

THE TAXONOMIC SIGNIFICANCE OF  
THE ANATOMY OF THE  
RESTIONACEAE

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1.1 ABSTRACT.

The monocotyledonous family RESTIONACEAE contains 28 genera. The species are xeromorphic and occur almost exclusively in the southern hemisphere, being concentrated mainly in South Africa and Australia.

A study of the historical review shows that conventional taxonomic methods utilising characters of gross morphology, flower and fruit structure are of limited application in the classification of the family, since nearly all species are dioecious, and all have reduced floral parts and reduced or no leaf blades.

The vegetative anatomy, particularly of culm material, is described and illustrated for several species of each of the genera. A short account is given of nodal structure and stomatal development.

Culm anatomical characters in particular are shown to be of taxonomic significance, and certain taxonomic changes are suggested on the basis of these characters.

The relationships between the Restionaceae and other members of the Farinosae are discussed briefly.

The anatomy of the plants is discussed with relation to the environment in which they grow.

It is concluded that the anatomical characters of the Restionaceae must be taken into account when the family is revised taxonomically.

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2. INTRODUCTION

2.1.1. GENERAL INTRODUCTION.

The RESTIONACEAE is a family of perennial, herbaceous, monocotyledonous plants bearing a close morphological resemblance to members of the Juncaceae and Cyperaceae.

HABIT

The culms arise from a tufted or creeping rhizome and are simple or branched, erect or flexuose, terete, quadrangular or flattened, solid or fistular. Deciduous or persistent leaf sheaths are present at each node, each sheath being split to the base. The sheath is rarely produced at the apex into a reduced, linear, foliaceous blade, which is frequently deciduous. A ligule is present in very few species, Lepyrodia scariosa R.Br. being an example. Radical leaves with equitant bases and terete or flattened blades are found in Anarthria and Ecdeiocolea, two genera which have been moved from the Restionaceae only recently; now there are no species with radical leaves (Cutler and Shaw, in press). The culm is photo-synthetic in all species. The rhizome is covered with brown, scarious scales; hairs also occur in some species. In Sporodanthus traversii F. Muell. it reaches nearly 2 cm. in diameter, and is thick and tough in many other species.

Species vary in height from about 10 cm. to 2 m., Elegia verticillaris Kth. from South Africa is an example of the taller species.

The flowers are small, dioecicus or rarely monoecious. They are borne in spikelets, in lax inflorescences, or in individual spikelets. A spathella may be present; if so it

ensheaths the base of the inflorescence. The perianth consists of 3-6 scarious or hyaline segments which may be similar or dissimilar, in 2 series, or, rarely, absent.

Male flowers have 3 stamens, which are opposite to the inner perianth segments. The filaments are slender free, or, rarely, connate; the anthers are unilocular, rarely bilocular, and are dorsifixed. They are frequently apiculate, introrse, and open by longitudinal slits. There may or may not be a rudimentary ovary present.

The female flower has a 1-3 locular capsule that may be dehiscent or indehiscent. There may be 1-3 styles which are free or variously connate. Styles are slender and occasionally plumose. A solitary ovary occurs in each loculus; it is orthotropous and pendulous from the apex. The fruit is nut-like and dry, or capsule and is compressed or 3-sided. The seeds are pendulous, and have copious endosperm.

#### DISTRIBUTION

The distribution is almost entirely in the southern hemisphere, the main concentrations being in South and South Western Australia and coastal to sub-coastal regions of Cape Province, South Africa. Species are also found in Tasmania, New Zealand and the Chatham Islands, Madagascar, the Malay Peninsula, and Chile and Patagonia in South America. One species is found North of the equator, in Indo China and one species occurs in Malawi (*see map, p. 8*).

In South Africa the family is represented by 12 genera, all found between the latitudes 31 S and 35 S, in Cape

Province. The highest density is found in the South West corner of the province, the area defined by Tulbagh in the North, Riversdale in the South East and the coast. This is the wettest region, receiving up to 60 ins. of rain per annum in places in a normal winter. The complete range of the family is defined by two arms radiating from this region, one to the NNW, ending at the coast in Little Namaqualand and the other to the ENE, following the lowland strip up the coast as far as Pondoland. The density becomes very low, only about 1-5 species in a Division, towards the end of these arms. The normal rainfall in these regions is from 10-20 ins. per annum. Species have been recorded at up to and over 6,000 ft. In the Basutoland Highlands they may attain greater altitudes.

The Australian representatives of the family occur both in the East and the West. Species are also recorded in Queensland. The distribution of species is discontinuous - very few growing in both East and West; Leptocarpus tenax R.Br. being a striking exception.

Gardner, (1946), gave an account of the vegetation and climate of Western Australia in which he described the habitats in which the Restionaceae grow. For the majority of species, the sandy, seasonably wet regions provide suitable conditions.

