB, Humansdorp District, SCHÖNLAND, S. 3061 (GRA).

9.3 Miles north-west of Kareedouw, in fynbos, 273m above sea level, 3324CC, Humansdorp District, ACOCKS 20032 (PRE).

Kouga River, near the drift on the road from Zuuramys, 900ft above sea level, 3424BB, Humansdorp District, FOURCADE 3104 (GRA).

Slang River, on the beach, 3424BA, Humansdorp District, PHILLIPS 58344 (PRE).
Witelsbos SAFCOL forest, in the marsh areas near a damaged dam, on the slopes of the Tsitsikammaberg, in an area cleared of indigenous forests, 3424AA, Humansdorp District, SONNENBERG 488 (GRA, UN).

Cape Morgan Nature Reserve, in an old vlei, near the gate, grassland, sandy soil, 3228CB, Kei Mouth District, SONNENBERG 414 (GRA).

Kei Mouth, 20 yards from the sea, in grassland, 3228CB, Komga District, ARNOLD 555 (PRE).

Near Kei Mouth, in a marsh, 2000ft above sea level, 3228CB, Komga District, FLANAGAN 1005 (GRA, PRE).

3325DC, Port Elizabeth, KEMSLEY 39, 180 (GRA).

Cape Recief, in damp areas beyond the fresh water pond, 3425BA, Port Elizabeth, OLIVIER 3014 (GRA).

Gamtoos River Mouth, 3325CC, Port Elizabeth District, LUBKE 2672 (GRA).

30 Miles North of the Otterford Forestry Reserve, in a river bed, 3325CC, Port Elizabeth District, RODIN 1153 (PRE).

Walmer, 3325DC, Port Elizabeth, PATerson 2370 (GRA).

Van Stadens River Mouth, 3325CC, Port Elizabeth District, THERON 652 (PRE).

Fort Cunynghame, 3227AD, Stutterheim District, SIM 2712 (PRE).

3325CD, Uitenhage, PATerson 1925 (GRA).

Moist spots near the Swartkops River, 3325CD, Uitenhage District, ECKLON & ZEYHER 168 (PRE).

**F. pachyrrhiza Ridley Var. pachyrrhiza 1000**

Cape Morgan Nature Reserve, in an old vlei, near the gate, grassland, sandy soil, 3228CB, Kei Mouth District, SONNENBERG 416 (GRA, UN).

Marshes, 1000ft above sea level, 3228AD/CB, Kentani District, PEGLER 309 (GRA).

Swamps near Kei Mouth, 50ft and 1200ft above sea level, 3228CB, Komga District, FLANAGAN 970 (GRA).

**F. pubescens (Poir.) Kunth. 1100**

Overton Farm, ½ a mile from the sea, in open veld, on the hillsides, among the grass, 3327BB, East London District, HILNER 174 (GRA, PRE).

2500ft above sea level, 3225DA/DC, Somerset-East, ANON sn. (GRA No. 1356).

Katberg, on the top of the mountain, in grassland, 2049m above sea level, 3226BC, Stokenstroom District, DYER 362 (GRA, PRE).

Dohne Hill, 3227CB, Stutterheim District, SIM 2846 (GRA).

**ISOLEPIS R.Br. 0468020**

*I. cernua (Vahl.) Roem & Schult. 200*

Alicedale, 3326AC, Albany District, CRUDEN 309 (GRA).

Committees Drift, at the bridge, in a river bed, 3326BB, Albany District, ARNOLD 630 (PRE).
Rockcliff near Sidbury, 3326AC, Albany District, DALY 780 (GRA, PRE).

Bushman's River Mouth, Klipfontein Stream, on a river bank, 90m above sea level, 3326DA, Alexandria District, ARCHIBALD 4530 (PRE).

Sandflats, 305m above sea level, 3325BD, Alexandria District, ARCHIBALD 3953 (PRE); ROGERS 3246 (GRA).

Below Gaika's Kop, in the waterfall's marsh, 1445m above sea level, 3326DB, Amatole Mountains, PHILLIPSON & FURNESS 77 (PRE).

Brak Water, in small cove, off the Kowie River, 3326BD, Bathurst District, DYER 627 (GRA).

Kariega River, 3326DB, Bathurst District, BRITTEN 2403 (PRE).

Noos Boosak, Kariega River, at the edge of fresh water pool, 3326DB, Bathurst District, BRITTEN 2403 (GRA).

Trappes Valley, 3326BD, Bathurst District, DALY 699 (GRA).

3227CB, East London, RATTRAY 732 (GRA).

Gonubie River, 2000ft above sea level, 3227DD, East London District, SCHLECTER 6142 (GRA).

Van Ryneveld Pass Dam, 3224BA, Graaff-Reinet District, SMOK 3922 (PRE).

Blauuwrantz, at the edge of the water, 3326BC, Grahamstown District, HILNER 81 (GRA).

Hamilton Reservoir, in clumps above the waterline, on sandy soil, at the edge of the dam, 1850ft above sea level, 3326BC, Grahamstown District, LUBKE 59 (GRA); PAINE 5 (GRA); SONNENBERG 252, 254 (GRA).

Near Grahamstown, ½ a mile past Hamilton Dam, in stream and in the mud, 1800-2000ft above sea level, 3326BC, Grahamstown District, DYER 231 (GRA).

Howieson's Poort, 3-4 miles along the valley, in a stream bed, 2000ft above sea level, Grahamstown District, DYER 201, 202, 203, 204 (GRA).

Shaw's Farm, Governors Kop, 10 miles from Grahamstown, at the highest point in district, on the side of stream, 3326BC, Grahamstown District, HILNER 257 (GRA).

Slaaikraal Dam, 3326BC, Grahamstown, DARBYSHIRE sn. (GRA No. 10261).

Keiskamma River Mouth, in the estuary, 3327AD, Hamburg, GALPIN 7719 (PRE).

in clumps under the trees in the natural forest, 3226DB, Hogsback, LUBKE 128 (GRA).

Marsh, 3226DB, Hogsback, RATTRAY 394 (GRA).

Gaika's Kop, on the banks of a small stream, 200m further up Gaika's from the old forestry tower, wet soil, 3226DB, Hogsback District, SONNENBERG 327 (GRA, UN).

At the junction of Happy Valley and the Cathcart roads, on a river bank, 1402m above sea level, 3226DB, Hogsback District, PHILLIPSON & FURNESS 189 (PRE).

Cape St. Francis, in the coastal fynbos, 34° 11' S, 24° 50' E, 3434BA, Humansdorp District, LUBKE 1847 (GRA).

Sea Vista, at the main beach, in the vlei area of dunes, 34° 10' S, 24° 50' E, 3424BA, Humansdorp, LUBKE 1801, 1825 (GRA).

Boma Pass, Keiskamma River, on a river bank, 3227CA, Keiskammahoek District, ACOCKS 9097 (PRE).

Near Keiskammahoek, on a stream bank, 2000ft above sea level, 3227CA, Keiskammahoek District, DYER 317, 325 (GRA).
Cata Peak Ridge, in streams, 5000-6000ft above sea level, 3227DB, King William’s Town District, DYER 338 (GRA).

Dperie, 1220m above sea level, 3227CB, King William’s Town District, SIM 20261 (PRE).

William's Farm, "Orange Grove", about 4 miles West of King William’s Town, on the river banks, 3227CD, King William’s Town District, HILNER 128 (GRA).

1.1 Miles north-west of Zele Post Office, 460m above sea level, 3227CD, King William’s Town District, ACOCKS 20281 (PRE).

Along streams, 610m above sea level, 3227DB, Komga District, FLANAGAN 933 (GRA, PRE).

Kei Mouth, the seashore marsh, 3228CB, Komga District, VORSTER 2244 (PRE).

Kei River Mouth, 18 kilometre’s from the sea, in the grassland, 3228CB, Komga District ARNOLD 553 (PRE).

Van Stadensberg, 3325CC/CD, Port Elizabeth District, ANON sn. (GRA No. 2115).

Toise River, on the river bank, 3400ft above sea level, 3227DA, Stutterheim District, HILNER 358 (PRE), 360, 522 (GRA).

Aasvoelkranz, East of Oubosstrand, in a stony seepage, 3m above sea level, 3424AB, East-Tstsikamma, TAYLOR 9970 (PRE).

Holbak River, Krompoort Farm, on a river bed, 3325AC, Uitenhage District, SMOOK 3853 (PRE).

Swartkops River, 3325CD, Uitenhage District, HOLLAND 614 (GRA); ZEYHER 38, 4381 (PRE).

**I. costata** (Boeck.) A.Rich var. **macra** (Boeck.) B.L.Burtt. 220

3 Miles from Amabele, in a marsh, 3227DA, Amabele District, DE VRIES 108 (PRE).

Suurberg, muddy places in the ravine near the Sanatorium Commonage, 3325DB, Alexandria District, SCHOENLAND, R. 3186 (GRA).

Below Gaika's Kop, in the waterfall's marsh, 1450m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 124 (GRA, PRE).

3226CA, Bedford, NICOL 80 (GRA).

Turpin Municipal Dam, on the clay river bank, 3226CA, Bedford District, ARNOLD 766 (PRE).

Featherstone Kloof, in a marsh, 1400ft above sea level, 3326BC, Grahamstown, LUBKE 165 (GRA).

Grahamstown Nature Reserve, in swampy areas, on a stream bed, 3326BC, Grahamstown, MARTIN sn. (GRA No. 9628).

Near Grahamstown, on a stream bank off Howieson's Poort road, under trees, on a bank that is not shaded, 2000ft above sea level, 3326AD/BC, Grahamstown District, DYER 200 (GRA, KEW).

The stream near the Foresters Cottage, on the edge of the stream, on the muddy river bank, 4000ft above sea level, 3226DB, Hogsback, LUBKE 108 (GRA).

Gaika's Kop, 100m from the old forestry tower, on the wet river banks of a small stream, 3226DB, Hogsback District, SONNENBERG 326 (GRA).

Gaika's Kop, in the marsh on the way to the hiking hut, 3226DB, Hogsback District, SONNENBERG 362, 371 & 374 (GRA, UN).

Central Hog, on the Gaika's Kop side, in a marsh, 5 kilometres from the Hog, grassland, 3226DB, Hogsback District, SONNENBERG 305 (GRA, UN).
Third Hog, on the Gaika’s Kop side, in a marsh, grassland, 3226DB, Hogsback District, SONNENBERG 316 (GRA, UN).

Headlands, in the swamp at the edge of the cliff, 4150ft above sea level, 3226DB, Hogsback, NOEL sn. (GRA No. 10679).

6.2 Kilometre’s before Hogsback, travelling from Alice, forest, stony river bank, 3226DB, Hogsback District, ARNOLD 767 (PRE).

Huntersdown Dam, in clumps at the edge of the dam, 3226DB, Hogsback, LUBKE 141 (GRA).

Kettle Spout Falls, on the banks of the river that feeds the falls, 700m from the falls, on the forest/fynbos margin, 3226DB, Hogsback, SONNENBERG 290 (GRA, UN).

Kettle Spout Falls, on the banks of the marsh that is the source for the river that feeds the falls, sandy soil, 3226DB, Hogsback, SONNENBERG 332 (GRA, UN).

Witte Els Bosch, in the margins of the forest near river, 230m above sea level, 3424AA, Humansdorp District, FOURCADE 3014 (GRA, PRE).

On a river bank, 3227CA, Keiskammahoek, DYER 316 (GRA).

In the mud of the stream bank, below the Forest Station, near Cata Peak, 4500ft above sea level, 3227CB, Keiskammahoek District, DYER 344 (GRA).

Southern-slopes of Mount Thomas near Keiskammahoek, 1370m above sea level, 3227CA, Keiskammahoek District, STRONG 3683 (GRA).

The ridge to the west of Mount Thomas near Keiskammahoek, 1370m above sea level, 3227CA, Keiskammahoek District, STORY 3685 (PRE).

Fort Cunynghame, 3000ft above sea level, 3227DB, Stutterheim District, SCHÖNLAND, R. 40 (GRA).

Amatole Mountains near Ghulu Kop, in a mountain stream with Scirpus prolifer, 4000ft above sea level, 3227CA, King William’s Town District, DYER 315 (GRA).

On a river bank, 610m above sea level, 3227DB, Komga, FLANAGAN 1008 (PRE).

5 Miles out of Komga, on the road to King William’s Town, in a damp watercourse, 4000ft above sea level, 3227DB, Komga District, DYER 802 (GRA, PRE).

Redhouse, on the path to the golf house, 3325DC, Port Elizabeth District, PHILLIPS 39286 (PRE).

Hogsback Forestry road, edge of water, 1219m above sea level, 3226DB, Seymour, GIBBS-RUSSELL 3003 (PRE).

Boschberg, Glen Avon, on stony ground, 1006m above sea level, 3225DA, Somerset-East District, HILLIARD & BURTT-DAVY 13212 (PRE).

Toise River, on a river bank, 3227DA, Stutterheim District, HILNER 360, 376, 544 (PRE).

**I. diabolica (Steud.) Schrad.**

Along the Hogsback Pass, in the forest, 914m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 921 (PRE).

Oliphantskop Pass, in the fynbos next to a seepage area, 730m above sea level, 3325BD, Alexandria District, ACOCKS 21423 (PRE).

Turpin Municipal Dam, 3226CA, Bedford, ARNOLD 763, 765 (PRE).
Kasouga, in a moist sheltered part of the dune, at the edge of the dune hill, 3326DA, Bathurst District, BRITTEN 2361 (GRA).

Trappes Valley, 3326BD, Bathurst District, DALY 650, 685 (GRA).

Toise River, in the mud, on the river banks, 3227AD, Cathcart District, HILNER 545 (GRA).

1800ft above sea level, 3326BC, Grahamstown, SONDER 1353 (GRA).

Near Grahamstown, in a small hollow, on a hill beyond Hamilton Dam, to the South of the town, in short grass with *Ficinia tristachya*, 1800ft above sea level, 3326BC, Grahamstown District, DYER 206 (GRA).

5 Kilometre's from Grahamstown on the Grahamstown-Port Alfred road, on the Farm Waterloo, in sandy soil, in *Eucalyptus* invaded savannah grassland, 3326BC, Grahamstown District, SONNENBERG 238 (GRA).

Hill 60, at the summit, 3326BC, Grahamstown, HILL, DB. 17773 (GRA).

Prospect Field, Rhodes University, in open grassland, 3326BC, Grahamstown, VENGADAJELLUM 60 (GRA).

Gaika's Kop, below a Kranz, 400m from the summit, on the banks of a small marsh, 3226DB, Hogsback District, SONNENBERG 323 (GRA, UN).

Central Hog, in a marsh, 5 kilometres away from the Hog, on the Gaika's Kop side, grassland, 3226DB, Hogsback, SONNENBERG 302 (GRA, UN).

Third Hog, near a small stream, on the Gaika's Kop side, grassland, 3226DB, Hogsback, SONNENBERG 321 (GRA, UN).

Siberia Marsh, grassland, 3226DB, Hogsback, SONNENBERG 345 (GRA, UN).

Buffelsbos, in annual derived sourveld, (Dominants-*Thamnochortus glaber-Digitaria monodactyla*), 90m above sea level, 3424AB, Humansdorp District, COWLING 1473 (GRA).

6.3 Kilometre's from town, on the road to Krom Bay, in a marsh, 3424BB, Humansdorp District, ARNOLD 663 (PRE).

2.6 Kilometre's from the turn-off to Kei Mouth, in grassland, 3228CB, Komga District, ARNOLD 548 (PRE).

Walmer, 3325DC, Port Elizabeth, PATerson 2380, 3260 (GRA).

Katberg, near the rocks and in the grass at the top of the mountain, 6500-7000ft above sea level, 3226DA, Stokenstroom District, DYER 364 (GRA).

Dohne Research Station, 3227CB, Stutterheim District, ACOCKS 9056 (PRE).

Springs Nature Reserve, near the earth dam, 3325CD, Uitenhage District, OLIVIER 2627 (PRE).

*I. fluitans* (L.) R.Br. 300

Coombsvale Farm, near the farm at Coombs Dam, on the waters edge, 3326BD, Albany District, ARNOLD 637 (PRE).

Plateau at head of the Amatola Basin, in Dohne Sourveld, in a swamp, 1525m above sea level, 3227CA, Amatole Mountains, ACOCKS 15721 (PRE).

Hogsback Mountains, 3226DB, Amatole Mountains, RATTRAY 21 (GRA).

Hogsback Mountains, in marshes, 3226DB, Amatole Mountains, RATTRAY 391 (GRA).