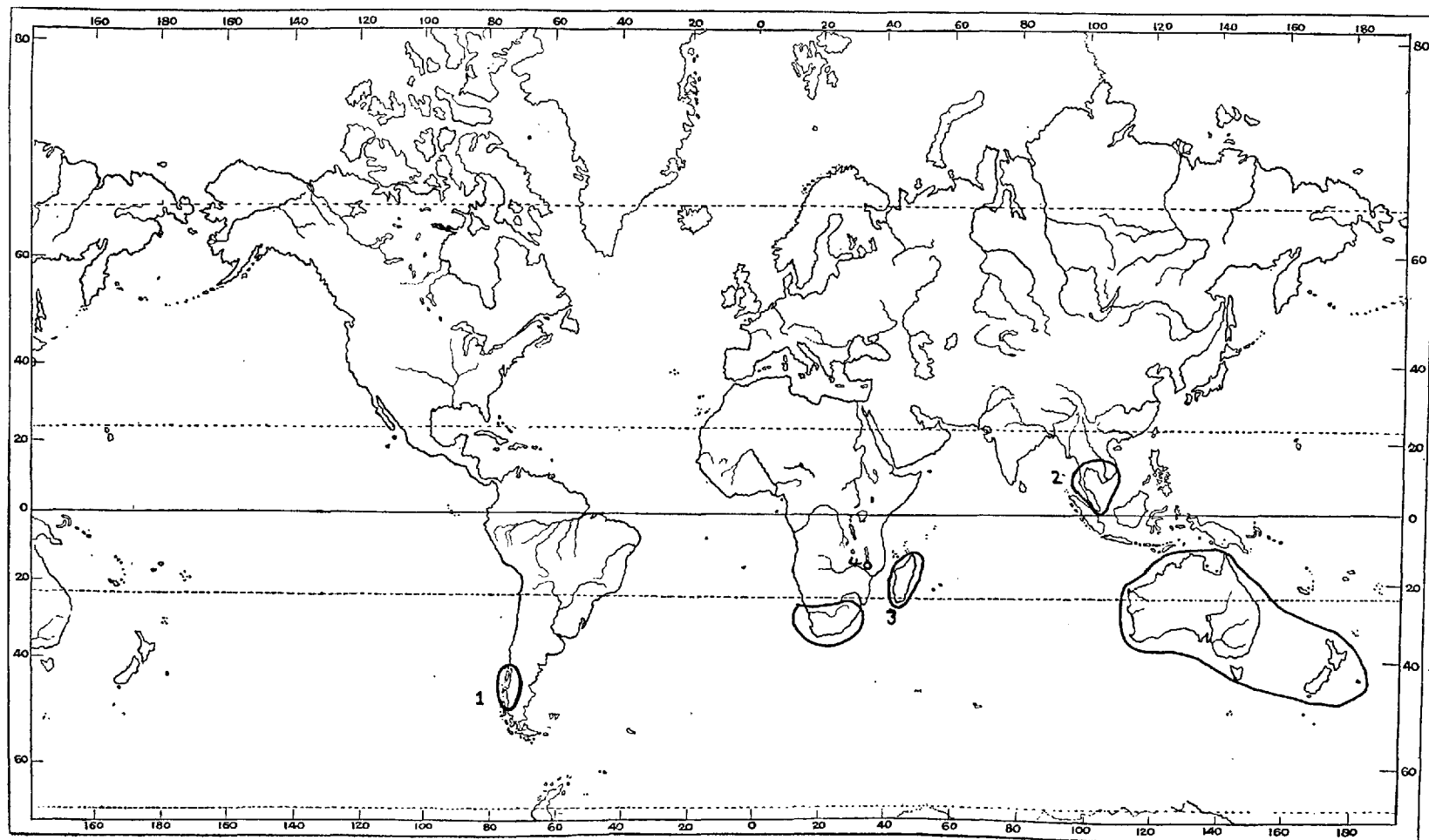
Diels, (1904), stated that some of the Australian species grow in drier regions than the most drought resistant species of South Africa.

In general the habitats favoured by the Restionaceae are fairly moist, with winter rains; they are subjected to a period of drying normally corresponding to the dormant phase of the plants life cycle.

No species has been found to occur both in South Africa and Australia, although several genera ~~are~~ represented in both countries.



Distribution map The range of the family is indicated by the enclosed areas. Most species occur in South Africa and Australasia. 1-*Leptocarpus chilensis*. 2-*L. disjunctus*. 3-*Restio madagascarensis*. 4-*R. maheni*.



## 2.1.2. HISTORICAL SECTION: INTRODUCTION

The family name RESTIACEAE was originated in 1810 by Robert Brown. Several genera, now recognised as belonging to the family, had, however, been described prior to that date. Linnaeus included those named by him in the GRAMINEAE; these were later referred to the JUNCACEAE by Jussieu. These genera, and several new ones named by Brown constituted his RESTIACEAE.

The historical account which follows highlights works in which new genera were described and articles in which major taxonomic revisions of the family were made.

The family is taxonomically difficult; good exomorphic characters for use in classification are few. Many different interpretations of the relative merits of characters have been made over the years. Plants have many synonyms, these often being from several genera.

There was confusion in the nomenclature from the outset; collections from South Africa were described simultaneously by Linnaeus and Bergius. It was only comparatively recently that it was realised that the first named Restio should really be called Thamnochortus. The historical survey leads up to the works which have been used as authoritative by recent workers, and gives a picture of the morass into which the present day student has to stride in his attempts to identify a restionaceous plant.

### HISTORICAL SECTION: 1766-1964.

In November, 1767, the 'Addenda' to the Mantissa by Linnaeus were published; it is dated 1766. Elegia was described in the Mantissa and the Addenda contained notes on the species

Restio dichotomus, which was included in the section Dioecia, Triandra, the Gramineae. For many years this was taken to be the first description of a Restio species, and it was used as the type for the genus Restio. However, in 1767, in September, some plants were described by Bergius. They had been sent to him by Capt. Grubb, from South Africa. Among these was a plant which he called Thamnochortus fructicosa (Gen. et Sp. nov). Very much later this was found to be identical with Restio dichotomus L. Since there is good documentary evidence that the Bergius specimen was the first named, the Linnean name had to be discarded (Sprague, 1929). Bullock, (1959), proposed a new type for the genus Restio. He chose R. triticius Rottb., one of 3 species named by Rottboel in 1772. Rottboel also named the genus Chondropetalum.

Jussieu, (1789), in his Genera Plantarum, moved Restio from the Gramineae and put it in the order Juncei. Thamnochortus Berg. and Chondropetalum Rottb. were included in his concept of the genus Restio. He also placed Eriocaulon L., Xyris L. Aphyllanthes L., and Juncus L. in the same order.

Willdenowia was described by Thunberg in 1790.

Labillardiere, using the sexual system of classification in his work 'Novae Hollandiae Plantarum Specimen' (1804-1807) retained the class Dioecia, division Triandra of Limnads. He described and illustrated 3 species: Restio tetraphyllus, Calorophus elongatus and under the heading Monadelphia,

Schoenodum tenax, stating "this genus is associated with Juncus without doubt".

The first work of major importance was done by Robert Brown, who in 1810 (Prodromus Florae Novae Hollandiae), described 7 new genera: Lyginia, Anarthria, Lepyrodia, Leptocarpus, Loxocarya, Chaetanthus and Hypolaena. These, together with Jussieu's Juncei and his Aphelia, Desvauxia, Alepyrum, Eriocaulon, L. and Xyris, L. made up the new family Restiaceae. He pointed out that Xyris has many seeds in each loculus whereas the other genera only have one, and in this respect there could be some doubt as to its correct taxonomic status. He noted that the seed has no albumen and is a different shape from those of the Commelinaceae. He observed that the Restiaceae were similar to the Cyperaceae, the main difference being in the leaf sheath, which is split to the base in the Restiaceae, and connate in the Cyperaceae.

Brown described each genus in turn, and made many observations on synonymy and interrelationships. He removed R. scariosus Thb. and R. spicigerus Thb. from Restio, and placed them in Thamnochortus. He included R. imbricatus Thb. and R. distachyus Rottb. in Leptocarpus. He thought Calorophus Labill. contained genuine species of Restio. Lepyrodia was stated to have affinities with Elegia. Schoenodum tenax Labill. (♂) was included in Lyginia. Although he realised that Loxocarya is similar to Restio he retained it as a separate genus because of the form of its style. He included the ♀ specimen of Schoenodum tenax Labill. under the name Leptocarpus

tenax. The similarities between Chaetanthus and Leptocarpus, when weighed against the differences in styles and perianth segments, were not sufficient to cause him to put them together,

Brown commented on the difficulty he encountered when trying to identify plants of different sex but of the same species. This has been emphasised by later authors.

In 1828, the manuscripts of the late Palisot de Beauvois were published by Desvaux. Among these were observations on the + 'Restionées' and 'Elegiées', which were described as separate groups or families. The Restionées were subdivided into 2 groups: (i) with 1 style; Thamnochortus and with some reservations, Loxocarya and Chaetanthus, and with bi- or tripartite stigmas, Restio, Willdenowia, Schoenodum, Lyginia and Leptocarpus. (iia) with 2 styles; Caunomois Beauv., Caleopsis Beauv., and Hypoleana. (iib) with 3 styles; Elegia, Chondropetalum, Lepirodia and with reservations, Anarthria. (The descriptions following the synopsis of the group gave the spellings Cannomois and Calopsis for the new genera; these spellings were later adopted.) A second list was published in the same work which did not divide the group into Restionées and Elegiées, but put all the genera into the one group, Restionées. This was probably the intention of the original author, the second list being a revision of the first.

C. G. Nees von Esenbeck, (1830), in an account of the family considered that the genera Restio, Thamnochortus and

+ Family names ending in -ées are not recognised by the Code of Botanical Nomenclature.

Elegia should constitute one taxon. He found species which bridged the gaps between these genera. The 1-styled condition which separated Thamnochortus from Leptocarpus was found to be derived, by abortion, in some species. He therefore set up a new combination of species in the genus Restio, and divided it into 3 groups: (i) Restio proprii, species 1-17, with synonyms in Willdenowia, Restio, Thamnochortus and Elegia. (ii) Thamnochorti, species 18-23, with synonyms in Restio, Leptocarpus, Chondropetalum, Schoenus and Juncus e capitae bonae spei paniculis juxis juliformibus Breyn Centur. (iii) Elegiae, species 24-35, with synonyms in Chondropetalum, Restio, and Elegia. In the same work Nees retained the genera Hypolaena R.Br. and Willdenowia Thb., and proposed the new genera Nematanthus and Lepidanthus. Lepidanthus willdenowia Nees was said to be synonymous with Willdenowia striata Spr.

Besides giving taxonomic information, Nees also commented on certain points of morphological interest. He interpreted the disc which subtends the floral parts in Willdenowia as being the 'disappearing end member of the axis'. He described the leaves in detail, noting that they were better developed on sterile culms than on flowering ones. Also, since there are no expanded leaves, the stems take over their normal function. He pointed out that diagnostic characters based on the presence or absence of leaf blades, or the possession of sterile culms had been misleading, and had caused confusion in the past, and warned against their use.

Nees published again in 1832, in Lindley's Nat. Syst.,

Ed.2. He maintained his earlier position as regards the genus Restio, and erected the further genera Leucoploeus, Mesanthus, Cucullifera, Anthochortus, Ceratocaryum and Hypodiscus.

Not all of the genera recognised by Nees were accepted by Endlicher, who, in his Genera Plantarum (1836), subordinated Nematanthus, Hypodiscus, Leucoploeus and Mesanthus as divisions of Willdenowia. He split Restio up once more, reconstituting Thamnochortus Berg. and Elegia +Thunb. (including Chondropetalum Rottb.) as genera in their own right. Restio L. itself included Calorophus Labill., Cannomois Palis<sup>⊕</sup> and Calopsis Palis. Some of the species of Restio from Forster's herbarium, and Schoenodum tenax Labill. were put into Leptocarpus R.Br.; both Thamnochortus Berg. and Elegia +Thunb. also included some Restio species. Cucullifera Nees was included in Hypolaena R.Br.

He retained unaltered Anthochortus Nees, Ceratocaryum Nees, Lepidanthus Nees, Loxocarya R.Br., Chaetanthus R.Br., Anarthria R.Br., Lyginia R.Br. and Lepyrodia R.Br.