3227DB, East London, RATTRAY 872 (GRA).

3326BC, Grahamstown, DALY & SOLE 186 (GRA).
Fern Kloof, on a rocky slope, under a wet cliff, amongst the grass and ferns, 1900ft above sea level, 3326BC, Grahamstown, LUBKE 75 (GRA).

On the hill between the Hospital and Mayors Seat, 3326BC, Grahamstown, DALY & SOLE 186 (PRE).

Osmunda Kloof near Howieson’s Poort, 3326BC, Grahamstown District, CHEADLE 711 (PRE).

Slaaikraal Dam, 3326BC, Grahamstown, DARBYSHIRE sn. (GRA No. 10313).

3226DB, Hogsback, M’DOWELL sn. (GRA No. 29863)

Marsh, 1463m above sea level, 3226DB, Hogsback, RATTRAY 21 (PRE).

Beneath the Mountain, at Gaika’s Kop, in a marsh, 1402m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 162 (PRE).

The lower Pine forest, near the Foresters Cottage, at the edge of the stream, 3226DB, Hogsback, LUBKE 132 (GRA).

The marsh behind the first Peak, aquatic, 4550ft above sea level, 32° 38' 32" S, 27° 00' 58" E, 3227CA, Hogsback, FURNESS & PHILLIPSON 1 (GRA).

The first Peak, on the West facing side, in wet places, opposite shrub, 1585m above sea level, 3226DB, Hogsback, PHILLIPSON 1225 (PRE).

Kettle Spout Falls, on the banks of the stream that feeds the falls, at the fynbos/forest margin, 700m from the falls, 3226DB, Hogsback, SONNENBERG 299 (GRA, UN).

Siberia Marsh, in the small marsh leading to Siberia, grassland, 3226DB, Hogsback, SONNENBERG 377 (GRA, UN).

Boschberg, 3225DA, Somerset-East District, BAKER 1885 (GRA, PRE).

Witelsbos SAFCOL forestry, in a marshy area cleared of *Eucalyptus* trees, near the SAFCOL Offices, 700m from the N2 to Storms River, 3424AA, Humansdorp District, SONNENBERG 461 (GRA, UN).

*I. incomtula* Nees 460

Humewood, 3325DC, Port Elizabeth, DALY 1052 (GRA); PATERSON 2300 (GRA).

Redhouse, 3325DC, Port Elizabeth, PATERSON 2124 (GRA).

0.8 Kilometre’s West of the Swartkops River Mouth turn-off, travelling from Van Stadens River Mouth, opposite the wood, 3325DC, Port Elizabeth District, ARNOLD 652 (PRE).

*I. karroica* (C.B.Clarke) J.Raynal 600

Mountain Zebra National Park, 3325AB, Cradock District, BRYNARD 66 (PRE).

Bank Mountain, Weltevrede Mountains, Mountain Zebra National Park, on the side of the Mountain, on the cliffs, 3325AB, Cradock District, LIEBENBERG 7622A (PRE).

Weltevrede Fountain Dam, Mountain Zebra National Park, in the mountains, on a river bank, 3325AB, Cradock District, LIEBENBERG 7626 (PRE).

*I. ludwigii* Kunth. 650
8 Miles out of Grahamstown, on the Kowie road, in the "Isoetes" pool, 1800ft above sea level, 3326BC, Grahamstown District, LUBKE 90 (GRA).

Coldspring, 3326AD, Grahamstown District, GLASS 747 (GRA), 38961 (PRE).

Faraway, Portion 3 of Coldsprings, on a moist South-facing Witteberg Quartzite slope, in a wet hollow, in heathland, 700m above sea level, 3326AD, Grahamstown District, JACOT-GUILLARMOD 8756 (GRA).

Fern Kloof, on a rock surface, under a cliff, amongst moss and ferns, 3326BC, Grahamstown, LUBKE 75 (GRA).

Near Grahamstown, 1800ft above sea level, 3326BC, Grahamstown District, SONDER 371, 1350 (GRA).

In donga's with little or no water, on the hills to the East of Grahamstown, 1800ft above sea level, 3326BC, Grahamstown District, DYER 171 (GRA).

Firdene Farm, Stones Hill, in a shallow vlei, with rocky sides, 250m from the Grahamstown-Stones Hill road, next to the farm road, 3326BC, Grahamstown District, SONNENBERG 235 (GRA).

Grahamstown Nature Reserve, in the natural amphitheatre, on a stream bed, 3326BC, Grahamstown, MARTIN sn. (GRA No. 9629).

In a watercourse above the Grey Reservoir, 3326BC, Grahamstown, DALY & CHERRY 970 (GRA).

Hamilton Reservoir, on the wet banks of the reservoir, amongst Fuirena hirsuta plants, 3326BC, Grahamstown, SONNENBERG 259 (GRA).

Towards Mayor's Seat, in a dry vlei below a rock ledge, shaded by Pine trees, in the centre of the vlei, at times covered by the water, 3326BC, Grahamstown, BRITTEN 597, 927 (GRA).

Mountain Drive, in a small pool near the path leading to the Radio Station, 3326BC, Grahamstown, MARTIN sn. (GRA No. 8124).

Rabbitswood, in cracks of rock, on a river bank, 2000ft above sea level, 3326BC, Grahamstown District, LUBKE 83 (GRA).

Witte Els Bosch, on the flats, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 894 (GRA).

Marsh, 365m above sea level, 3227CD, King William’s Town, FALANNAGAN 1893 (GRA), 2204 (PRE).

Swartkops, Riverside, river bank, 3325CD, Port Elizabeth District, RAMMASAMMY-COOK 57 (GRA).

Boschberg, 3225DA, Somerset-East District, MACOWAN 1350 (GRA).

East end of Kabaku Hills, in the forest, 3227CB, Stutterheim District, ACOCKS 9650 (PRE).

I. marginata (Thunb.) Dietr. 720

Camtarha River, at the edge of A cliff, on a river bank, 120m above sea level, 3326CB, Alexandria District, ARCHIBALD 5673 (PRE).

Bushman's River Mouth, grassland, 30m above sea level, 3326DA, Alexandria District, KILLICK 1763 (PRE).

Kasouga Mouth, in the dunes, 3326DA, Bathurst District, BRITTEN 2361 (PRE).

Trappes Valley, 3326BD, Bathurst District, DALY 2646 (TM).

Slang River, near the mouth, in estuary sand, 3424BA, Humansdorp District, FOURCADE 1830 (PRE).

Walmer, 3325DC, Port Elizabeth, PATerson 3260 (PRE).

Van Stadens River Mouth, 5 kilometre’s before the mouth, opposite the wood, 3325CC, Port Elizabeth District, ARNOLD 651 (PRE).
**I. natans** (Thunb.) Dietr. 720

Coombsvale Farm, near Coombs, 3326BD, Albany District, ARNOLD 635 (PRE).

Northern slopes of Gaika's Kop, on the wet slopes of the grassveld, near a river, 5300ft above sea level, 3226DB, Amatole Mountains, LUBKE 362 (GRA).

Below Gaika's Kop, 200m North of the waterfall, at the confluence of streams, in marsh, 1440m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 131 (PRE).

In a shallow stream behind Gaika's Kop and Happy Valley, 1409m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 201 (PRE).

Between Gaika's Kop and the Hogsback Peaks, in a marsh, 1463m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 209 (PRE).

Shaw’s Farm, Governors Kop, 10 miles from Grahamstown, on the highest point in the district, common on a half-submerged side of the stream, in stagnant water, 3326BC, Grahamstown District, HILNER 259 (GRA).

Hamilton Reservoir, at the waters edge, 1850ft above sea level, 3326BC, Grahamstown District, LUBKE 62, 367, 368 (GRA).

In the stream near the Foresters Cottage, on a stream bank, 4000ft above sea level, 3226DB, Hogsback, LUBKE 129 (GRA).

Gaika's Kop, in the marsh on the way to the hiking hut, 3226DB, Hogsback District, SONNENBERG 364 (GRA, UN).

The stream near the ridge, South of the 1st Hogs peak, 1386m above sea level, 3226DB, Hogsback, PHILLIPSON & FURNESS 29 (PRE).

First Hog, on the Gaika's Kop side, 5 kilometres from the Hog, marsh, Hogsback District, SONNENBERG 304 (GRA, UN).

Kettle Spout Falls, on the river bank of the stream that feeds the falls, at the margin of the forest/fynbos, 3226DB, Hogsback District, SONNENBERG 291 (GRA).

Above Kettle Spout Falls, on marshy ground at the edge of the stream, 4500ft above sea level, 3226DB, Hogsback District, LUBKE 351 (GRA).

Marshes, 3226DB, Hogsback, RATTRAY 395 (GRA).

Rhywers Glen Swamp, 3226DB, Hogsback, MARTIN s.n. (GRA No. 9672).

Slang River, on the beach, 3424BA, Humansdorp District, PHILLIPS 39288 (PRE).

Witte Els Bosch, in ditches on the flats, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 934 (GRA).

Along streams, 1000ft above sea level, 3228CB, Kentani District, PEGLER 1102 (GRA).

Along streams near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 918 (GRA, PRE).

Boschberg Mountains, 4500ft above sea level, 3225DA, Somerset-East District, BAKER 1742 (GRA).

**I. pellocolea** B.L.Burtt.

Gaika's Kop, 200m uphill from the old forestry tower, on the stream banks of a small stream, wet soil, 3226DB, Hogsback District, SONNENBERG 329 (GRA, UN).
**I. prolifera** (Rottb) R.Br. 740

Beggars Bush near Grahamstown, 3326BC, Albany District, ANON *sn.* (GRA No. 12317).

In the alluvium of an un-named tributary of the Mooi river, 1.5 kilometre's from the Ecca Pass-Committees Drift turn-off from the Plutovale road, in Ecca Shales, 3326BB, Albany District, SONNENBERG 201 (GRA).

Bushman's River, 3326DA, Alexandria District, DALY 792 (GRA).

Coerney River Valley, 305m above sea level, 3325CB, Alexandria District, JOHNSON 1002 (PRE).

Hopewell, 185m above sea level, 3326BD, Bathurst District, ACOCKS 23505 (PRE).

3326BC, Grahamstown, MACOWAN 1865 (GRA)-**TYPUS**.

Bottom of Botha's River Valley, 3326BC, Grahamstown District, SCHÖNLAND, S. 4416 (GRA).

Faraway, Portion 3 of Coldsprings, on a South-facing moist Witteberg quartzite slope, in a moist depression, 3326AD, Grahamstown District, JACOT-GUILLARMOD 8600 (GRA).

Grey Dam, in a watercourse, 3326BC, Grahamstown, DALY & CHERRY 974 (GRA, PRE); SLATTER & SCOTT *sn.* (GRA No. 6211).

Near Grahamstown, in a stream and on mud, ½ a mile past Hamilton Dam, 3326BC, Grahamstown, DYER 170 (GRA).

Hamilton Reservoir, near the waters edge, 3326BC, Grahamstown, LUBKE 60, 369 (GRA); SONNENBERG 250 (GRA).

Howieson's Poort, swamp, 3326AD, Grahamstown District, BRITTEN 970 (GRA).

Howieson's Poort, alongside the river, in damp sandy places, 1500ft above sea level, 3326AD, Grahamstown District, SCHÖNLAND, S. 583 (GRA).

Kotch Creek, Rhodes University, 3326BC, Grahamstown, SWIFT *sn.* (GRA No. 6214).

Near Mayors seat, on stony & marshy ground, at the edge of a vlei, shaded by Pines, on a rock ledge below the vlei, 3326BC, Grahamstown, BRITTEN 929 (GRA, PRE).

Palmiet River, Howieson's Poort, on a sandy river bank, 33° 22' S, 26° 29' E, 3326AD, Grahamstown District, VAN NOORDT 2 (GRA).

Shaw’s Farm, Governors Kop, 10 miles from Grahamstown, near water, 3326BC, Grahamstown District, HILNER 253 (GRA, PRE).

Hoffmans Bosch, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 2980 (GRA).

Witelsbos SAFCOL forest, in an area cleared of *Eucalyptus* forest, near the SAFCOL Offices, 700m from the N2 to Storms River, 3424AA, Humansdorp District, SONNENBERG 459 (GRA, UN).

Witelsbos SAFCOL forest, in the understorey of indigenous forest, on the Tsitsikammaberg side of the N2 to Storms River, sandy soil, 3424AA, SONNENBERG 482 (GRA, UN).

Witte Els Bosch, on the margins of the forest, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 1219 (GRA).

Fort Cunynghaled, 3000ft above sea level, 3227CB, Stutterheim District, SCHÖNLAND, R. 45 (GRA).

3325DC, Port Elizabeth, FRIES & NORLIND 490 (PRE).

Baakens River Valley, 3325DC, Port Elizabeth, DREGE 624 (GRA).
The river in the Van Stadens Pass, next to small bridge, 3325CC, Port Elizabeth District, ARNOLD 655 (PRE).

Swartkops River, 3325CD, Uitenhage District, ZEYHER 38966 (PRE).

*I. sepulcralis* Steud. 800

Governors Kop Farm, 10 miles from Grahamstown, in river, 3326BC, Grahamstown District, HILNER 256 (PRE).

Nature Reserve, 8 kilometre's North of Uitenhage, 3325CD, Uitenhage District, SMOOK 3828 (PRE).

*I. setacea* (L.) R.Br. 900

Heatherton Towers Farm, Fish River Valley, in a stream bed, 950ft above sea level, 3326BB, Albany District, LUBKE 156 (GRA).

Weltevrede Farm, Mountain Zebra Park, at the waters edge, 3225AB, Cradock District, LIEBENBERG 7648 (PRE).

Gaika's Kop, in the river above the storage dam for the hiking hut, 1 kilometre from the hut, near the edge of the Gaika's marsh, wet rocky river banks, 3226DB, Hogsback District, SONNENBERG 370 & 376 (GRA, UN).

The main road just West of the Humansdorp turn-off, on the right hand side of the road, in a marshy place on the road side, 3424BB, Humansdorp District, IMMELMAN 305A (PRE).

Barendse Farm, in a vlei, 3326DB, Port Alfred, BRITTEN 751A (GRA, PRE).

Springs Nature Reserve, in the damp areas, in valley bush, 3325CD, Port Elizabeth, OLIVIER 2624 (GRA).

Katberg Pass, on a cliff, 3226DA, Stokenstroom District, HILLIARD & BURTT-DAVY 12405/B (PRE).

*I. sororia* Kunth. 1000

At the bottom of Botha's River Valley, near Botha's Hill, 3326BC, Grahamstown District, SCHÖNLAND, S. 4417 (GRA).

Near Grahamstown, on damp mud, ½ a mile past Hamilton Dam, 1800ft above sea level, 3325BC, Grahamstown District, DYER 230 (GRA, KEW).

*I. striata* (Nees) Kunth. 1050

Lottering and Harrison River, 3424BB, Humansdorp District, ANON sn. (PRE No. 39048).

Swartkops River, in a river bed, 3325CD, Uitenhage District, ZEYHER 4389 (PRE).

*I. verrucosula* (Steud.) Nees 1200

Krompoort Farm, Holbakrivier, in the river bed, 3325AC, Uitenhage District, SMOOK 3854 (PRE).

Swartkops River, 3325CD, Uitenhage District, ZEYHER 38980 (PRE).

**KYLLINGA** Rottb. 0462000
**K. alata Nees 100**

Round Hill (Oribi Reserve), 50m up the hill from the Conservation house, near the path to the trig beacon, in a grassy area, 375m above sea level, 3326BD, Bathurst District, SONNENBERG 274 (GRA, UN).

Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth, SONNENBERG 400 (GRA, UN)

**K. alba Nees 200**

Waaiheuvel Ridge, on the Salem-Alexandria road, in grassland, 155m above sea level, 3326CB, Alexandria District, ARCHIBALD 5331 (PRE).

Alice Airstrip, in the grass, 625m above sea level, 3226DB, Alice, PHILLIPSON 193 (PRE).

Kasouga, 3326DA, Bathurst District, OLIVIER 727 (GRA).

Dwesa Forest Reserve, on the grassy, sandy flood plain of the Kabole River estuary, 3228BD, Butterworth District, JACOT-GUILLARMOD 7900 (GRA).

Toise River, 3227DA, Cathcart District, HILNER 539 (GRA, PRE).

Rooplaat, Mountain Zebra Park, 1465m above sea level, 3225AB, Cradock, District, MULLER 575 (PRE).

Southernwood, 3227DD, East London, LEWIS 49 (GRA).