(Masters, [1869], cautioned those using Endlicher's classification since the grouping and splitting had been done without examining the material.)

The next major work was carried out by Kunth, (1841), who mistakenly attributed the family name to Endlicher and Restiacearum Genera to Brown. He made free use of the descriptions by Nees and Brown.

+ Note incorrect citation of authority. ⊕ = Palis de Beauvois.

He split Restio into 'Cape' and 'Novae Hollandiae' species. Among the Cape species of Restio he noted the following synonyms involving other genera: R. sulcatus Kth. = W. striata Spr. and Lepidanthus Nees; R. perplexus Kth. = ?Thamnochortus, R. dichotomus Kth. conf. T. dichotomus. He suggested that the species having 3 stigmas should be separated into a new genus, but made no concrete proposition. Included in the Restio species from Australia he recognised some with synonyms in other genera: R. gracilis = Schoenodum tenax Labill. ♀; and R. lateriflorus = Calorophus elongatus Labill., Lepyrodia elongata Spr. and Leptocarpus squarrosus Sieb.

The genus Calopsis+ Beauv. Desv. was reported to have possible affinities with Thamnochortus; all the species had synonyms in Restio.

He thought that Thamnochortus should contain some of Thunberg's and Rottboel's Restio species and also Restio, subsection 2, sensu Nees. T. virgatus had E. paniculatus amongst its synonyms.

Staberoha, a new genus, was said to fit midway between Schoenodum Labill. and Thamnochortus Br., and included synonyms from among species of Restio, Leptocarpus and Willdenowia.

Schoenodum Labill. (excl. pl. masc.) and some species of Leptocarpus R.Br. were retained.

Kunth saw affinities between Cannomois and Willdenowia

He proposed 2 more new genera, Boeckhia and Dovea. Boeckhia was described with 2 species, B. striata and B. laevigata, and was said to be related to Hypolaena. Dovea was claimed to have affinities with Elegia. Hypolaena itself + Beauv. ex Desv.



was thought to resemble Willdenowia Thb., while Willdenowia was extended to include Nematanthus Nees.

As in Endlicher's work, (1836), Elegia Thunb. was regarded as a genus in its own right, and included Nees' 'Restionis sect. 3'. Species of the genera Chondropetalum, Restio and Willdenowia were present in the synonymy for Elegia species.

Lepyrodia R.Br. was retained; it was remarked that it appears to show affinities with Elegia Thunb. The other genera of Robert Brown to remain unchanged were Lyginia, Loxocarya, Leptocarpus (pro parta fasciculata), Chaetanthus and Anarthria.

Rhodochoma Nees was said to look similar to Restio verticillata (Elegia verticillata) Nees.

Kunth had doubts about the position of Hypodiscus Nees and Leucoploeus Nees, and quoted synonyms from Restio.

Genera named by Nees and remaining unaltered in this work were Ceratocaryum, Cucullifera, Mesanthus, and Anthochortus.

Nees von Esenbeck published again in 1864, 5 years after the work by Kunth. He erected a new genus Desmocladus, species D. brunonianus, the former Restio fasciculatus of R.Brown. This work also included new species in the genera Restio, Lepyrodia, Anarthria and Leptocarpus. Lepidobolus was also erected in this paper.

In 1853 Lindley published an account of the family in which he recognised the following genera; Rhodochoma Nees, Leptocarpus R.Br., Loxocarya R.Br., Chaetanthus R.Br., Dover.

Kth., Hypodiscus Nees, Leucoploeus Nees, Mesanthus Nees, Anthochortus Nees, Ceratocaryum Nees, Lepidanthus Nees, Anarthria R.Br., Lyginia R.Br., Lepyrodia R.Br., Thamnochortus Berg., Staberoha Kth., Calopsis Beauv., Cannomois Beauv. and Boeckhia Kth.

Hypolaena R.Br. included Cucullifera Nees; Willdenowia Thb. contained Nematanthus Nees; Chondropetalum Rottb. was placed in Elegia L. He thought that both Desmocladus Nees and Lepidobolus Nees were close to Restio.

Gay, (1853), described one species of Leptocarpus, L. chilensis, in the 'Flora of Chile'. This is the only member of the family known to occur in South America. (It was also found by P. W. James in Patagonia in 1961).

Five more genera were proposed by Steudel in 1855; these were: Onychosepalum, Askidiosperma, Chaetodiscus, Ischyrolepis, and Eurostorhiza. He also included an anomalous genus, Prionosepalum, stating that it has a similar habit to the Restiaceae but was only doubtfully related to the family.

His other genera were as in Lindley, (1853), with the exception of Schoenodum Labill., Cuculifera Nees, and Calorophus Labill., which he recognised. He attributed Elegia to Thunberg and mis-spelt Dovea Kth., calling it Dowia. This synopsis was mainly a work of compilation, but new species were named for several genera. Little was given by way of synonymy.

Hooker, in his 'Flora of New Zealand', (1864), included 5

species of Restiaceae, only 1 of which was endemic. The genera represented are Leptocarpus and Calorophus, and 2 now included in the Centrolepidaceae, Gaimardia and Alepyrum.

Baillon, (1878), worked on the family. It was his opinion that Restio L., Elegia L., Askidiosperma Steud., Leptocarpus R.Br., and Dovea Kth. are closely related. He incorporated the remaining genera into 3 sub-groups: (i) Calorophees; Calorophus Labill., Hypodiscus Nees, Staberoha Kth., Cannomois Beauv. and Willdenowia Thb. (ii) Thamnochortees; Thamnochortus Berg., Chaetanthus R.Br., Onychosepalum Steud., Lepidobolus Nees and Loxocarya R.Br. (iii) Lyginees; Lyginia R.Br., Anarthria R.Br. and Ecedeicolea F.v.Muell.

Masters, (1878), produced a monograph on the family in which he considerably reduced the number of genera by extensive grouping. The work was introduced by a brief historical account at the end of which it was concluded that the family is a natural group separate from, but related to the Cyperaceae, Gramineae, Centrolepidaceae, Eriocaulaceae, Commelinaceae, and Xyridaceae.

He regarded the following to be of doubtful position: Chaetanthus R.Br., Anthochortus Nees and Chaetodiscus Steud.

Genera considered to be inadmissible and those in which they were included are: Boeckhia Kth. = Hypodiscus; Calorophus Labill. = Hypolaena; Craspidolepis Steud. = R. garnotianus; Cucullifera Nees = Cannomois; Desmocladus Nees = Hypolaena; Eurostorhiza = Caustis pentandra; Lepidanthus Nees = Hypodiscus; Loxocarya R.Br. = R. loxocarya; Loxocarya Benth. =

Hypolaena; Nematanthus Nees = Willdenowia; Spirostylis Nees in mss. herb. Sond. = Willdenowia; Schoenodum Labill. = Leptocarpus; Staberoha Kth. = Thamnochortus.

The table of geographical distribution given by Masters included 234 known species, 156 of which were from South Africa, 77 from Australia, Tasmania and New Zealand and 1 from Chile.

A summary of the main taxonomic trends in the family up to the time of Masters, 1878, is given in Table

The year 1878 also saw the publication of Bentham's Flora of Australia. It included an account of 11 genera. It was stated that although Restio and Leptocarpus also occur in South Africa there are no species common to the 2 continents. He noted that Leptocarpus is also found in New Zealand. The other 9 genera, all endemic, are Lyginia R.Br., Ecdeiocola F.v.Muell., Anarthria R.Br., Lepyrodia R.Br., Hypolaena R.Br., Loxocarya R.Br., Lepidobolus Nees, Chaetanthus R.Br., and Onychosepalum Steud.

Bentham found difficulty in matching plants of the same species when they were of different sex.

Bentham and Hooker, Genera Plantarum, (1883), recognised 20 genera in the family. They gave a description and account of the distribution of each genus. The genera were as follows: Lyginia R.Br.; Ecdeiocola F.v.Muell.; Anarthria R.Br.; Lepyrodia R.Br.; Restio L. (incl. Rhodochoma Nees, Megalotheca F.v.Muell., Ischyrolepis Steud., and Craspidolepis Steud.); Dovea Kth.; Askidiosperma Steud.; Elegia L. (incl.

Chondropetalum Rottb. and Lamprocaulos Mast.); Leptocarpus R.Br. (incl. Calopsis Beauv. and Schoenodum Labill.♀) was divided into 3 sub-sections (i) Calopsis, all South African, (ii) Diplanthesis, Australia and New Zealand, all extropical, (iii) Homoeanthesis, Tropical Australia and 'Cochin-China'; Loxocarya R.Br. (incl. Haplostigma F.v.Muell. and Desmocladus Nees); Lepidobolus Nees; Chaetanthus R.Br. (incl. Prionosepalum Steud.); Onychosepalum Steud.; Thamnochortus Berg.; Staberoha Kth.; Hypolaena R.Br. (incl. Calorophus Labill. and Calostrophus F.v.Muell.), divided into 3 sub-groups: (i) Tennes; Australia and New Zealand, (ii) Restioideae; 2 species, Australia, (iii) Africanae; Hypodiscus Nees (incl. Leucoploeus Nees, Boeckhia Kth. and Lepidanthus Nees); Willdenowia Thb. (incl. Nematanthus Nees and Anthochortus Nees); Ceratocaryum Nees (very close to Willdenowia).

Anarthria R.Br. was noted among the anomalous forms, since it has radical leaves.

Genera excluded by Bentham and Hooker were Eriocaulon L. and Centrolepis Labill., both of which took on family status. Chaetodiscus Steud. was put in the Eriocaulaceae, and Eurostorhiza Steud. was said to be synonymous with Caustis pentandra R.Br., Cyperaceae.

In 1888, Hieronymus regrouped the genera. The family was now called Restionaceae, using the correct root 'Restion'. The family was divided as follows:

Diplantherae: Lyginia, Ecdeiocola, Anarthria.

- Haplantherae: Aa Lepyrodia, Restio, Dovea, Askidiosperma,  
Elegia, Leptocarpus.
- bI Staberoha, Hypolaena, Hypodiscus, Cannomois,  
 II Willdenowia.
- Ba Loxocarya.
- b Lepidobolus, Chaetanthus, Onychosepalum,  
Thamnochortus.

In this arrangement the synonymy was as follows: Lyginia R.Br. incl. Schoenodum Labill.; Lepyrodia R.Br. incl. Sporadanthus F.v.Muell.; Restio L. incl. Rhodochoma Nees, Megalotheca F.v.Muell., Ischyrolepis Steud. and Craspodolepis Steud.; Leptocarpus R.Br. incl. Haplostigma F.v.Muell. and Desmocladus Nees; Chaetanthus R.Br. incl. Prionosepalum Steud.; Hypolaena R.Br. incl. Calorophus Labill. and Calostrophus F.v.Muell.; Hypodiscus Nees incl. Leucoploeus Nees and Boeckhia Kth.; Cannomois Beauv. incl. Nematanthus Nees, and Ceratocaryum Nees.

Some anatomical work was done by Van Tieghem, who, in 1888, described the mode of development of lateral roots in many plants, both Monocotyledons and Dicotyledons. He discussed his observations on the root of Elegia deusta and remarked that the lateral roots arose from only the outer ring of a double pericycle and this was a rare occurrence in Monocotyledons, but widespread in Dicotyledons.