In a dry river, South of town, amongst the grass, 2000ft above sea level, 3226DC, Fort Beaufort District, DYER 237A (GRA).

Below Brickhill’s, 1800ft above sea level, 3326BC, Grahamstown, BENNIE 354 (GRA).

5 Kilometre’s Outside Grahamstown, on the Cradock road, on the aerodrome commonage, 3326AB, Grahamstown District, GERMISHUIZEN 1568 (PRE).

On the Hogsback Upper Plateau, in the grassland approaching the summit, 6000ft above sea level, 3226DB, Hogsback, MARTIN sn. (GRA No. 4272).

Paradise Beach, in dune fynbos, 20m above sea level, 3424BB, Humansdorp District, COWLING 166 (GRA).

Qolora River Mouth, on the hillsides, amongst the grass, 3228CB, Kentani District, HILNER 457 (GRA).

Pastures near Kei Mouth, 60m above sea level, 3228CB, Komga District, FLANAGAN 927 (GRA, PRE).

3326DB, Port Alfred, POTTS 226 (GRA), 4251 (TM).

Redhouse, 3325DC, Port Elizabeth, PATERSON 259 (GRA).

Dohne Research Station, 915m above sea level, 3227CB, Stutterheim District, ACOCKS 9223 (PRE).

**K. brevifolia Rottb. 320**

1 Kilometre from the Hagga Hagga turnoff from the Kei Mouth road, on the road to Hagga Hagga, in a marsh on the left hand side of the road, 3228CB, Hagga Hagga District, SONNENBERG 443 (GRA, UN).

**K. elatior Kunth. 500**

3226CA, Bedford, NICOL 89 (GRA).

Overton Farm, 11 miles West of East London, 3327BB, East London District, HILNER 240 (PRE).
Witelsbos SAFCOL forest, in a marsh near the foresters cottages, 400m from the N2, at the edge of the Witelsbos forests, 3424AA, Humansdorp District, SONNENBERG 490 (GRA, UN).

Centenary Dam, at the waters edge, 3228CB, Kei Mouth District, SONNENBERG 438 (GRA).

1 Mile north-west of Zele Post Office, in forest near a river, 460m above sea level, 3227CD, King William’s Town District, ACOCKS 20279 (PRE).

Between Komga and Kei Mouth, 305m above sea level, 3228CA, Komga District, FLANAGAN 1789 (PRE).

\[ \textit{K. erecta} \text{ Schumach. 550} \]

Boknesstrand, in the grasslands, 8m above sea level, 3326DA, Alexandria District, BURROWS 2691 (GRA).

Bushman's River Mouth, in grassland, 30m above sea level, 3326DA, Alexandria District, KILLICK 1766 (PRE).

Bathurst Commonage, in the grasslands between the bushclumps, 500m from the Bathurst-Southwell road, 5 kilometre's from Bathurst, in sandy soil, 3326DB, SONNENBERG 228 (GRA).

Whitney, in grassland, 90m above sea level, 3326DA, Alexandria District, ARCHIBALD 5068 (PRE).

Riet River Mouth, on the river banks, 3327CA, Bathurst District, LUBKE 96 (GRA).

Trappes Valley, 3326BD, Bathurst District, DALY 661 (GRA), 12934 (TM).

3327BB, East London, DALY & CHERRY 479 (TM).

Between Cove Rock and Igoda River, 15m above sea level, 3327BB, East London District, GALPIN 7355 (GRA, PRE).

Overton Farm, 11 miles West of East London, in an old dried vlei near the cottage, ½ a mile from the beach, 3227BB, East London District, HILNER 214 (GRA).

The Museum at Selbourne, 30m above sea level, 3227DD, East London, SMITH 3706 (PRE).

3326BC, Grahamstown, DALY & CHERRY 202 (PRE), 10624 (TM).


On the hill above the Hospital, 3326BC, Grahamstown, DALY & CHERRY 916 (GRA, PRE).

Kowie road, 8 miles from Grahamstown, on the edge of the "Isoetes" pool, 1800ft above sea level, 3326BC, Grahamstown District, LUBKE 88 (GRA).

Towards Mayors seat, in a dry vlei below a rock ledge, shaded by Pines, 3326BC, Grahamstown, BRITTEN 943 (GRA).

7 Miles from Grahamstown, on the Port Alfred road, on the grassy banks of a vlei, 3326BC, Grahamstown District, MARTIN \textit{sn.} (GRA No. 8125).

Swampy ground below the Nature Reserve, 3326BC, Grahamstown, BRITTEN 5852 (PRE).

At the Kettle Spout Falls, at the edge of the marsh, in wet soil, 4000ft above sea level, 3226DB, Hogsback, LUBKE 144 (GRA).

Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth, SONNENBERG 410 (GRA).

Qolora River Mouth, on open hillsides, 3228CB, Kentani District, HILNER 467 (GRA).

Rock Cove, amongst the grass, in moist places, 20ft above sea level, 3228CB, Kentani District, PEGLER 1480 (GRA).
Common in damp spots, near the Cemetery, 3000ft above sea level, 3227CD, King William’s Town, HILNER 138 (GRA).

Rooikrans/Maden Dam, in moist soil, at the margin of the water, amongst the grasses and in the wet soil around the dam, 580m above sea level, 3227DC, King William’s Town, GIBBS-RUSSEL 4030 (GRA, PRE).

610m above sea level, 3227DB, Komga, FLANAGAN 917 (PRE).

8 Kilometre’s from Port Alfred on the way to Bathurst, near Hayes Siding, close to a dam, in grassland, 3326DB, Port Alfred District, RETIEF 300 (PRE).

Redhouse, 3325DC, Port Elizabeth, PATerson 2200 (GRA).

Toise River, on a river bank, 3227DA, Stutterheim District, HILNER 367 (GRA, PRE).

**K. melosperma Nees 800**

Gaika's Kop, on the north-eastern side of the fire-break, near the bottom of the slope, 3226DB, Amatole Mountains, PHILLIPSON 1296 (PRE).


Overton Farm, 11 miles West of East London, on marshy soil, in a running stream bed, ½ a mile from the sea, 3227BB, East London District, HILNER 210 (GRA).

1500ft above sea level, 3326BC, Grahamstown, ANON 673 (GRA).

Buikhuizen's Poort, 1500ft above sea level, 3326BC, Grahamstown District, MACOWAN 673 (GRA).


Marshes and streams, 1000ft above sea level, 3228CB, Kentani District, PEGLER 240 (GRA).

Fort Cunynghame Plantation, on the banks of a small stream, in deep sandy soil, in small patches, 3000ft above sea level, 3227CB, Stutterheim District, SCHÖNLAND, R. 43 (GRA).

William’s Farm, "Orange Grove", 4 miles West of King William’s Town, 1250ft above sea level, 3227CD, King William’s Town District, HILNER 126 (GRA).

Marshy places near Komga, 2000ft above sea level, 3227DB, Komga District, FLANAGAN 18913 (GRA).

Port Alfred Golf Course, 3326DB, Port Alfred, NOEL sn. (GRA No. 9918).

Commonage, 3227CB, Stutterheim, ACOCKS 9240 (PRE).

**K. pauciflora Ridley 1100**

Beneath Gaika's Kop, in a marsh, 1409m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 159 (PRE).

Overton Farm, 11 miles West of East London, in the grass on the hill side, 0m above sea level, 3227BB, East London District, HILNER 378 (GRA).

Botha's Hill, 2200ft above sea level, Grahamstown District, SONDER 476 (GRA).

In the marsh on the main ridge, above the Foresters Cottage, towards "The Hogsback", 5500ft above sea level, 3226DB, Hogsback District, DYER 775 (GRA).
Gaika's Kop, at the edge of the Pine forest, at the edge of the marsh below the mountain, on the way to the hiking hut, 3226DB, Hogsback District, SONNENBERG 356 (GRA, UN).

Siberia marsh, grassland, 3226DB, Hogsback District, SONNENBERG 348 (GRA).

**K. pulchella Kunth. 1200**

Menziesberg, on a North-Eastern-facing slope, in wet flush grassland, 1097m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1188 (PRE).

Mountain Zebra National Park, near the top of Bank Mountain, 2000m above sea level, 3225BA, Cradock District, LIEBENBERG 7128 (PRE).

Amongst the rocks near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 1261 (GRA, PRE).

Dohne, 3227CB, Stutterheim District, ACOCKS 9495 (PRE).

Toise River, on the river banks, 3227DA, Stutterheim District, HILNER 359 (GRA, PRE).

**MARISCUS Gaertn. 0459030**

*M. albomarginatus C.B.Clarke 100*

De Bega Heights, in grassland, 275m above sea level, 3326CB, Alexandria District, ARCHIBALD 4216 (PRE).

Cintsa River Mouth, in the estuary, 3228CC, East London District, VORSTER 2747 (PRE).

Gunfire Hill, 3326BC, Grahamstown, BRITTEN 5909 (GRA).

Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth, SONNENBERG 409 (GRA, UN).

Braklaagte, near Kirkwood, in valley bushveld, in the thicket between the trees, 300m above sea level, 3325DC, Port Elizabeth District, HOFFMAN 1031 (GRA).

*M. capensis (Steud.) Schrad. 300*

Bushman's River Mouth, in the dunes, on the west bank, 3326DA, Alexandria District, ANON sn. (GRA No. 1262).

Sandiles Kop, University of Fort Hare, 646m above sea level, 3226DD, Alice, GIFFEN 1587A (PRE).

Bathurst Commonage, near the ruins of the old Pineapple Research Station, near some old large Blue gum's, in close integrating, disturbed savannah, approximately 5 kilometre's from Bathurst, 3326DB, Bathurst District, SONNENBERG 224 (GRA).

Roundhill (Oribi Reserve), grassland, 3326DB, Bathurst District, SONNENBERG 276 (GRA).

Andries Vosloo Kudu Reserve, 3326BA/BB, Fort Brown, PALMER 311 (GRA).

Andries Vosloo Kudu Reserve, in valley bushveld, in the bushclumps, 3326BA/BB, Fort Brown, PALMER 402 (GRA).

Trappes Valley, 3326BD, Bathurst District, DALY 676 (GRA).

Fish River Valley, near Fort Brown, 3326BA, Fort Brown, HUTTON 1582 (GRA, PRE).

Opposite Glenmore, East of the Fish River, in Ecca shale over clay, in a heavily eroded gully near an intermittent stream, 300m above sea level, 3326BB, Grahamstown District, JACOT-GUILLARMOD 8777 (GRA).
Grahamstown Golf Course, next to the second tee, grassy thicket, sandy soil, 3326BC, Grahamstown,
SONNENBERG 267 (GRA, UN).

15-16 Miles from Grahamstown on the Peddie road, at the junction between Karoid Scrub and veld, 1500ft above
sea level, 3326BC, Grahamstown District, DYER 1362 (GRA).


South of Jansenville, in Noorsveld, in a fenced ungrazed area, 3224DC, Jansenville District, HOFFMAN 643
(GRA).

Golf Course Plot, in Acacia grassland, 2000ft above sea level, 3227CA, Keiskammahoek, WELLS 3107 (GRA).

3326DB, Port Alfred, BRITTEN sn. (GRA No. Dec. 1917).

Blue Water Bay, 3325DC, Port Elizabeth, URTON 759 (PRE).

Suurberg Mountains, in damp areas, in a valley near the top of the berg, 3325BC, Port Elizabeth District, HILL 1491
(PRE).

\textit{M. congestus} (Vahl.) C.B.Clarke \textbf{500}

Wagon Drift, in a vlei, 3226CB, Adelaide District, CUMMING \textit{sn}. (GRA No. 29243).

Oakwell Farm, in the valley beneath house, on an alluvial plain, in the seepage of the big dam, 33° 17' 33'' S, 26° 20'
21'' E, 3326AB, Albany District, HOBSON, S. 1333 (GRA).

Boknesstrand, on the fore-dunes, 3326DA, Alexandria District, BURROWS 2836 (GRA).

Jane Muirhead Nature Reserve, Bushman's River Mouth, 3326DA, Alexandria District, ANON \textit{sn}. (GRA No. 1264);
NOEL \textit{sn}. (GRA No. 12084); SONNENBERG 197 (GRA).

Whitney Vlei, in grassland, 90m above sea level, 3326DA, Alexandria District, ARCHIBALD 5084 (PRE).

Suurberg, 3325BD, Alexandria District, HOLLAND 94 (GRA).

Suurberg, near the Sanatorium, in muddy places, in a ravine, 3325BD, Alexandria District, SCHÖNLAND, S. 3191
(GRA).

322DD, Alice, PAHL 48 (GRA).

2 Miles East of Alice, on river banks, 3226DD, Alice District, THERON 1657 (PRE).

On the road to Peddie, at the pond below the commonage, on the left hand side of the road, at the waters edge, 594m
above sea level, 3226DD, Alice District, PHILLIPSON 182 (PRE).

In the University of Fort Hare campus parking lot, 516m above sea level, 3226DD, Alice, GIBBS-RUSSEL 3696
(PRE).

Halfway along the Hogsback Pass, 944m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1035 (PRE).

Kleinemonde, 3326CA, Bathurst District, WHITE 834 (GRA).

8 Kilometre's from Port Alfred, on the way to Bathurst, near Hayes Siding, in grassland, 3326DB, Bathurst District,
RETIEF 298 (PRE).

Round Hill (Oribi Reserve), on a moist stream bank, 375m above sea level, 3326BD, Bathurst District,
WIRMINGHAUS 434 (GRA).

Toise River, in the mud, on river banks, 3227AD, Cathcart District, HILNER 362, 363 (GRA), 543 (GRA, PRE).

\textit{M. congestus} (Vahl.) C.B.Clarke \textbf{500}

Wagon Drift, in a vlei, 3226CB, Adelaide District, CUMMING \textit{sn}. (GRA No. 29243).

Oakwell Farm, in the valley beneath house, on an alluvial plain, in the seepage of the big dam, 33° 17' 33'' S, 26° 20'
21'' E, 3326AB, Albany District, HOBSON, S. 1333 (GRA).

Boknesstrand, on the fore-dunes, 3326DA, Alexandria District, BURROWS 2836 (GRA).

Jane Muirhead Nature Reserve, Bushman's River Mouth, 3326DA, Alexandria District, ANON \textit{sn}. (GRA No. 1264);
NOEL \textit{sn}. (GRA No. 12084); SONNENBERG 197 (GRA).

Whitney Vlei, in grassland, 90m above sea level, 3326DA, Alexandria District, ARCHIBALD 5084 (PRE).

Suurberg, 3325BD, Alexandria District, HOLLAND 94 (GRA).

Suurberg, near the Sanatorium, in muddy places, in a ravine, 3325BD, Alexandria District, SCHÖNLAND, S. 3191
(GRA).

322DD, Alice, PAHL 48 (GRA).

2 Miles East of Alice, on river banks, 3226DD, Alice District, THERON 1657 (PRE).

On the road to Peddie, at the pond below the commonage, on the left hand side of the road, at the waters edge, 594m
above sea level, 3226DD, Alice District, PHILLIPSON 182 (PRE).

In the University of Fort Hare campus parking lot, 516m above sea level, 3226DD, Alice, GIBBS-RUSSEL 3696
(PRE).

Halfway along the Hogsback Pass, 944m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1035 (PRE).

Kleinemonde, 3326CA, Bathurst District, WHITE 834 (GRA).

8 Kilometre's from Port Alfred, on the way to Bathurst, near Hayes Siding, in grassland, 3326DB, Bathurst District,
RETIEF 298 (PRE).

Round Hill (Oribi Reserve), on a moist stream bank, 375m above sea level, 3326BD, Bathurst District,
WIRMINGHAUS 434 (GRA).

Toise River, in the mud, on river banks, 3227AD, Cathcart District, HILNER 362, 363 (GRA), 543 (GRA, PRE).
Mountain Zebra Park, next to the waters edge, 3225AA, Cradock District, MEYER 7520 (PRE).

Mountain Zebra Park, next to the fountain, on a river's bed, 3225AA, Cradock District, BRYNARD 160 (PRE).

Mountain Zebra Park, at the Main Camp, 3225AA, Cradock District, LIEBENBERG 7641 (PRE).

Mountain Zebra Park, on a river bed, 1465m above sea level, 3225AA, Cradock District, MULLER 620 (PRE).

In the sand dunes, 3227BB, East London, RATTRAY 732 (GRA).

Katberg, near the Sanatorium, in damp places, 4100ft above sea level, 3226DA, Fort Beaufort District, SCHÖNLAND, S. 4303 (GRA).