The main anatomical work on the Restionaceae was published by E. Gilg in 1891. Previous to this only isolated species had been examined by Pfitzer (1869-70), whose work was not intended to be taxonomic. Pfitzer was more interested in the interrelationships between anatomical characters and physiology;

the descriptions in his work are fairly accurate, but the physiological observations were mainly speculative. Pfitzer was the first to define Stützzellen and Schutzzellen (protective cells and pillar cells, Cutler, 1964). His long account of the 'outer layer' of material, outside the normal epidermis in R. diffusus Spr. is of interest. Later workers confirmed his suspicions that the layer is really cellular, and demonstrated that it is composed of flattened, scale-like hairs.

The anatomical observations made by Gilg have remained substantially unchallenged since they were first recorded. His work opens with a section on comparative anatomy of culm, rhizome and root. Only culm structure was considered to any great extent; the other organs, being less readily available, were treated in a superficial manner. Studies were made on 83 species, from 15 genera (Leptocarpus, 17, Hypolaena, 13, Loxocarya, 2, Restio, 4, Lamprocaulos, 1, Willdenowia, 9, Hypodiscus, 10, Thamnochortus, 14, Lyginia, 1, Anarthria, 5, Lepyrodia, 2, Lepidobolus, 1, Dovea, 1, Elegia, 2, and Cannomois, 1,). He used Masters' synonymy.

Ground tissue, vascular tissue, mechanical cylinder, parenchyma sheath, assimilatory tissues and epidermis were all described in the section on the culm.

There is a long section on stomatal arrangement, in which the various species were classified according to the work of Tschirch.

Leaf structure was described in Anarthria and Restio graminifolium Kth., but in no other species.

Root structure was described in 3 species only, since

other material was not available. In an equally short section the structure of the rhizome was discussed.

The second section of the work is headed 'Xerophytic properties of the Restiaceae'. There are frequent quotations from Pfitzer and Tschirch about the aridity of the regions in which the plants were growing. The account of the observed anatomical 'adaptations' was largely speculative; the work belongs to a period in which physiology was in its infancy. Many of the comments are plausible, but would need to be substantiated by experiments.

In the third section there was an attempt to use anatomical characters in the taxonomy of the family. Gilg opened this section by stating that one may think it likely, in view of Schwendener's work on the Gramineae, (1890), that grouping based on anatomical structure would bear only a rough approximation to those based on morphology. He then drew attention to the fact that other workers had found close similarities between the results of the 2 approaches (.e.g., by Engler, 1878). He went on to say that in the Restiaceae he had found anatomical characters to be of great value. He considered that the adverse conditions under which the plants grew intensified rather than suppressed the anatomical generic differences.

Gilg noted that certain characters, normally useful in classification, were of no value in this family. Stomatal position with relation to the culm surface was a case in point.

He commented 'The individual species of Restiaceae have almost all been described under several names already, since



the difficulty of their certain identification is enormous'.

As stated above, Gilg followed Masters' synonymy. He was quick to find that he could divide some of Masters' genera into several distinct parts, basing his divisions on anatomical characters. These parts frequently corresponded to genera as defined by previous authors, particularly Kunth and Nees.

One of the most striking observations by Gilg was that it is often quicker to decide upon the probable genus of an unknown restionaceous plant by examining a T.S. of the culm with a hand lens than by examining all the morphological features.

The work proceeded with a severe criticism of the 'lumping' techniques used by Masters, particularly when he put under 1 generic name plants from Australia and South Africa. Gilg found evidence which suggested that such combinations were quite unnatural.

Some of the taxonomic conclusions reached by Gilg follow.

Leptocarpus R.Br., sensu Masters includes a distinct part with synonyms in Calopsis Kth. and one species of Thamnochortus Berg. Hypolaena R.Br. sensu Masters divides readily into groups defined by Loxocarya R.Br., Anthochortus Nees and Calorophus Labill. Hypolaena could be further subdivided into Bentham's Euhypolaena and African species. He found the Australian species of Hypolaena and Leptocarpus to be indistinguishable from one another.

Restio loxocarya Mast. (Hypolaena pubescens Nees) corresponds in structure with Hypolaena in South Africa. He redivided Willdenowia Thb. sensu Masters into Willdenowia Thb.,

Nematanthus Nees and Lamprocaulos Mast.

Although Masters had included Staberoha Kth. in Thamno-  
chortus Berg. authors after him had separated it out again;  
this separation was endorsed by Gilg. Dovea Kth. and Elegia L.  
were found to be very similar and Gilg could only separate them  
with difficulty. He saw Anarthria R.Br. as a genus apart, and  
possibly one which should be removed from the family.

Gilg lacked the material to make an investigation into the  
genera Chaetanthus R.Br., Onychosepalum Steud., Ecdeiocola F.v.  
Muell., Askidiosperma Steud., Loxocarya R.Br. and Restio L.,  
but gave brief accounts of the anatomy of the other genera then  
recognised.

In 1900, Masters erected the new genus Phyllocomos, from  
Australian material.

The next 2 people to work on the family were Bailey (1902)  
and Rodway (1903). They were the authors of the Flora of  
Queensland and the Tasmanian Flora, respectively. The species  
represented in the Queensland flora were members of the genera  
Lepyrodia, Restio, Leptocarpus and Hypolaena. Hypolaena was  
divided into 2 sections: (i) Calorophus, including H. lateri-  
flora Benth. (incl. R. lateriflorus R.Br., Calostrophus  
lateriflorus F.v.Muell., Calorophus elongatus Labill.,  
Lepyrodia elongata Spreng., Leptocarpus squarrosus Nees and R.  
crispatus Nees). (ii) Euhypolaena, with H. fastigiata R.Br.  
(R. clavatus R.Br.). The same genera were recorded for  
Tasmania by Rodway.

Diels, (1904), in an account of the genera and species of South-Western Australia, made several important observations. He considered that the primitive, endemic genera occurred there. Also the Western species differed from those in the East, except in a few cases. Leptocarpus tenax, for example, occurs in both regions.

There was a wealth of information about the habitats of the species described. It was stated that most of the species were concentrated on and characteristic of the flat, alluvial plains, composed of sand mixed with clay and poor in humus. Such localities were said to be soaked in the wet season, and, particularly near to the south coast, to retain a quantity of water even in the summer. In very dry years even this water would go, and the region became much more like the dry area north of the Swan River. The tallest tussock species were found in these Southern regions; they grow in isolated clumps, with bare ground in between. The alluvial flora was composed almost entirely of Lepyrodia, Leptocarpus and Chaetanthus, with a few species of Restio, Dielsia and Anarthria were reported to be characteristic of wetter, lower places. He noticed that the gradation in soil moisture content/<sup>was</sup> closely reflected in the composition of the restionaceous cover. In the dry regions only Ecdeiocolea and Lepidobolus were found. Lepidobolus penetrates regions of very low rainfall, being found in the 20 cm. per year belt. Restionaceae were absent from the loamy sand of the west Erimea. Diels suggested that the Restionaceae do not occur on areas with a high salt content, in contrast to the Centrolepidaceae, which were said to be salt tolerant.

The year 1904 also saw the introduction of 2 new genera by Fitzgerald; these were Hopkinsia and Harperia. He reported that Hopkinsia shared characters with the androecium of Anarthria and the gynoecium of Loxocarya. Harperia was said to be similar in some respects to Loxocarya and Lepidobolus. Both genera were found growing in saline regions.

Malmanche, (1919), gave an incomplete historical account of the family, followed by some anatomical observations. He maintained that Gilg's (1891) work contained several errors and that the descriptions were frequently confused. Malmanche gave details of 9 genera only, illustrations of stomata of 10 species and several culms in T.S. and L.S. The work was superficial, but 2 points of interest arise. Firstly, chlorenchyma structure was said to provide characters of taxonomic value, and secondly, epidermal characters were stated to enable one to distinguish between individual species. There was no account of rhizome structure, and no attempt was made to describe the distribution of tissue types.

In 1926, Uberfeld gave an account of sexual dimorphism in the family.

The most important taxonomic work on the family for the South African representatives was published in 1928, by N. S. Pillans. Pillans examined a very large number of herbarium sheets from the main collections, and based his observations on an extensive knowledge of the material available. The resultant paper contained descriptions of many new combinations, and a large number of new species. Lists of synonyms given in

this work have been extracted, and are contained in appendix I at the end of this thesis. In the majority of cases the names and combinations described by Pillans have remained unaltered.

He placed signed 'determinavit' slips on the sheets that he examined in the Kew herbarium. The arrangement of the Kew specimens follows the sequence published by Pillans. The present author has regarded Pillans as a reliable source of correctly named South African material.

Some field workers have experienced difficulties when attempting to use the keys given by Pillans. This is probably due mainly to the extreme difficulty encountered when attempting to identify restionaceous material on morphological characters alone, rather than to any major shortcomings in the keys themselves. The main problem is that the keys were constructed on the basis of characters of plants of one sex only.

Pillans recognised the following South African genera: Chondropetalum Rottb., Restio L., Elegia L., Leptocarpus R.Br., Thamnochortus Berg., Staberoha Kth., Hypolaena R.Br., Hypodiscus Nees, Cannomois Beauv. ex Desv., Willdenowia Thb., Anthochortus Nees and Phyllocomos Mast.

He appears to have disregarded some of the taxonomic suggestions made in Gilg's anatomical work, since he has retained combinations or names that had been cast in doubt by Gilg.

Pillans gave no account of previous literature. He restricted his references to those contained in the list of synonyms. He appears to have based his ideas mainly on his

own observations.

Following closely on the work of Pillans, in 1929, F. J. Meyer gave an account of the anatomy of the Restionaceae in volume IV of the famous series written in collaboration with Solereder.

This work contains many original observations, but it also duplicates many of Gilg's. There are frequent quotations from Gilg and Pfitzer. The anatomy of stem, leaf, root and rhizome were described, but extensive details were given only for stem material. Few taxonomic and no physiological interpretations were given. The work can be described as critical only in as much as the author stated whether his observations were in line with those of his predecessors or not. He stated that his own observations extended to 28 species from the genera Lyginia, Anarthria, Lepyrodia, Restio, Leptocarpus, Thamnochortus, Staberoha, Hypolaena, Hypodiscus and Willdenowia, all from herbarium material.

The account of stem structure included observations on the various tissues as outlined by Gilg. He made special mention of concentric vascular bundles in the periphery of stems of some species of Anarthria and Thamnochortus. The types of vessel/<sup>end</sup>wall perforations were listed for several species.

A list of species having no vascular bundles free in the central ground tissue was given. The list was compiled largely from Gilg, but included some original observations. The arrangement of vascular bundles was erroneously said to have taxonomic significance.

A moderately long section was devoted to the cortical region of the culm, with its chlorenchyma, protective and pillar cells. This section was more comprehensive than its counterpart in Gilg's paper, but included many of Gilg's observations in a little-modified form.

Epidermal cells were described both in T.S. and surface view. The position of the stomata relative to the epidermal surface was reported to be of taxonomic significance, but only at the species level. A list of the position of the stomata was given for various species. The unusual arrangement of the stomata in Lyginia barbata, first mentioned by Gilg, was commented upon.

Trichomes were dealt with more extensively than by previous authors.

Meyer was the first person to record the occurrence of silica-bodies in the family. He gave a long account of their distribution among the species he had examined. He observed the rounded silica-bodies in stegmata, particularly in association with sclerenchymatous cells and in the sheath of parenchymatous cells separating the chlorenchyma from the sclerenchyma. The oblong silica-bodies in parenchymatous ground tissue cells and the finely granular silica particles were also noticed. Silica-bodies were also recorded in the epidermal cells of some plants, Lepyrodia scariosa was cited as an example.