Andries Vosloo Kudu Reserve, in a shrub clearing, 425m above sea level, 3326BA, Fort Brown District, GIBBS-RUSSEL 3558 (PRE).

3326BC, Grahamstown, DALY & CHERRY 923 (PRE), 10630 (TM); MACOWAN 496 (GRA)-SYNTYPE.

Belmont Valley, in the lands, 3326BC, Grahamstown District, BRITTEN 513 (GRA).

Bloukrantz Nature Reserve, in valley bushveld, in a moist ditch on the road side, 250m above sea level, 33° 23' S, 26° 43' E, 3326BC, Grahamstown District, HALL 47 (GRA).

Bloukrantz Nature Reserve, in valley bushveld, 250m above sea level, 33° 23' S, 26° 43' E, 3326BC, Grahamstown District, LLOYD 51, 52 (GRA).

Brakkloof, 3326BA, Grahamstown District, WHITE 12 (PRE).

Brick work’s Dam, between the high and low water level, on gradually sloping banks, 3326AD, Grahamstown District, TAYLOR 16 (GRA).

Brooklands, on a South-East-facing slope, in grassland, 280m above sea level, 33° 30' S, 26° 37' E, 3326BC, Grahamstown District, PENNEFEATHER & PARSONS 19 (GRA).

Caravan Park, in a moist river bed, 3326BC, Grahamstown, SMOOK 14 (GRA).

Dassie Kranz, below the Kranz, towards the Bay road, in marsh, 3326BC, Grahamstown, BRITTEN 615 (PRE).

New Dottenes, on dry stony ground, 3326BC, Grahamstown, OLANDER 21 (GRA).

Grahamstown Nature Reserve, in swampy ground near the picnic site, 3326BC, Grahamstown, BRITTEN sn. (GRA No. A2074).

Below the Grahamstown Nature Reserve, in a marsh, 3326BC, Grahamstown, BRITTEN 5849 (PRE); MARTIN sn. (GRA No. 9632, 90292A, 90292B).

Grahamstown Potteries Dam, 3326AD, Grahamstown, SILBERBAUER 20 (GRA).

Grey Dam, 3326BC, Grahamstown, ANON sn. (GRA No. 1911).

Hamilton Reservoir, abundant in the white soil about six feet above the waters edge, 1850ft above sea level, 3326BC, Grahamstown LUBKE 58 (GRA).

The hill above the Grahamstown Hospital, 3326BC, Grahamstown, DALY & CHERRY 923 (GRA).

Shaw’s Farm, Governors Kop, 10 miles from Grahamstown (highest point in the District), half submerged, at the side of the stream, in stagnant water, 3326BC, Grahamstown District, HILNER 260 (GRA).

Slaaiakraal Dam near Grahamstown, 3326BC, Grahamstown District, DARBYSHIRE sn. (GRA No. 10263).

Strowan Farm Reservoir, on the flood plain along the margin of the Reservoir, 600m above sea level, 3326AD, Grahamstown, BETHUNE 12 (GRA); COETZEE 26 (GRA).
Between Ulster and Mooirivier, at the waters edge of a dam, 3326BA Grahamstown District, SMOOK 4035 (PRE).

On the grassy river banks, adjacent to a running stream, 3226DB, Hogsback, WILSON 7 (GRA).

SAFCOL Camping site, marsh, 3226DB, Hogsback, SONNENBERG 353 (GRA).

3424BB, Humansdorp, BRITTEN 1207 (PRE).

Hoffmans Bosch, in the cultivated lands, 3424AA, Humansdorp District, BRITTEN 1207 (GRA).

Oyster Bay, in the dunes, 70ft above sea level, 3424BB, Humansdorp, BLACKER 3 (GRA).

Sea Vista, on the main beach, 34° 10' S, 24° 50' E, 3424BB, Humansdorp, LUBKE 1821 (GRA).

Witte Els Bosch, in the flats, 3424AA, Humansdorp District, FOURCADE 1156 (GRA).

Cape Morgan Nature Reserve, in an old marsh near the gate, grassland, sandy soil, 3228CB, Kei Mouth District, SONNENBERG 419 (GRA).

Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth, SONNENBERG 402 (GRA).

Marshes, 1000ft above sea level, 3228CB, Kentani District, PEGLER 1085 (GRA).

3227CD, King William’s Town, SIM 2855 (GRA, PRE).

Fort Cunynghame, about 1 mile from the Foresters House, on an open hillside amongst the grass, in dry sandy soil, 3000ft above sea level, 3227CB, Stutterheim District, SCHÖNLAND, R. 28, 71 (GRA).

Rooikrans/Maden Dam, the plants are in the wet soil at the margin of the dam and amongst the grass in the wet soil around the dam, 580m above sea level, 3227DB, King William’s Town, GIBBS-RUSSEL 4040 (GRA, PRE).

610m above sea level, 3227DB, Komga, FLANAGAN 1014 (PRE).

5 Miles out of Komga, on the King William’s Town road, in a damp water course, 4000ft above sea level, 3227DB, Komga District, DYER 799 (GRA).

Near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 1263 (PRE).

Kei Mouth, 3228CB, Komga District, LUBKE 2519A (GRA).

Near Kei Mouth, in a marsh, 60m above sea level, 3228CB, Komga District, FLANAGAN 957 (PRE).

3326DB, Port Alfred, TYSON sn. (GRA).

On the East coast, in a swamp, 0m above sea level, 3326DB, Port Alfred, NARAN 12 (GRA).

In the stable sand behind the beach, 3325DC, Port Elizabeth, NOEL 1114 (GRA).

Driefontein Farm, Suurberg State Forest, Tussock grassland, 33° 18' S, 25° 35' E, 3325BC, Port Elizabeth District, LUBKE 2064 (GRA).

Schoenmakerskop, 3325DC, Port Elizabeth District, PATERSON 547 (GRA).

Hogsback Forestry road, opposite the shrub, 1219m above sea level, 3226DB, Seymour, GIBBS-RUSSEL 3007 (PRE).

Hogsback Forest Reserve, in sandy soil, in cleared forest land, 750m above sea level, 3226DB, Seymour District, DAHLSTRAND 2918 (GRA).

Dohne Hill, 3327CB, Stutterheim District, SIM 2833 (GRA, PRE).

Along the Toise River, on the river bank, 3227AD, Stutterheim District, HILNER 362, 363 (PRE).
M. dubius (Rotb.) Kukenth. ex G.E.C. Fischer 1000

Bloukrantz Nature Reserve, Valley Bushveld, 250m above sea level, 33° 23' S, 26° 43' E, 3326BC, Albany District, LLOYD 52B, 116 (GRA).

Blaauwkraantjies Drift, common in the grass near the river, 3326BD, Bathurst District, BRITTEN 2740 (GRA).

Great Fish Point, in the dune woodland, 3327CA, Bathurst District, MARTIN sn. (GRA No. 8874).

Near the Fish River, at the Fish River Mouth, near the holiday shacks, behind the dunes, 5m above sea level, 3327AC, Bathurst District, PHILLIPSON 292 (PRE).

Round Hill (Oribi Reserve), in the grass on the river banks, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 138 (GRA).

Southwell, 3326DA, Bathurst District, WARREN A1686 (GRA).

Cintsa River, in grassland, on estuary sand, 3228CC, East London District, VORSTER 2744 (PRE).

Cintsa River Mouth, in grassland, 3228CC, East London District, VORSTER 2745 (PRE).

On a road verges, in coastal thicket, 500m from the sea and 1.5 kilometre's West of Cintsa West, 3227CC, East London District, SONNENBERG 246 (GRA).

Proposed National Botanical Gardens, Eastern Beach, in the coastal forest, 55m above sea level, 3327BB, East London District, LUBKE & STRONG 2786 (GRA).

Overton Farm, 11 Miles West of East London, 500 yards from the sea, fairly plentiful in the sheltered valleys, 3327BB, East London District, HILNER 193 (GRA, PRE).

Gamtoos River Valley, near Hankey, 150ft above sea level, 3324DD, Hankey District, FOURCADE 2585 (GRA).

Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth, SONNENBERG 405 (GRA, UN).

200ft above sea level, 3326DB, Port Alfred, SCHLECHTER 2740 (GRA).

Grassland, 3326DB, Port Alfred West, BRITTEN 5193 (PRE).

0.5 Kilometre's North of the Kowie River Mouth, next to a sand road, just behind the dunes, 3326DB, Port Alfred, ARNOLD 826 (PRE).

M. durus (Kunth.) C.B.Clarke 1100

26.2 Kilometre's South-east of Salem, on the road to Bushman's River Mouth, in open Bushveld around a pan, on sandy soil, in full sunlight, 3326DA, Albany District, VORSTER 2331 (GRA, PRE).

13.2 Kilometre's South-east of Salem, on the road to Kenton-on-Sea, in low bushveld, in a dried up pool, on clay and in full sunlight, 3326DA, Albany District, VORSTER 2330 (GRA, PRE).

6.7 Miles south-east of Salem, at the pan on the ridge, on the edge, 3326AD, Albany District, ACOCKS 23290 (GRA).

10 Miles from Salem, on the Wesley Woods road, in grassland, 335m above sea level, 3326AD, Albany District, ACOCKS 12050 (PRE).
Langebosch Heights, Alexandria Forest, 185m above sea level, 3326CB, Alexandria District, JOHNSON 1054 (PRE).

Just West of Alexandria, on the road to Port Elizabeth, in Bushveld, in short grassland, next to the road in sand and full sunlight, 3326CB, Alexandria District, VORSTER 2333 (GRA, PRE).

Bushman's River Mouth, in grassland, 30m above sea level, 3326DA, Alexandria District, ARCHIBALD 3948 (PRE).

At the turn-off to Southwell, travelling from Bushman's River Mouth, in grassland, 3326DA, Alexandria District, ARNOLD 605 (PRE); VORSTER 2283 (GRA, PRE).

Hopewell, 185m above sea level, 3326BD, Bathurst District, ACOCKS 23510 (PRE).

10.9 Kilometre's from Port Alfred, on the road to Bathurst, in short grassland, 3326DB, Bathurst District, VORSTER 2288 (GRA, PRE).

3227BB, East London, RATTRAY 845 (GRA).

5m above sea level, 3327AD, Hamburg, ACOCKS 21828 (PRE).

4 Kilometre's East of Humansdorp, on the road to Komdraai, in grassland, 3424BB, Humansdorp District, VORSTER 2342 (PRE).

3326DB, Port Alfred, BRITTEN 6619 (PRE).

Near the Kowie River, in a dry vlei (marsh), 10m above sea level, 3326DB, Port Alfred, DYER 624 (GRA, PRE).

West Bank flats, North of the bridge that was inundated in the big floods, 3326DB, Port Alfred, BRITTEN 1929 (GRA).

West Bank, the Grahamstown road vlei, 3326CB, Port Alfred District, BRITTEN 750 (GRA), 750A (GRA, PRE).

3326DB, Port Alfred West, BRITTEN 750B (PRE); TYSON 159 (GRA).

Baakens River Valley, 3325DC, Port Elizabeth, DREGE 628 (GRA).

Port Elizabeth Valley, 3325DC, Port Elizabeth District, PATERSON 2317 (GRA, PRE).

**M. indecorus (Kunth.) Podlech 1600**

Alice Airstrip, 625m above sea level, 3226DB, Alice, PHILLIPSON 1254 (PRE).

Near the top of Koonap Heights, in a small pool at the roadside, 3226DC, Amatole Mountains, SCHÖNLAND, S. 3702 (GRA, PRE).

Amherst Siding, between Seymour and Fort Beaufort, 3226DA, Fort Beaufort District, ROBBERTSE 957 (PRE).

On a dry hill South of Fort Beaufort, amongst the grass, 2000ft above sea level, 3226DC, Fort Beaufort District, DYER 237 (GRA).

3326BC, Grahamstown, SALISBURY 378 (GRA).

Gunfire Hill, 3326BC, Grahamstown, BRITTEN 5907 (PRE).

N quamaya Ridge, 3.2 miles from Keiskammahoek Bridge, on the road to Debe Nek, in a shrub clearing, 765m above sea level, 3227CA, Keiskammahoek District, STORY 3391 (PRE).

Among shrubs along the valley of the Kei River, near Komga, 548m above sea level, 3227DB, Komga District, FLANAGAN 1017 (PRE).
**M. involutus** C.B.Clarke 1700

William’s Farm, "Orange Grove", 4 miles West of King William’s Town, river bank, 3227CD, King William’s Town District, HILNER 127 (GRA).

3227CB, Stutterheim, ROGERS 12732 (GRA).

Toise River, on the river banks, 3227AD, Stutterheim District, HILNER 375 (GRA).

Van Stadens River, 300ft above sea level, 3227CC, Uitenhage District, MACOWAN 2084 (GRA)- **SYNTYPE**.

**M. macrocarpus** Kunth 1950

Nahoon, 3227DD, East London District, NANNI 39331 (PRE).

Near Buccaneer’s Retreat, 150m from Cintsa West river mouth, in the coastal thicket and on exposed dunes on the verge of the thicket, on a steep 1st dune, 3227CC, East London District, SONNENBERG 248 (GRA).

Cintsa River Mouth, on the margin of coastal dune forest, in loose white sand, 300m from the sea, 1 kilometre West of Cintsa West, in a gully, 3228CC, East London District, SONNENBERG 245 (GRA).

Cintsa River Mouth, in a gully with sharp sides, 100m from the Cintsa West river mouth, 3228CC, East London District, SONNENBERG 244 (GRA).

Cintsa River Mouth, on the margin of coastal dune forest, on loose white sand above the high water mark, in partial shade, 3228CC, East London District, VORSTER 2750 (GRA).

Proposed National Botanical Gardens, Eastern Beach, in the bushclump, 45m above sea level, 3327BB, East London District, LUBKE & STRONG 2837 (GRA).

Floor of the forest, in shade, 3327AD, Hamburg, VORSTER 2255 (GRA, PRE).

3326DB, Port Alfred, POTTS 211 (GRA).

**M. pseudo-vestitus** C.B.Clarke 2500

Honeydale Farm, Trollops Burn-Browse Plots, 3226DD, Alice District, GIBBS-RUSSEL 3106 (GRA).

Hopewell, 185m above sea level, 3226DB, Bathurst District, ACOCKS 23501 (PRE).

Trappes Valley, 3226DB, Bathurst District, DALY 663 (GRA, PRE), 12933 (TM).

Cintsa River Mouth, in grassland, 3228CC, East London District, VORSTER 2746 (PRE).

11.2 Miles West-South-West of East London, 60m above sea level, 3327BA, East London District, ACOCKS 21850 (PRE).

13 Kilometre’s East of Coombs Valley, in grassland, 3326BD, Grahamstown, VORSTER 2315 (PRE).

Near Komga, on stony ground, 610m above sea level, 3227DB, Komga District, FLANAGAN 2202 (GRA, PRE).

St. John’s, Kubusie River Valley, on a cliff, 610m above sea level, 3227AD, Stutterheim District, ACOCKS 9193, 9420 (PRE).
**M. solidus** (Kunth) P.J.Vorster

3 Miles from Amabele, in a garden, 795m above sea level, 3227DA, Amabele District, DE VRIES 60 (PRE).

Turpin Dam, Gallery Forest (weekly developed Montane Forest), along the stream in wet soil, in partial full shade, 3226CA, Bedford District, VORSTER 2423 (GRA).

Cintsa River Mouth, in grassland, 3228CC, East London District, VORSTER 2740 (PRE).

10 Kilometre's before the Cintsa turn-off, on the Port Elizabeth road, 3227DB, East London District, ARNOLD 567 (PRE).


Blaauwkrantz, on the river bank, 3326BC, Grahamstown District, HILNER 89 (GRA).

Brookhuizen Poort, 2000ft above sea level, 3326AC, Grahamstown District, MACOWAN 662 (GRA)- **SYNTYPE**.

Grahamstown Nature Reserve, Dassie Kranz, in Montane Forest, at the margin of a glade, 3326BC/AD, Grahamstown District, VORSTER 2297 (GRA).

the vlei East of the road, at the Entrance to Hamburg, in wet heavy soil, not in water, in full sunlight, 3327AD, Hamburg, VORSTER 2250, 2257 (GRA).

On a river bank, 610m above sea level, 3227DB, Komga, FLANAGAN 977 (PRE).

Damp places, in the woods near Komga, 2000ft above sea level, 3227DB, Komga District, FLANAGAN 921 (GRA).

In a dry watercourse, 3326DB, Port Alfred, BRITTEN 772 (GRA).

3227CB, Stutterheim, ROGERS 12732 (GRA).

Toise River Station, in short grassland, along the stream, in moist soil, in full sunlight, 3227AD, Stutterheim District, VORSTER 2427 (GRA).

Swartkops River, 3325CD, Uitenhage District, BURCHELL 4431 (PRE).

**M. sumatrensis** (Retz.) J.Raynal 2920

600m West of West-Kleinemonde, on a North-facing sand dune slope, in dune forest, under a large *Mimusops caffra*, 3326CA, Bathurst District, SONNENBERG 206 (GRA).

Tharfield Private Nature Reserve, near west Kleinemonde, 3326CA, Bathurst District, SONNENBERG 198 (GRA).

Cintsa River Mouth, in grassland, 3228CC, East London District, VORSTER 2749 (PRE).

Cintsa West, on a river bank, in thicket, sandy soil, 3228CB, East London District, SONNENBERG 242 (GRA).

Murraysberg, 5000ft above sea level, 3224BA, Graaff-Reneit, TYSON 143 (GRA).

Centenary Dam, on the banks, 3228CB, Kei Mouth District, SONNENBERG 436 (GRA).

Waste land, 1000ft above sea level, 3228CB, Kentani District, PEGLER 1088 (GRA).

Rooikrans/Maden Dam, plants in wet soil, at the water margin and among the grass in the wet soil around the dam, 580m above sea level, 3227DC, King William’s Town District, GIBBS-RUSSEL 4044 GRA, PRE).

Marshy spots near Kei Mouth, 100ft above sea level, 3228CB, Komga District, FLANAGAN 957 (GRA).
Grassy slopes near Komga, in the valleys, in grassland, 610m above sea level, 3227DB, Komga District, FLANAGAN 1016 (GRA, PRE).

Marshy spots near Komga, 2000ft above sea level, 3227DB, Komga District, FLANAGAN 1263 (GRA).

**M. tabularis (Schrad.) C.B.Clarke Subsp. tabularis 2940**

Round Hill (Oribi Reserve), in a grassy area, 250m from the Conservation house, below the house, neat the Bathurst road, 3326BD, Bathurst District, SONNENBERG 281 (GRA, UN).

Toise River, on a hillside, 3400ft above sea level, 3227AD, Cathcart District, HILNER 542 (GRA).

Fish River Valley, 3326BA, Fort Brown District, HUTTON sn. (GRA No. A2075).

Hill 60, in a shallow depression, 3326BC, Grahamstown, HILL, DB. 1421 (GRA).

3227DB, King William’s Town, SIM 2858 (GRA).

Brakkloof, 3325DC, Port Elizabeth, WHITE 21 (GRA).

Cradock Place, 100ft above sea level, 3325DC, Port Elizabeth Downs, GALPIN 6411 (GRA).

Redhouse, 3325DC, Port Elizabeth, PATERSON 220 (GRA).

3325CD, Uitenhage, ECKLON & ZEYHER sn. (GRA).

**M. tabularis (Schrad.) C.B.Clarke Subsp. major**

Grassland 1 kilometre from Kei Mouth, 3228CB, Kei Mouth District, SONNENBERG 411 (GRA, UN).

**M. thunbergii (Vahl.) Schrad. 2950**

Near Hogsback, at the junction of Happy Valley and Cathcart road, at the edge of the stream, 1402m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 192 (PRE).

Riet River Mouth, 500m from the sea, on a river bank, at the edge of a salt vlei, 3326CA, SONNENBERG 214 (GRA).

On the road to Three Sisters, 3326DB, Bathurst District, BRITTEN 732B (PRE).

Tebe River, on the road to Three Sisters, 3326DB, Bathurst District, BRITTEN 733 (GRA).

Fairford, 3226BD, Cathcart District, COTTERRELL 40 (GRA, PRE).

Dassie Kranz, 3326BC/AD, Grahamstown District, SALISBURY 255 (GRA).

Kettle Spout Falls, on the banks of the river that feeds the falls, on the forest/fynbos margin, 700m from the falls, 3226DB, Hogsback, SONNENBERG 292 (GRA, UN).

Kettle Spout waterfall, in the marsh, 3226DB, Hogsback District, LUBKE 143 (GRA).

At the old saw mill, in a swamp, 4800ft above sea level, 3226DB, Hogsback, LUBKE 347 (GRA).

500ft above sea level, 3424BB, Humansdorp, ROGERS 2936 (GRA).

44.8 Kilometre's West of Humansdorp, on the road to Knysna, in a marsh, 3424AB, Humansdorp District, VORSTER 2346 (PRE).

Krom River, on the muddy river banks, 3424BB, Humansdorp, MORRISON 74 (GRA).
Witte Els Bosch, on the flats, 3424AA, Humansdorp District, FOURCADE 834 (GRA).

A wooded Kloof above Humansdorp, 140m above sea level, 3424BB, Humansdorp, GALPIN 4833 (GRA, PRE).

Kei River Mouth, in grassland, 3228CB, Komga District, ARNOLD 560 (PRE); VORSTER 2247 (PRE).

Between Rietfontein and the Kowie river, on the road to Port Alfred, 3326DB, Port Alfred District, BURCHELL 3992 (PRE).

Rufanes River Mouth, on the right bank of the stream, behind the coastal sand dunes, 3326DB, Port Alfred District, MARTIN *sn.* (GRA No. 3095).

Along the road to Sea view, in a marsh, 3325DC, Port Elizabeth District, THERON 1114 (PRE).

Walmer, 3325DC, Port Elizabeth, PATERSON 834 (GRA).

Next to the turn-off to Walmer, on wet sand, in full sunlight, in a marsh, 3325DC, Port Elizabeth District, VORSTER 2334 (GRA, PRE).

At old road between Cape Town and Port Elizabeth, near Van Stadens River, in grassland, on a river bank, 3325CC, Port Elizabeth District, VORSTER 2337 (PRE).

Van Stadens River, 3325CC, Port Elizabeth District, SCHLECHTER 25 (PRE).

23 Kilometre's from Uitenhage, on the road to Groendal Dam, on a stony river bank, 3325CD, Uitenhage District, ARNOLD 1064 (PRE).

* M. uitenhagensis Steud. 2980 *

Fish River Valley between Committees Drift and Hunts Drift, in sweet Karoo veld, 1500ft above sea level, 3326BB, Albany District, DYER 904 (GRA).

5.25 Miles North of Cradock, on stony ground, 915m above sea level, 3225BA, Cradock District, ACOCKS 16321 (PRE).

Mountain Zebra Park, on stony soil, 3225AD, Cradock District, VAN DER WALT 7 (PRE).

3326BC, Grahamstown, DALY & SOLE 105 (GRA).

10 Kilometre's from Grahamstown on the road to Bathurst, in a shrub clearing, 3326BC, Grahamstown District, ARNOLD 824, 829 (PRE).

Gunfire Hill, 3326BC, Grahamstown, BRITTEN 5912 (GRA).

Zuurbron Kloof, along the road to Hankey, 3324DD, Hankey District, FOURCADE 4919 (PRE).

Gamtoos Valley, in dry grassland, adjacent Scotts Cave, 3324DD, Humansdorp District, WELLS 2748 (GRA, PRE).

Just East of Humansdorp, on the road to Krombaai, in a marsh, 3424BB, Humansdorp District, BURTT-DAVY 13472 (PRE).

Rooideberg Farm, on dolerite crests, northern slopes, rocky slopes, 3224AD, Kendrew District, SONNENBERG & HOBSON 501 (GRA, UN).

3325DC, Port Elizabeth, DREGE 8771 (PRE).

Addo Elephant Nature Park, on the way to the goat camp, 3325BC, Port Elizabeth District, LIEBENBERG 7755 (PRE).

Downs, Cradock Place, 30m above sea level, 3325DC, Port Elizabeth, GALPIN 6409 (PRE).
Markman Industrial Area, on clay-gravel soil, 20m above sea level, 3325DC, Port Elizabeth District, DAHLSTRAND 2723 (GRA, PRE).

St. Johns, Kubusie River Valley, in grassland, 700m above sea level, 3227CB, Stutterheim District, ACOCKS 9422 (PRE).

Commando Drift Dam Nature Reserve, 40 kilometre's East of the Cradock Management Survey Area, 1020m, 3225BB, Tarkastad District, PALMER 796 (PRE).

Adolphskraal, in grazed Noorsveld, 3325CA, Uitenhage District, SMOOK 3871 (PRE).

22 Kilometre's from Uitenhage on the road to Groendal Dam, on stony ground, 3325CD, Uitenhage District, ARNOLD 1068 (PRE).

**PYCREUS** Beav. 0459010

**P. betschuanus** (Boeck.) C.B.Clarke 300

Gaika's Kop Area, beneath the mountain, in a marsh, 1409m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 157 (PRE).

Toise River, in the mud, on the river banks, 3227AD, Cathcart District, HILNER 374, 524 (GRA).

**P. chrysanthus** (Boeck.) C.B.Clarke 400

The pond, 1 kilometre along the Calderwood road, travelling from the Peddie road, in shallow water, 579m above sea level, 3226DD, Alice District, PHILLIPSON 229 (PRE).

Tortoise Pond, on the Grahamstown road, 516m above sea level, 3226DD, Alice District, GIFFEN 932 (PRE).

**P. cooperi** C.B.Clarke 470

Gaika's Kop, in a marsh, near the start of a small river, 3226DB, Hogsback District, SONNENBERG 392 (GRA, UN).

Third Hog, on a stream bank, on the Gaika's Kop side, 3226DB, Hogsback District, SONNENBERG 311 (GRA, UN).

**P. intactus** (Vahl.) J.Raynal 950

Kei Mouth golf course, sandy soil, 3228CB, Kei Mouth, SONNENBERG 407 (GRA, UN).

Marshy places near Kei Mouth, 60m above sea level, 3228CA, Komga District, FLANAGAN 961 (GRA, PRE).

On the margin of grass/thicket, on a slope overlooking Morgan's Bay, wet soil, 3228CB, Morgan's Bay, SONNENBERG 422 (GRA, UN).

Schoenmakers Kop, 3325DC, Port Elizabeth, PATERSON 546 (GRA).

**P. maracanthus** C.B.Clarke 1100

Suurberg, in muddy, shady places, in a ravine, 3325BD, Alexandria District, SCHÖNLAND, S. 3184 (GRA).

3 Miles from Amabele, in grassland, 795m above sea level, 3227DA, Amabele District, DE VRIES 17 (PRE).
Gaika's Kop, beneath the mountain, 1409m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 158 (PRE).

Below Gaika's Kop, 1 kilometre North of the Waterfall, in a marsh, 1440m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 102 (PRE).

Between Gaika's Kop and the Hogsback Peaks, in a marsh, 1463m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 207 (PRE).

Toise River, 3227DA, Cathcart District, HILNER 537 (PRE).

Howieson's Poort, in a swamp, 3326AD, Grahamstown District, BRITTEN 977 (GRA).

1275m above sea level, 3226DB, Hogsback, GIFFEN 1273, 58045 (PRE).

In marshes, 4800ft above sea level, 3226DB, Hogsback, RATTRAY 3, 4 (GRA).

Gaika's Kop, in the marsh on the way to the hiking hut, on the marsh/Pine forest margin, 3226DB, Hogsback District, SONNENBERG 367 (GRA, UN).

Kettle Spout Falls, 700m away, marsh, 3226DB, Hogsback District, SONNENBERG 300 (GRA, UN).

First Hog, in a marsh 5 kilometres from the Hog, on the Gaika's Kop side, grassland, 3226DB, Hogsback District, SONNENBERG 303 (GRA, UN).

3227CD, King William’s Town, SIM 2852 (PRE).

Pastures near Komga, 2000ft above sea level, 3227DB, Komga District, FLANAGAN 930 (GRA).

Boschberg, 4500ft above sea level, 3225DA, Somerset-East District, SONDER 1365 (GRA).

Dohne Pasture Research Station, 3227CB, Stutterheim District, ACOCKS 8908 (PRE).

Stutterheim Commonage, in a donga, 795m above sea level, 3227CB, Stutterheim District, ACOCKS 9450 (PRE).

*P. mundii* Nees. 1300

Gaika's Kop, the area beneath the mountain, in a marsh, 1402m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 163 (PRE).

Thomas River, on the Cathcart to Stutterheim road, 22 kilometres North of the road, along the river, 1006m above sea level, 3227AD, Amatole Mountains, PHILLIPSON 245 (PRE).

Bathurst Commonage, in the grassland between the bushclumps, 500m from the Southwell-Bathurst road, 5 kilometre's from Bathurst, in sandy soil, 3326BD, Bathurst District, SONNENBERG 229 (GRA).

At the junction of Happy Valley and the Cathcart roads, on the bank of the river, in Riverine scrub, 1402m above sea level, 3226DB, Hogsback, PHILLIPSON & FURNESS 187 (PRE).

Witelsbos SAFCOL forest, in a marsh, near the foresters cottage, 400m from the N2 to Storms River, at the edge of the Witelsbos forests, 3424AB, Humansdorp District, SONNENBERG 491 (GRA, UN).

On the river banks, near Keiskammahoek, 2000ft above sea level, 3227CA, Keiskammahoek District, DYER 320 (GRA).

Humewood, 3325DC, Port Elizabeth, PATERSON 26540 (GRA).

Cumakala River, 795m above sea level, 3227CB, Stutterheim District, ACOCKS 9470 (PRE).

250ft above sea level, 3325CD, Uitenhage, SCHLECHTER 2550, 2553 (GRA).
**P. nitidus (Lam.) J.Raynal 1400**

Suurberg, 3325BD, Alexandria District, HOLLAND 93 (GRA).

University of Fort Hare, 516m above sea level, 3226DD, Alice, GIFFEN 704 (PRE).

Toise River, on a hillside, 3400ft above sea level, 3227AD, Cathcart District, HILNER 537 (GRA).

Andries Vosloo Kudu Reserve, 40 kilometre's north-east of Grahamstown, in Valley Bushveld, on the banks of the Kentucky Dam, 250m above sea level, 3326BA, Fort Brown District, PALMER 355 (GRA).

3326BC, Grahamstown, SCHÖNLAND, S. 206 (GRA, PRE).

Coldspring, on swampy ground, off Paradise Kloof, 3326AD, Grahamstown District, BRITTEN 2673 (GRA).

Near Dassie Kranz, the swamp near the Bay road, 3326AD/BC, Grahamstown, BRITTEN 616 (GRA).

Grahamstown Nature Reserve, the swampy ground below the Nature Reserve, 3326BC, Grahamstown District, BRITTEN 5850 (GRA).

Howieson's Poort, 3326AD, Grahamstown District, HUTCHINSON 1540 (PRE).

Cochin Farm, near Marsh Sands, in a gully, grassland, 3228CB, Hagga Hagga District, SONNENBERG 455 (GRA, UN).

In a marsh, in a valley, 305m above sea level, 3228CB, Kentani District, PEGLER 1136 (PRE).

3227CB, King William’s Town, SIM 2852 (GRA).

Fort Cunynghame, 3000ft above sea level, 3227CB, Stutterheim District, SCHÖNLAND, R. 72 (GRA).

Van Staden’s Mountains, 460m above sea level, 3325CC, Port Elizabeth District, ZEYHER 4357 (PRE).

Van Staden’s River, 50ft above sea level, 3325CC, Port Elizabeth District, BAKER 2083 (GRA).

Swartkops, 3325DC, Port Elizabeth, ZEYHER 4357 (GRA).

In the Aqueducts, 3325CD, Uitenhage District, ZEYHER 634 (PRE).

**P. oakfortensis C.B.Clarke 1500**

3226DB, Hogsback, RATTRAY 398 (GRA).

In grassland, 305m above sea level, 3228CB, Kentani District, PEGLER 150 (PRE).

610m above sea level, 3227DB, Komga, FLANAGAN 930 (PRE).

7 Miles from the coast, on the Kei Mouth road, 3228CB, Komga District, DYER 4492 (PRE).

Dohne Hill, 3227CB, Stutterheim District, SIM 2845 (GRA).

**P. polystachyos (Rottb.) Beauv.**

Queens road near Grahamstown, 3326BC, Albany District, SCHÖNLAND, S. 4352 (GRA, PRE).

Camtarha River, 3326CB, Alexandria District, ARCHIBALD 5663 (PRE).

Sandflats, behind the dunes, 305m above sea level, 3325DB, Alexandria District, ARCHIBALD 3950 (PRE).
Suurberg, in muddy places near the Sanatorium, 2100ft above sea level, 3325BD, Alexandria District, SCHÖNLAND, S. 3187 (GRA).

Hayes Siding, 8 kilometre's from Port Alfred, between Port Alfred and Bathurst, in grassland, 3326DB, Bathurst District, RETIEF 264, 307 (PRE).

Overton Farm, 11 miles West of East London, in an old vlei, near the cottage, ½ a mile from the beach, 3327BB, East London District, HILNER 151 (GRA, PRE).

Near the Holiday shacks, behind the dunes, 4m above sea level, 3327AC, Fish River Mouth, PHILLIPSON 299 (PRE).

3326BC, Grahamstown, BRITTEN 928 (PRE); DALY & SOLE 32 (PRE); MACOWAN 569 (GRA).

Near the Grey Reservoir, 3326BC, Grahamstown, DALY 32 (GRA).

Howieson's Poort Dam, 3326AD, Grahamstown District, BRITTEN 5963 (PRE).

Howieson's Poort, Palmiet River, in a swamp, 3326AD, Grahamstown District, BRITTEN 974 (GRA, PRE).

Below the Nature Reserve, in a marshy area, 3326BC, Grahamstown, BRITTEN 5848 (PRE).

Towards Mayor's Seat, in a dry vlei below the rock ledge, shaded by Pines, 3326BC, Grahamstown, BRITTEN 928 (GRA).

Thomas Baines Nature Reserve, 3326AD, Grahamstown District, PALMER 1637 (GRA).

In a marsh near a stream, 305m above sea level, 3228CB, Kentani District, PEGLER 350 (GRA, PRE).

Rooikrans/Maden Dam, 3227CB, King William’s Town District, GIBBS-RUSSEL 4041B (PRE).

Marshy spots near Kei Mouth, 60m above sea level, 3228CB, Komga District, FLANAGAN 959 (GRA, PRE).

Redhouse, 3325DC, Port Elizabeth, PATERSON 546B (PRE).

Bethelsdorp, 3325CD, Uitenhage District, PATERSON 546B (PRE).

Matthew’s Place Farm, Wilderness Reserve, Zunga Catchment Basin, near Groendal, Great Winterhoek Mountains, in a rocky grassland area, on a gravel river bank, in wet spots on Enon clay conglomerate, 106m above sea level, 3325CA, Uitenhage District, SCHARF 2052 (GRA, PRE).

The springs near Uitenhage, 3325CD, Uitenhage District, SCHÖNLAND, S. 3732 (GRA).

Swartkops River, on a river bank, 3325CD, Uitenhage District, ECKLON & ZEYHER 11 (PRE).

Zwartkop, 3325DC, Uitenhage District, SCHLECHTER 21 (PRE).
**P. polystachyos (Rotlb.) P.Beauv. Subsp. polystachyos**

Witelsbos SAFCOL forest, in an area cleared of *Eucalyptus* trees, 2 kilometres from the SAFCOL Offices, 700m from the N2 to Storms River, wet soil, 3424AA, Humansdorp District, SONNENBERG 465 (GRA, UN).

**P. unioloides (R.Br.) Urb. 2300**

Marshy spots near Kei Mouth, 60m above sea level, 3228CB, Komga District, FLANAGAN 958 (GRA, PRE).

On a stream side, on the commonage, on the river banks, 765m above sea level, 3227CB, Stutterheim District, ACOCKS 9516 (PRE).

**RHYNCHOSPORATA Vahl. 0492000**

**R. barrosiana Guaglianone**

Cape Morgan Nature Reserve, in an old marsh near the gate, grassland, sandy soil, 3228CB, Kei Mouth District, SONNENBERG 417 (GRA, NE, UN).

**R. brownii Roem & Schult. 100**

South-east of the 1st Hogsback Peak, on un-submerged hummocks, 1386m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 14 (PRE).

Beneath Gaika's Kop, 1402m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 160 (PRE).

Featherstone Kloof, on wet ground, on the banks of the Vof River, amongst herbs, 1550ft above sea level, 3326BC, Grahamstown, LUBKE 74 (GRA).

Howieson's Poort, 3326AD, Grahamstown District, MACOWAN 1354 (GRA).

Osmunda Kloof, 3326BC, Grahamstown, MARTIN sn. (GRA No. 3129).

Near the Flanborough Hotel, in swampy grassland, 3226DB, Hogsback, MARTIN sn. (GRA No. 8931).

Near the Foresters Cottage, in a marshy stream bank, 4000ft above sea level, 3226DB, Hogsback, LUBKE 133 (GRA).

Kettle Spout marsh, in waterlogged soil, at the waters edge, 4000ft above sea level, 3226DB, Hogsback, LUBKE 146 (GRA).

Third Hog, in a marsh on the Gaika's Kop side, grassland, 3226DB, Hogsback District, SONNENBERG 313 (GRA, UN).

Tore Doone, on a rocky slope, in Pine forest, 3226DB, Hogsback, SONNENBERG 334 (GRA, UN).

Robertson Falls, on the rocky river banks above the falls, 3226DB, Hogsback District, SONNENBERG 337 (GRA) & 338 (GRA, UN).

Witelsbos SAFCOL forest, 600m from the Kromdraai turnoff on the N2 to Storms River, on the margin of Pine forest, wet sandy soil, 3424AA, Humansdorp District, SONNENBERG 472 (GRA, UN).

Witte Els Bosch, on the flats, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 2418 (GRA).

In a marsh, 365m above sea level, 3228CB, Kentani District, PEGLER 2096 (PRE).
Gassy and marshy places near Kei Mouth, 30m above sea level, 3228CB, Komga District, FLANAGAN 2364 (GRA, PRE).

Double Mouth, on the hill above, 3228CB, Morgan's Bay, SONNENBERG 426 (GRA).

Dohne Hill, 3227CB, Stutterheim District, SIM 2844 (GRA).

Fort Cunynghame, 3227AD, Stutterheim District, SIM 2685 (GRA, PRE).

Stutterheim Commonage, in a donga, 795m above sea level, 3227CB, Stutterheim District, ACOCKS 9451 (PRE).

**SCHOENOPLECTUS Palla 0468010**

*S. decipiens* (Nees) J.Raynal 400

3226DD, Alice, GIFFEN 1599, 57550 (PRE).

Paryshoogte road, 16 kilometer's south-east of Cookhouse, opposite the substation of the Eastern Cape Grassland Farm, in grassland, 3225DD, Cookhouse District, SMOOK 3981 (PRE).

7 Kilometre's from Grahamstown, on the road to Bedford, 3326AB, Grahamstown District, ARNOLD 1130 (PRE).

The land around Cradock road pond, 3326BC, Grahamstown District, SILBERBAUER 27 (PRE).

Firdene Farm, in a shallow water resting area with rocky sides, 3326AD, Grahamstown District, SONNENBERG 236 (GRA).

Stowan Farm Dam, 3326AD, Grahamstown District, BRITTEN 5976 (PRE).

Wildebeeskuil Farm, in wet areas, 760m above sea level, 3225CA, Pearson District, HOBSON, CB. 140 (GRA).

Addo Elephant Park, 100m above sea level, 3325BC, Port Elizabeth District, HALL-MARTIN 1931 (PRE).

Addo Elephant Park, at the buck camp, 100m above sea level, 3325BC, Port Elizabeth District, LIEBENBERG 7751 (PRE).

Addo Elephant Park, Korhaan Vlakte, 100m above sea level, 3325BC, Port Elizabeth District, ARCHIBALD 5267 (PRE).

In a dry farm dam, 8 kilometre's from Riebeek-East, near the Gxetu river, 3326AA, Riebeek-East District, SONNENBERG 219 (GRA).

3325CD, Uitenhage, ZEYHER 39205 (PRE).

Swaartkops River, 3325CD, Uitenhage District, ZEYHER 4386, 39207 (PRE).

*S. littoralis* (Schrad.) Palla 750

In the salt marshes at Kei Mouth, 3228CB, Komga District, FLANAGAN 2343 (GRA, PRE).

Redhouse, 3325DC, Port Elizabeth, PATERSON 2039 (GRA).

Swaartkops River, in a channel, 3325CD, Uitenhage District, ZEYHER 13 (PRE).

*S. paludicola* (Kunth.) Palla ex J.Raynal 900
Above the Fish River Valley, 10 miles from Grahamstown, in low succulent scrub, around a seasonal pool of water, 3326BA, Albany District, LUBKE 103 (GRA).

Above the Fish River Valley, in low succulent scrub, on shaley soil, 15 miles from Grahamstown, 3326BA, Albany District, LUBKE 106 (GRA).

Sandflats, 3325BD, Alexandria District, ROGERS 2184A (GRA).

The road to Peddie, at the pond below commonage, on the right hand side of the road, 594m above sea level, 3226DD, Alice District, PHILLIPSON 184 (PRE).

Near the top of Koonap Heights, in a damp place, 3226DC, Amatole Mountains, SCHÖNLAND, S. 3701 (GRA).

The valley between Menziesberg and Pefferskop, at the margin of a small dam, 945m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 1328 (GRA, PRE).

Coombs near Coombsvale Farm, at the edge of the water, near the lake, 3326BD, Albany District, ARNOLD 636 (PRE).

Above Turpin Dam, on the Dam bank, 915m above sea level, 3226CA, Bedford District, ACOCKS 16261 (PRE).

Tay River banks, 40 kilometres from Cathcart, near Rockford, 3226BD, Cathcart District, SONNENBERG 382 (GRA, UN).


3326BC, Grahamstown, SCHLECHTER 2611 (GRA).

At the bottom of Botha's River Valley, near Botha's Hill, 3326BC, Grahamstown District, SCHÖNLAND, S. 4419 (GRA).

Choriois Pan, 3326BC, Grahamstown District, POWER sn. (GRA No. 6164).

Cradock road pond, around the pond, 3326BC, Grahamstown District, SILBERBAUER 27 (GRA).

Kotch Creek, Rhodes University, 3326BC, Grahamstown, SWIFT sn. (GRA No. 6229).

Strowan Farm, the lower dam, adjacent the water, 3326AD, Grahamstown District, SILBERBAUER 11 (GRA).

8 Miles from Grahamstown, on the Port Alfred road, in 6 inches of water, 1800ft above sea level, 3326BC, Grahamstown District, LUBKE 86 (GRA).

Firdene Farm, in a shallow pan of seasonal water, near the farm road, 150m from the summit of Stones Hill, 3326BC, Grahamstown District, SONNENBERG 199 (GRA).

The stream of the old Hogsback road, 4000ft above sea level, 3226DB, Hogsback District, LUBKE 154 (GRA).

SAFCOL camping site, marsh, 3226DB, Hogsback, SONNENBERG 354 (GRA, UN).

3227CD, King William's Town, SIM 2854 (PRE).

Marshy places near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 1259 (PRE).

5 Miles from Kei Mouth road, 3228CB, Komga District, DYER 4497 (PRE).

Double Mouth Nature Reserve, 4 kilometres from the camp site, on the banks of a small pool, grassland, 3228CB, Morgan's Bay District, SONNENBERG 432 (GRA, UN).

At a stream crossing, 3326AD, Salem, WELLS 3884 (GRA).

Besters Hoek, at the lakes edge, 3225DA, Somerset-East, HILLIARD & BURTT-DAVY 13251 (PRE).
Boschberg Mountains, 2500ft, 3225DA, Somerset-East District, BAKER 1964B (GRA).

3 Miles from Amabele, near to the water, 2600ft above sea level, 3227DA, Stutterheim District, DE VRIES 30 (GRA).

Potsdam Farm, 4 kilometre's West of Fort Jackson, in Riverine Thicket, 120m above sea level, 3227DC, Stutterheim District, LUBKE, EVERAD & AVIS 2732 (GRA).

Toise River, on a river bank, 3227AD, Stutterheim District, HILNER 371 (GRA, PRE).

Dohne Pasture Research Station, in a marsh, 3227CB, Stutterheim District, ACOCKS 8899 (PRE).

Despatch, 3325CD, Uitenhage District, HOLLAND 571 (GRA).

**S. triqueter (L.) Palla 1400**

Bushman's River Mouth, at the margin of the new Chara Pool, 15m above sea level, 3226DA, Alexandria District, ARCHIBALD 5910 (PRE).

Kowie road, 7 miles from Grahamstown, in a small pond, 3326BC, Grahamstown District, MARTIN sn. (GRA No. 8045).

**SCHOENOXIPHIUM Kukkonen 0521000**

**S. basutorum Turrill 100**

Cochin Farm, on the banks of a small river, in indigenous vegetation, near Marsh Sands, 3228CB, Hagga Hagga District, SONNENBERG 446 (GRA, UN).

**S. bracteosum Kukkonen**

Kettle Spout Falls, on the banks of the river that feeds the falls, 700m from the falls on the Pine forest/fynbos margin, 3226DB, Hogsback District, SONNENBERG 294 (GRA, UN).

Robertson Falls Dam, on the slopes of the first Hog, on the banks of a small stream, stony soil, 3226DB, Hogsback District, SONNENBERG 386 (GRA, UN).

**S. ecklonii Nees 160**

3325DC, Port Elizabeth, PATERSON 1147 (GRA).

3225DA, Somerset-East, STEWART 11 (GRA).

Cockscomb, 1525m above sea level, 3324DB, Uitenhage District, ESTERHUYSSEN 28037 (PRE).

**S. filiforme Kukenth. 200**

Under the rocks at the summit of the Great Winterberg Mountains, 2345m above sea level, 3226AD, Great Winterberg, GALPIN 5605 (GRA, PRE).

Katberg, towards "The gorge", amongst the short grass, 6500-7000ft above sea level, 3226DA, Stokenstroom District, DYER 365 (GRA).
**S. lanceum** (Thunb.) Kukenth. 240

Witte Els Bosch, in the forest, 850ft above sea level, 3424AA, Humansdorp District, FOURCADE 917 (GRA).

Witte Els Bosch, in the forest, 700ft above sea level, 3424AA, Humansdorp District, FOURCADE 1451 (GRA).

Marshy spots near Komga, 2000ft above sea level, 3227DB, Komga District, FLANAGAN 915 (GRA).

**S. lehmannii** (Nees) Stevd. 250

3226CB, Adelaide, MARLOTH 3487 (PRE).

Path to Alice from Hogsback, 750m above sea level, 3226DB, Amatole Mountains, DAHLSTRAND 2675 (PRE).

6.2 Kilometre's before Hogsback, travelling from Alice, below the Escarpment, on a stony river bank, 3227CA, Amatole Mountains, ARNOLD 768 (PRE).

Lushington River, on the rivers' edge, on rocky slopes, Riverine thicket, 3326DB, Bathurst District, SONNENBERG 217 (GRA, UN).

Trappes Valley, 3326BD, Bathurst District, DALY 595 (PRE).

Fort Gray Nature Reserve, in the forest, 120m above sea level, 3327BB, East London District, GELDENHUYS 754 (PRE).

Andries Vosloo Kudu Reserve, in a shrub clearing, 425m above sea level, 3326BA, Fort Brown District, GIBBS-RUSSEL 3579 (PRE).

Gaika's Kop, in the marsh on the way to the hiking hut, on the marsh/Pine forest margin, 3226DB, Hogsback District, SONNENBERG 361 (GRA, UN).

Madonna and Child Falls, at the foot of the falls, on the rocky slopes, 3226DB, Hogsback District, SONNENBERG 340 (GRA, UN).

Cata Forestry Reserve, in the grassland, 1065m above sea level, 3227CA, Keiskammahoek District, WELLS 3197 (PRE).

Maden Dam, Dpirie Forest, 610m above sea level, 3227CB, King William’s Town District, ACOCKS 9289 (PRE).

In a clearing in the woodlands, 610m above sea level, 3227DB, Komga, FLANAGAN 908 (PRE).

on river banks near the Morgan's Bay turnoff, from the Kei Mouth road, 3228CB, Morgan's Bay District, SONNENBERG 429 (GRA, UN).

Kabusi Forest, 3227CB, Stutterheim District, SPIES 1692 (PRE).

**S. rufum** Nees 260

Kettle Spout Falls, in the marsh on the side of the river that feeds the falls, fynbos, 3226DB, Hogsback, SONNENBERG 296 (GRA, UN).

Boschberg Mountains, 4500ft above sea level, 3225DA, Somerset-East District, MACOWAN 1616, 1866 (GRA).

**S. schweikerdtii** Merxmuller & Podlech 300
Gaika's Kop, on the banks of a small stream, 100m uphill from the old forestry tower, 3226DB, Hogsback District, SONNENBERG 328 (GRA, UN).

Witelsbos SAFCOL forest, in the understorey of indigenous forest, on the Tsitsikammaberg side of the N2 to Storms River, sandy soil, 3424AA, Humansdorp District, SONNENBERG 480 (GRA, UN).

\textit{S. sparteum} (Wahlenb.) C.B.Clarke 550

Blaauwkrantz, in damp shady places, near the river bank, 3326BC, Albany District, HILNER 70 (GRA).

Bushman's River Mouth, in grassland, 30m above sea level, 3326DA, Alexandria District, KILLICK 1765 (PRE).

Katberg near the Sanatorium, in the forest, 4200ft above sea level, 3226DA, Adelaide District, SCHÖNLAND, S. 4330 (GRA).

Menziesberg, on the ridge running North-east of the mountain, in grassland, 1524m above sea level, 3226DB, Alice District, PHILLIPSON & HUTCHINGS 83 (PRE).

Woodstock Farm, on the hill above the railway line, 546m above sea level, 3226DD, Alice District, GIFFEN 177 (PRE).

Hogsback Mountains, along the road to the Hogsback Hydro, in forest, 1032m above sea level, 3226DB, Amatole Mountains, GIFFEN 1588 (PRE).

Round Hill (Oribi Reserve), in the thicket amongst the rocks, in the shade, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 332 (GRA).

Trappes Valley, 3326BD, Bathurst District, DALY 595, 634, 709 (GRA), 2620 (TM).

Glencairn, 1465m above sea level, 3226BD, Cathcart District, HILNER 2413 (GRA, PRE).

Toise River, on a hillside, amongst the grass, 3400ft above sea level, 3226DA, Cathcart District, HILNER 538 (GRA, PRE).


Fish River Valley, 3326BA, Fort Brown District, HUTTON \textit{sn.} (GRA No. 1891); SCHÖNLAND, S. 1581 (GRA).

3326BC, Grahamstown, ALEXANDER-PRIOR 39114 (PRE).

Faraway, Portion 3 of Coldsprings, in moist areas of the grassy heathlands, on a Southern-facing slope, 700m above sea level, 3326AD, Grahamstown District, JACOT-GUILLARMOD 9242 (GRA).

Gowies Kloof, 3326BC, Grahamstown, ROGERS 3828 (GRA).


Grahamstown Nature Reserve, in Southern-facing thicket, 3326BC, Grahamstown, ANON \textit{sn.} (GRA No. 19765); MARTIN \textit{sn.} (GRA No. 9640).

Above Grey Reservoir, 3326BC, Grahamstown, DALY & CHERRY 915 (GRA).

Gunfire Hill, 3326BC, Grahamstown, BRITTEN 5919 (GRA).

Paradise Kloof, in natural forest, 3326BC, Grahamstown, LUBKE 81 (GRA).

1250m above sea level, 3226DB, Hogsback, GIFFEN 513 (PRE); RATTRAY \textit{sn.} (GRA).

Auckland Trust Forest, 750m above sea level, 3226DB, Hogsback, DAHLSTRAND 2675 (GRA).

Gaika's Kop, in the marsh on the way to the hiking hut, on the Pine forest/marsh margin, 3226DB, Hogsback District, SONNENBERG 366 (GRA, UN).
Grassy slopes, 3226DB, Hogsback, RATTRAY 298 (GRA).

Third Hog, in a small stream, on the Gaika's Kop side, grassland, 3226DB, Hogsback District, SONNENBERG 317 (GRA, UN).

Wolfsridge Forest Reserve, 8 miles from the Hogsback Village, 4500ft above sea level, 3226DB, Hogsback District, LUBKE 353 (GRA).

Boshoek, in dry grassy fynbos, on Enon conglomerate hills overlooking the Gamtoos River, the dominants are Protea repens-Themeda, 60m above sea level, 3324DD, Humansdorp District, COWLING 804 (GRA).

Near Krom Drift, in false fynbos, on Bokkeveld Shale, 84m above sea level, 3424AB, Humansdorp District, COWLING 694 (GRA).

Osbosch, in broadleaf sclerophyll shrubland, on Bokkeveld Shale, 15m above sea level, 3424BB, Humansdorp District, COWLING 326 (GRA).

Sclerophyll (broadleaf) woodland, on Bokkeveld Shale, the dominants are Buddleria suligna and Hippobromus pauciflora, 5m above sea level, 3424BB, Humansdorp District, COWLING 400 (GRA).

4 Kilometre's South of Humansdorp, on the road to St. Francis, in fynbos, 80m above sea level, Humansdorp District, DAVIDSE 33615 (PRE).

Witte Els Bosch, in grassy places, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 3135 (GRA).

Cata Forest, 3500ft above sea level, 3227CA, Keiskammahoek District, WELLS 3197 (GRA).

Gxulu Kop, on the edge of the fire break, 1500m above sea level, 3227CA, Keiskammahoek District, ROBINSON 60298 (PRE).

The forest at the edge of a stream, 1000ft above sea level, 3228CB, Kentani District, PEGLER 1097, 1098 (GRA).

Valleys along the forest, in damp soil, 1000ft above sea level, 3228CB, Kentani District, PEGLER 1196 (GRA).

Fort Cunynghame, 3000ft above sea level, 3227CB, Stutterheim District, SCHÖNLAND, R. 21 (GRA).

Keiskammahoek Experimental Plot near Ghulu Kop, amongst the grass, 3227CA, King William’s Town District, DYER 245, 245A (GRA).

Valleys near Komga, in grassland, 610m above sea level, 3227DB, Komga District, FLANAGAN 905 (PRE), 906 (GRA, PRE), 907 (GRA).

In the woods near Komga, 2000ft above sea level, 3227DB, Komga District, FLANAGAN 908 (GRA).

3326DB, Port Alfred, HUTTON 40 (GRA).

Springs Reserve, 3325CD, Uitenhage District, OLIVIER 2629 (PRE).
**SCHOENUS L. 0477000**

*S. nigricans L. 300*

Camtarha River Valley, on a river bank, 120m above sea level, 3326CB, Alexandria District, ARCHIBALD 5780 (PRE).

South-east of Shaw Park, in dry veld and *Leucosperm* veld, 700ft above sea level, 3326DA, Bathurst District, MARTIN *sn*. (GRA No. 8852).

4.7 Miles from Kwelegra, on the road to East London, on a river bank, 3227DD, East London District, COMINS 1275 (PRE).

Cochin Farm, on the banks of a small river, in indigenous thicket, near Marsh Sands, sandy soil, 3228CB, Hagga Hagga District, SONNENBERG 445 (GRA, UN).

Assegai Bosch, 3324CD, Humansdorp District, FRIES & NORLIND 1242 (PRE).

Aston Bay, in grassland, 3424BB, Humansdorp District, ARNOLD 661 (PRE).

19m From the sea, in grassland, on stony ground, 3228CB, Kei Mouth, ARNOLD 556 (PRE).

On the sea shore, in a salt marsh at the high tide water mark, 3228CB, Kei Mouth, VORSTER 2245 (PRE).

Along streams near Komga, 610m above sea level, 3227DB, Komga District, FLANAGAN 916 (GRA, PRE).

In a salt marsh, 3326DB, Port Alfred, NOEL *sn*. (GRA No. 8301).

3325DC, Port Elizabeth, FRIES & NORLIND 165 (PRE).

Redhouse, 3325DC, Port Elizabeth, PATERSON *sn*. (GRA, July 1910).

Potsdam Farm, 4 kilometre's West of Fort Jackson, in Riverine Thicket, on the banks of streams and at the edge of pools, 120m above sea level, 3227DC, Stutterheim District, LUBKE, EVERAD & AVIS 2733 (GRA).

**SCIRPUS L. 0468000**

*S. diabolicus* (Stevd.) Schrad. 1000

Waterloo Farm, 5 kilometres from the Grahamstown, on the Grahamstown to Port Alfred road, 100m from the road in disturbed grassland, 3326BC, Grahamstown District, SONNENBERG 238 (GRA).

*S. dioecus* (Kunth.) Boeck. 1100

Mountain View Farm, Newevelt Mountains, in Karoid Merxmeullera Mountain Veld, on a dry stream bed, in the mountains, 3222BD, Beaufort-West District, GIBBS-RUSSEL 497 (GRA).

Boschberg, 3225DA, Somerset-East District, LEENDENTZ 5383 (GRA).

*S. falsus* C.B.Clarke 1400

South-Western-facing slope and the summit of Gaika's Kop, in the rock crevices near the top, 1646m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & HUTCHINGS 17 (PRE).
Gaika's Kop, 6400ft above sea level, 3226DB, Amatole Mountains, RATTRAY 340 (GRA).

At the summit of the 1st Hogsback, in rock cracks, 4000ft above sea level, 3226DB, Amatole Mountains, LUBKE 152 (GRA).

3226DB, Hogsback, RATTRAY 272 (GRA).

On a mountain slope, 4000ft above sea level, 3226DB, Hogsback, DE VILLIERS 12 (GRA).

Madonna and Child Falls, at the foot of the falls, on a rocky slope, 3226DB, Hogsback District, SONNENBERG 342 (GRA).

Robertson Falls, on the rocky river banks of the river that feeds the falls, 3226DB, Hogsback District, SONNENBERG 335 (GRA, UN).

Swallow Tail Falls, rock cracks, 4000ft above sea level, 3226DB, Hogsback, LUBKE 153 (GRA).

Cata Peak Ridge, in rock crevices, 5000-6000ft above sea level, 3227CA, King William's Town District, DYER 342 (GRA).

At the top of the Katberg, in damp soil, amongst the grass, 3227DA, Stutterheim District, DYER 1739, 1771 (GRA).

**S. ficinioides** Kunth. 1500

Below Gaika's Kop, in a marsh, 1445m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 79 (PRE).

Northern Slopes of Gaika's Kop, in a marsh, 5300ft above sea level, 3226DB, Amatole Mountains, LUBKE 362 (GRA).

At the edge of the waterfall, at Gaika's Kop, in a marsh, 1450m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 335 (PRE).

Gaika's Kop, 100m from the old forestry tower, near a large Pine tree, 3226DB, Hogsback District, SONNENBERG 324 (GRA, UN).

Gaika's Kop, 400m from the summit, marsh, 3226DB, Hogsback District, SONNENBERG 322 (GRA, UN).

Third Hog, in a marshy area, on the Gaika's Kop side, 3226DB, Hogsback District, SONNENBERG 312 (GRA, UN).

At the top of the Katberg, 3227BC, Stutterheim District, HUTCHINSON 1656 (PRE).

**S. globiceps** C.B.Clarke 1800

Rabbitswood near Grahamstown, in the rock cracks at the side of a stream, 2000ft above sea level, 3326DB, Bathurst District, LUBKE 83 (GRA).

Hamilton Dam, 3326BC, Grahamstown District, SWIFT sn. (GRA No. 6226).

**S. inanis** (Thunb.) Steud. 2300

In the river at the main camp of the Mountain Zebra Park, 3225AB, Cradock District, LIEBENBERG 7642 (PRE).

Mountain Zebra Park, 3225AB, Cradock District, MULLER 619 (PRE).

Upper Swart Kei, in the bed of the river, 1525m above sea level, 3226BC, Mount Hope, GALPIN 5604 (PRE).
**S. nodosus Rotth. 4500**

Blaauwkrantz Drift, on a river bank, 3326BC, Albany District, BRITTEN 1407 (GRA).

Kwaihoek (Dais Cross), in a dune slack, between main dunes at the headland, in a shallow pan in the dunes, 3m above sea level, 3326DA, Alexandria District, BURROWS 3204 (GRA).

The spring between Port Alfred and Kasouga, near Ship Rock, with *Juncus* spp., at the margin of the spring, 3326DB, Bathurst District, GIBBS-RUSSEL 4089 (GRA, PRE).

Near the freshwater Spring, at the base of a cliff, 3326CD, Cape Padrone, JACOT-GUILLARMOD 42 (GRA).

Cove Rock Beach, in the pioneer dunes, 3327BB, East London District, COMINS 1603 (GRA, PRE).

2000ft above sea level, 3326BC, Grahamstown, MACOWAN 1355 (GRA).

New Years River, below the Kaolin Mine, on the Southern side of the river pool, 600m above sea level, 3326AD, Grahamstown District, COETZEE 15 (GRA).

Strowan Farm, New Years River, on the flood plain, 600m above sea level, 3326AD, Grahamstown District, BETHUNE 8 (GRA).

Kabeljouws River, 3324DD, Humansdorp District, PHILLIPS 3326 (PRE).

Robhoek, on the seashore of the Great River Mouth, 3424AA, Humansdorp District, FOURCADE 1948 (PRE).

Kabeljouws River Bridge, before the Bay, on the road from the Gamtoos River, on a river bank, 3324BB, Jeffrey's Bay, ARNOLD 659 (PRE).

Qora River Mouth near Willowvale, on the beach, 3228CB, Kentani District, HILNER 512 (GRA).

Marshy spots near Kei Mouth, 60m above sea level, 3228CB, Komga District, FLANAGAN 999 (GRA, PRE).

3326DB, Port Alfred, TYSON 108 (GRA), 17069 (TM).

Rufanes River Mouth, in a dune slack, 2 kilometre's North of the mouth, 2m above sea level, 3326DB, Port Alfred District, SONNENBERG 269 (GRA, UN).

West bank, on the sand dune stretch, behind the dunes, 3326DC, Port Alfred District, BRITTEN 2127 (GRA, PRE).

3326DB, Port Alfred West, TYSON 646 (PRE).

Cape Recief, in the pioneer dunes near entrance, 3425BA, Port Elizabeth, OLIVIER 3038 (GRA).

Humewood, 3325DC, Port Elizabeth, BRITTEN 1997 (GRA); DAHLSTRAND 347 (PRE); PATERSON 4181 (PRE).

Outside the Marine Hotel, 3325DC, Port Elizabeth, DAHLSTRAND 347 (GRA).

Modderspruit, Swartkops River, 3325DC, Port Elizabeth District, OLIVIER 1763 (PRE).

Sardinia Bay near Skoenmakerskop, in the dune community, 3425BA, Port Elizabeth, OLIVIER 1815 (GRA).

Van Stadens River Mouth, in the estuary sand, 3325DC, Port Elizabeth District, BAKER 2086 (GRA, PRE).

At the mouths of the Coega and Swartkops Rivers, 30m above sea level, 3325CC, Uitenhage District, ZEYHER 4394 (PRE).

Swartkops River, 3325CD, Uitenhage District, ECKLON & ZEYHER 503 (PRE); THERON 577 (PRE); ZEYHER 49 (PRE).
**S. thunbergianus** (Nees) Levyns 6200

Bushman's River Mouth, in the marsh, 30 m above sea level, 3326DA, Alexandria District, KILLICK 1760 (PRE); TUCKER 1 (GRA).

Howieson's Poort, on the river bank of the Palmiet River, in Riverine thicket, 250 m from the Grahamstown to Port Elizabeth road, 600 m above sea level, 3326AD, Grahamstown District, SONNENBERG 233 (GRA).

Slang River, in the dune field, 3424BB, Humansdorp, PHILLIPS 3432 (PRE).

3228CB, Kei River Mouth, FLANAGAN 1779 (PRE).

Near Port Alfred, 3326DB, Port Alfred District, MARTIN *sn.* (GRA No. 10110).

15 m above sea level, 3326DB, Port Alfred West, GALPIN 2950 (PRE).

Cape Recief, in the damp area beyond the fresh water pond, 3425BA, Port Elizabeth, OLIVIER 3015 (PRE).

Sundays River, near the Sundays River Mouth, in dune pockets with *Juncus* sp., 3325AA, Port Elizabeth District, RIVERS-MOORE *sn.* (GRA No. 31505).

Swartkops River, on a river bank, 3325CD, Uitenhage District, ZEYHER 464 (PRE).

**S. venustulus** Boeck. 6600

Kasouga, in wet places, on the East bank of the lagoon, 3326DA, Bathurst District, MARTIN *sn.* (GRA No. 8770).

In a salt Vlei, in the mud at the edge, 3326DB, Port Alfred, BRITTEN 694 (GRA).

**SCLERIA** Berg. 0515000

**S. melanomphala** Kunth. 2200

In damp places, 1000 ft above sea level, 3228CB, Kentani District, PEGLER 322 (GRA).

In marshy places near Kei Mouth, 60 m above sea level, 3228CB, Komga District, FLANAGAN 988 (GRA, PRE).

Double Mouth, overlooking the mouth, grassland, 3228CB, Morgan's Bay, SONNENBERG 425 (GRA, UN).

**S. natalensis** C.B.Clarke 2300

1 kilometre from the Kromdraai turnoff on the N2 to Storms River, at the edge of the forest, on the banks of a small river, 3424AA, Humansdorp District, SONNENBERG 473 (GRA, UN).

**S. woodii** C.B.Clarke 3800

Coane Valley, 1200 ft above sea level, 3228CB, Kentani District, PEGLER 1498 (GRA), 2923 (GRA, PRE).

In grassy valleys near Komga, 610 m above sea level, 3227CB, Komga District, FLANAGAN 954 (GRA, PRE).

Dohne Hill, 915 m above sea level, 3227CB, Stutterheim District, SIM 197 (PRE).

Fort Cunynghame, 3227CB, Stutterheim District, SIM 2705 (GRA).
TETRARIA Beav. 0494000

**T. bromoides** (Lam.) Pfeiffer 600

Assagai Bosch, 3424BB, Humansdorp District, ROGERS 2002, 2003 (GRA), 2803 (GRA, BOLUS).

Witte Els Bosch, on the flats, 700ft above sea level, 3424AA, Humansdorp District, FOURCADE 2814 (GRA).

Cockscomb, 1220m above sea level, 3324DB, Uitenhage District, ESTERHUYSSEN 27542 (PRE).

Waainek Farm, Groendal Wilderness Reserve, Great Winterhoek Mountains, Krompoort River Catchment, 910m above sea level, 3325CA, Uitenhage District, SCHARF 2049 (PRE).

**T. capillacea** (Thunb.) C.B.Clarke 800

Faraway, Portion 3 of Coldsprings, on a Southern-facing Witteberg quartzite slope, in moist heathland, 700m above sea level, 3326AD, Grahamstown District, JACOT-GUILLARMOD 8497, 9585 (GRA).

Grahamstown Nature Reserve, 3326BC, Grahamstown, MARTIN 2909 (GRA).


Otterford, in mature Proteoid fynbos, TMS, also much *Protea exima, Leucadendron eucalyptifolium, Hyodiscus* spp., 500m above sea level, 3325CC, Hankey District, COWLING 1021 (GRA).

Otterford Forestry Reserve, in fynbos on TMS, mature fynbos dominants are *Leucadendron loerinse*, 550m above sea level, 3324DB, Hankey District, COWLING 242 (GRA).

Heathcliff, in grassy fynbos, on Enon conglomerate, 160m above sea level, 3324DD, Humansdorp District, COWLING 642 (GRA).

69 Kilometre's North-east of Rockland, on the way to Patensie, on the road in the Elandsberg Pass, in fynbos, 800m above sea level, 3324DB, Patensie District, DAVIDSE 33603 (PRE).

**T. compar** (L.) Lestib. 1100

11.2 Miles West-South-West of East London, in sour coastal thornveld, 60m above sea level, 3327BB, East London District, ACOCKS 21843 (GRA, PRE).

The Kloof entering Howieson's Poort from the south-east, 4 miles from Grahamstown, on a stream bank, 3326AD, Grahamstown District, MARTIN 3103 (GRA).

Howieson's Poort, 3326AD, Grahamstown District, MARTIN 2906 (GRA).

**T. compressa** Turrill 1200

Otterford Research Station, in mature fynbos, on TMS, 400m above sea level, 3325CC, Hankey District, COWLING 1142 (GRA, PRE).

Frames Drift, 3325DC, Port Elizabeth, PATERSOON 1963 (GRA).

Cockscomb, 1675m above sea level, 3324DB, Uitenhage District, ESTERHUYSSEN 27142 (GRA).
**T. cuspidata** (Rotth.) C.B.Clarke 1600

31.4 Kilometre's from Bathurst, on the road to Grahamstown, in grassland, on stony ground, 3326BC, Albany District, ARNOLD 614 (PRE); VORSTER 2294 (PRE).

15 Miles from Grahamstown, on the road to King William’s Town, in a swampy area above a dam, 3326BA, Albany District, MARTIN *sn.* (GRA No. 8231A).

Rockcliff near Sidbury, 3326AC, Albany District, DALY 823 (GRA).

Bushman’s River Mouth, on the Southern and south-western slopes, in fynbos, on shallow Witteberg soils, 3326DA, Alexandria District, MARTIN *sn.* (GRA No. 8228).

Below Gaika’s Kop, on a hillside adjacent to the waterfall, 1450m above sea level, 3226DB, Amatole Mountains, PHILLIPSON & FURNESS 118 (PRE).

On the summit of Gaika’s Kop, 6000ft above sea level, 3226DB, Amatole Mountains, LUBKE 361 (GRA); RATTRAY 69 (GRA).

Forestdale-Martindale road, 2 miles north-west of Martindale, on the Southern and south-western slopes, in a stream bed community, 3326BD, Bathurst District, MARTIN *sn.* (GRA No. 8229, 8230, 8231B).

Roundhill, in open grassland, 3326BD, Bathurst District, VENGADAJEULLUM 67 (GRA).

Roundhill (Oribi Reserve), in *Bobartia* grassland on a hill, 375m above sea level, 3326BD, Bathurst District, WIRMINGHAUS 363 (GRA).

2 Miles East of the Trappes Valley Station, in grassland, 245m above sea level, 3326BD, Bathurst District, ACOCKS 12783 (PRE).

The woodlands near Southwell, 245m above sea level, 3326DA, Bathurst District, ACOCKS 23910 (PRE).

Amalinda near East London, in the grassy valleys, 500ft above sea level, 3227BB, East London District, FLANAGAN 1786 (GRA, PRE).

3326BC, Grahamstown, DALY & SOLE 222 (GRA).

Blymounthus, Palmiet River, 200ft above sea level, 3326AD, Grahamstown District, SCHLECHTER 7325 (GRA).

Coldspring, 3326AD, Grahamstown District, DALY & SOLE 253 (GRA).

Faraway, Portion 3 of Coldsprings, in the heathlands on a Witteberg quartzite ridge, on stony ground, 700m above sea level, 3326AD, Grahamstown District, JACOT-GUIVARMOD 8996 (GRA, PRE).

Collingham Tower, on the north-western slopes of the hill, on the rocky hillside, in grassland, 3326BC, Grahamstown District, MARTIN *sn.* (GRA No. 3101).

Featherstone Kloof, on the wet ground of the grassveld, alongside a river, in moist shady places, 1400ft above sea level, 3326BC, Grahamstown, LUBKE 162, 163 (GRA).

Featherstone Kloof, on a south-western facing slope, 3326BC, Grahamstown, MARTIN *sn.* (GRA No. 3098).

At the end of the ridge, between Featherstone Kloof and Osmunda Kloof, in the Pines and the *Oldenbergia* sp., near Howieson's Poort, 3326AD, Grahamstown District, MARTIN *sn.* (GRA No. 3107).

Grahamstown Nature Reserve, in open *Themeda* sp. grassland, 3326BC, Grahamstown, MARTIN *sn.* (GRA No. 9638).

Osmunda Kloof, 3326BC, Grahamstown, MARTIN *sn.* (GRA No. 3128).

Thomas Baines Nature Reserve, 3326BC, Grahamstown District, ANON *sn.* (GRA No. 19659).
15 Miles from Grahamstown, on the Trumpeters Drift road, on marshy ground, 3326BC, Grahamstown District, DYER 523 (GRA).

Cochin Farm, on a hill overlooking the sea, opposite the main farm house, stony soil, 3228CB, Hagga Hagga District, SONNENBERG 454 (GRA, UN).

Gaika's Kop, 100m uphill from the old forestry tower, on the banks of a small stream, wet soil, 3226DB, Hogsback District, SONNENBERG 325 (GRA, UN).

Siberia marsh, grassland, 3226DB, Hogsback District, SONNENBERG 346 (GRA, UN).

Between the middle of the Hogsback Peaks, 1646m above sea level, 3226DB, Hogsback, PHILLIPSON & FURNESS 562 (PRE).

500ft above sea level, 3424bb, Humansdorp, ROGERS 2931 (GRA).


To the East of Boplaas, in fynbos, in a donga, 550m above sea level, 3324CD, Humansdorp District, ACOCKS 21283 (PRE).

Cape St. Francis, in dune fynbos, 10m above sea level, 3424BB, Humansdorp District, COWLING 22 (GRA).

Hoffmans Bosch, in a small Kloof forest near W.Blacks Farm, 3424BB, Humansdorp District, BRITTEN 1178 (GRA).

Krom River, on the road to Op Water, in Ericoid fynbos, in deep sand (TMS), 60m above sea level, 3424BB, Humansdorp District, COWLING 1293 (GRA).

Uitvlugt, 1200ft above sea level, 3424BB, Humansdorp District, FOURCADE 2627 (GRA).

Witte Els Bosch, on the flats, 750ft above sea level, 3424AA, Humansdorp District, FOURCADE 1374, 1731 (GRA).

Cata Peak Ridge, amongst the grass, 5000-6000ft above sea level, 3227CA, King William’s Town District, DYER 345 (GRA).

Mount Coke, 3327CD, King William’s Town District, SIM 1331 (GRA).

Pirie, 3227CB, King William’s Town District, SIM 2840 (GRA, PRE).

In the pastures near Kei Mouth, 60m above sea level, 3228CB, Komga District, FLANAGAN 926 (GRA, PRE).

Mountains near Loerie, near a cable way, stony soil, 3324CD, Loerie District, SONNENBERG 499 (GRA, UN).

3325DC, Port Elizabeth, KEMSLEY 248 (GRA).

Earn cliff, on a river bank, 45m above sea level, 3325DC, Port Elizabeth, GALPIN 6388 (GRA, PRE).

Gamtoos River Mouth, 3325CC, Port Elizabeth District, LUBKE 2668 (GRA).

Humewood, in the dunes, 10m above sea level, 3325DC, Port Elizabeth, DAHLSTRAND 149 (PRE); PATERSON 1109 (GRA).

Walmer, 3325DC, Port Elizabeth, PATERSON 2266 (PRE), 2367 (GRA).

Woodifields Kranz, Suurberg, 3325DC, Port Elizabeth District, FRIES & NORLIND 599 (PRE).

University of Port Elizabeth Campus, in the drift sands, 3325DC, Port Elizabeth, UPE BOTANY STAFF 154 (GRA).

Suurberg Mountains, in Themeda sp.\Heteropogon sp. veld, 3325BC, Port Elizabeth District, LUBKE 23 (GRA).
Suurberg State Forest, at the Foresters Cottage, adjacent the Driefontein Farm, 750m above sea level, 33° 18' S, 25° 33' E, 3325BC, Port Elizabeth District, LUBKE 2066 (GRA).

Devils Bellows Nek, in grassland, 1675m above sea level, 3226BC, Queenstown District, ACOCKS 12130 (PRE).

Boschberg, 4500ft above sea level, 3225DA, Somerset-East District, MACOWAN 1954 (GRA).

Dohne Pasture Research Station, in grassland, 915m above sea level, 3227CB, Stutterheim District, ACOCKS 8960 (PRE).

Deysels Plaat Farm, Groendal Wilderness Reserve, Great Winterhoek Mountain Range, Kariega Catchment Basin, on stony ground, 914m above sea level, 3325CA, Uitenhage District, SCHARF 1910 (PRE).

Groendal Wilderness Reserve, Grootberg 238, Great Winterhoek Mountain Range, Katein River Catchment, on the upper mountain slope, in Leucadendron spissifolium veld, on stony ground, 865m above sea level, 3325CA, Uitenhage District, SCHARF 2072 (GRA, PRE).

Strydomsberg Farm, Groendal Wilderness Reserve, Krompoort River Catchment, on stony ground, 1062m above sea level, 3325CA, Uitenhage District, SCHARF 1886 (PRE).

Strydomsberg Farm, Groendal Wilderness Reserve, Great Winterhoek Mountain Range, Krompoort River Catchment, on stony ground, 3325CA, Uitenhage District, SCHARF 1817 (PRE).

Strydomsberg 281 Farm, Groendal Wilderness Reserve, Krompoort River Catchment, near the peak, on stony ground, 918m above sea level, 3325CA, Uitenhage District, SCHARF 1881 (PRE).

_T. fimbriolata_ (Nees) C.B.Clarke 2200

3325DC, Port Elizabeth, ROGERS 20586 (GRA).

Walmer, 3325DC, Port Elizabeth, PATerson 2538 (GRA).

Groot Plaat Farm, Groendal Wilderness Reserve, Great Winterhoek Mountain Range, Krompoort River Catchment, 3325CA, Uitenhage District, SCHARF 1824 (PRE).

Waaiken Farm, Palmiet River Catchment, on stony ground, 1050m above sea level, 3325CA, Uitenhage District, SCHARF 1824 (PRE).

_T. fourcadei_ Turrill & Schönland 2400

Cockscomb, Great Winterhoek Mountain Range, 1220m above sea level, 3324DB, Uitenhage District, ESTERHUYSEn 27494 (PRE).

Zunga, Groendal Wilderness Reserve, Great Winterhoek Mountain Range, Great Winterhoek Catchment Basin, on stony ground, 979m above sea level, 3325CA, Uitenhage District, SCHARF 2042 (PRE).

_T. involucrata_ (Rottb.) C.B.Clarke 2800

Witte Els Bosch, on the flats, 3424AA, Humansdorp District, FOURCADE 2644, 2793 (GRA).

Otterford Forestry Reserve, in mature fynbos, on TMS, 550m above sea level, 3324DB, Hankey District, COWLING 238 (GRA).

Loerie, Otterford Forestry Reserve, 800m above sea level, 3324DB, Hankey District, DAHLSTRAND 795 (GRA, PRE).

30 Miles North of Otterford Forestry Reserve, opposite the wood, on stony ground, 3325CC, Hankey District, RODIN 1124 (PRE).
**T. macowaniana** B.L.Burtt 3150

North-west of the Southern Hogsback Peak, in grassland, 1585m above sea level, 3226DB, Amatole Mountains, PHILLIPSON 577 (PRE).

West of Cata, opposite the shrub, 1463m above sea level, 3227CA, Amatole Mountains, PHILLIPSON & FURNESS 234 (PRE).

Pirie, 3227CB, King William’s Town District, SIM 2842 (GRA, PRE).

Toise River, on grassy slopes, 915m above sea level, 3227AD, Stutterheim District, FLANAGAN 2303 (GRA, PRE)- ISOPARATYPE.

**T. microstachys** (Vahl.) Pfeiffer 3300

Kareedouw Pass, 1000ft above sea level, 3424BA, Humansdorp District, FOURCADE 1147 (GRA).

Palmiet Vlei, in damp hollows, 650ft above sea level, 3424BB, Humansdorp District, FOURCADE 2808 (GRA).

Witte Els Bosch, at the margin of the forest, 3424BB, Humansdorp District, FOURCADE 1420 (GRA).

**T. secans** C.B.Clarke 4500

Howieson's Poort, Palmiet River, 33° 22' S, 26° 29' E, 3326AD, Grahamstown District, JACOT-GUILLARMOD 6837 (PRE).

Paradise Kloof, on the Southern facing hillside, 3326BC, Grahamstown District, MARTIN sn. (GRA No. 2909).

Witte Els Bosch, 750ft above sea level, 3424BB, Humansdorp District, FOURCADE 138, 1138 (GRA).

**T. sylvatica** (Nees) C.B.Clarke 4700

3325DC, Port Elizabeth, FRIES & NORLIND 160 (PRE).

Waaiken Farm, Kanteins River, in grassland, on stony ground, 795m above sea level, 3325CB, Uitenhage District, SCHARF 1324 (PRE).

**T. triangularis** (Boeck.) C.B.Clarke 5100

On the slopes of the 1st Hogsback, 3226DB, Hogsback, STALLARD 19 (GRA).

On the north-eastern slopes of the 1st Hogsback, in the fynbos grassveld transient zone, 3226DB, Hogsback, LUBKE 346 (GRA).

Between the 1st Hogsback and Tore Doone, on the Upper Plateau, in grassland, 3226DB, Hogsback, MARTIN sn. (GRA No. 8089).

Kettle Spout Falls, on a rocky slope, on dry ground, 3226DB, Hogsback, LUBKE 150 (GRA).

Cockscomb, 1525m above sea level, 3324DB, Uitenhage District, ESTERHUYSEN 27085 (PRE).

**T. ustulata** (L.) C.B.Clarke 5200

Hoffmans Bosch, 3424BB, Humansdorp District, BRITTEN 1131 (GRA).
Hoffmans Bosch, in the veld below the kopje, 3424BB, Humansdorp District, BRITTEN 1155 (GRA).