Leaf, root and rhizome were treated in a little more detail than in Gilg's work.

The new data contained in Meyer's article are so dispersed throughout the text, that it is difficult to extract them. It

is also difficult to visualise the anatomical organisation of the whole plant from either this or Gilg's work.

The most recent anatomical account of the whole family was written by Frau Gilg-Benedict, wife of E. Gilg, in 1930. She listed literature on morphology and anatomy, and followed the list with a brief account of each genus. The generic limits used were those of Pillans; the numbers of species in each genus; and their distribution, from Masters and Pillans.

An account of exomorphological characters is illustrated by drawings of the habit of Restio cuspidatus Thb., and flower structure in Lyginia barbata R.Br., Anarthria scabra R.Br., Thamnochortus spicigerus Thb., Willdenowia argentia (Nees) Hieron., Restio sp. and Lepyrodia hermaphrodita R.Br. There are also several anatomical illustrations.

A dichotomous key is presented for the 29 genera described. It is based mainly on the characters of the anthers, fruit and of flower spike.

The anatomical details given were mainly from the culm structure since this was said to exhibit most characters of diagnostic value. Anatomical descriptions were brief and concise, but of limited accuracy because the number of species examined was often low. Special mention was made of characters shared by several genera. For example, the anatomy of Lepidobolus Nees was said to be the same as that of Onychosepalum Steud., and that of Elegia L. and of Chondropetalum Rottb. was noted to be very similar. Askidiosperma Steud. was separated, on both anatomical and morphological



grounds, from Chondropetalum Rottb., where it had been placed by Pillans.

Restio was described with an extensive synonymy which includes several genera not mentioned by previous authors. These were Baloskion Rafin, Chondropetalon Rafin, and Leiena Rafin. Little anatomical information was given about Restio, but it was noticed that there are differences between those from South Africa and those from Australia.

Sporadanthus F.v.Muell. was included in Lepyrodia R.Br.; the latter was thought to be an artificial genus since it contained 2 distinct anatomical groups.

Gilg-Benn<sup>ed</sup>dict found Thamnochortus to be distinct from all other genera.

The generic name Calopsis Beauv. ex Desv. was revived for those species of 'Leptocarpus' found growing in South Africa. The name Leptocarpus R.Br. was reserved for the remaining species growing in Australia, New Zealand, Indo-China and Chile. Good anatomical grounds were given for this distinction.

Anatomical characters are thought to be sufficient to distinguish Lamprocaulos Mast. from Elegia L. Chaetanthus R.Br. was found to be anatomically similar to Leptocarpus R.Br., and Harperia Fitz. to Loxocarya.

Masters' South African species of Hypolaena are grouped together as the new genus Mastersiella. Hypolaena R.Br. in Australia is thought to be close to Leptocarpus R.Br., also in Australia.

It was suggested that Willdenowia Thb. (incl. Nematanthus Nees) was made up of 2 distinct groups, and Ceratocaryum Nees

should be regarded as a separate genus and not as part of Willdenowia Thb.

Gilg-Benedict was the first of the workers on the taxonomy of the Restionaceae to make full use of anatomical data. In so doing she carried on the work initiated by her husband; she demonstrated without doubt that plant anatomy is just as important as macromorphology in taxonomic work.

Yojoro Kimura, (1956), gave an account of the systematics and phylogeny of the Monocotyledons. His concepts were based on 4 main characters: (i) apocarpy or syncarpy, (ii) ovary superior or inferior, placentation axile or parietal, (iii) perianth characters- none, small, differentiated into calyx or corolla, etc., (iv) the nature of the albumen. He gave a table of suggested family affinities and arranged the families in groups, classes and orders. The Restionaceae were included in the 'Restionales', together with the Flagellariaceae and the Centrolepidaceae, in the order Sicciflorae.

Hamann, (1961-1962), mentioned the class 'Restionales', pointing out that Kimura had placed them next to the 'Poales' (Gramineae). He endorsed this arrangement since an unfortunate form of numerical taxonomy used by him had yielded similar results to those of Kimura. The choice of characters upon which the analysis had been made was very poor, particularly from the anatomical point of view. Characters present in only 1 genus were marked as 'family' characters, with no regard for the fact that the genus may be abnormal. It is possible that with 20 different anatomical characters the whole of the system

would need to be extensively revised.

The affinities of the families are proposed by Hamann  
do not seem to  
mainly on the basis of floral characters which provide the most  
reliable form of evidence available in this instance, and his  
results should consequently be regarded with caution.

The Australian species have been worked on to a limited extent since Gilg-Benedict's article, but this new work has been done mainly on a regional basis. No comprehensive account of Australian representatives as a whole exists. Johnson and Evans, (1963), and Briggs, (1963), have worked on the cytotaxonomy of some species. Their results indicate that the present generic limits may be somewhat arbitrary.

The work described in this present thesis shows that the anatomy of the plants in the Restionaceae should be known before any attempt is made to classify them. Much of Gilg-Benedict's work in reviving certain genera is seen to be well founded. The earlier classifications failed largely because insufficient data were available for use by their authors. Even careful researchers, such as Pillans, made unnatural combinations because they had so few reliable characters with which to work. Masters' habit of combining taxa is seen to be unsuitable for the treatment of the family.

New combinations are suggested; for example the genus Restio Rottb. is seen to be unnatural since it divides readily into several groups, some of which correspond to extant genera, others of which have no obvious close relatives.

Two genera have been removed from the family as a direct result of this work. They are Anarthria and Ecdeiocola, each of which becomes the type genus of a new family, Anarthriaceae and Ecdeiocolaceae, respectively. (Cutler and Shaw, in press.)

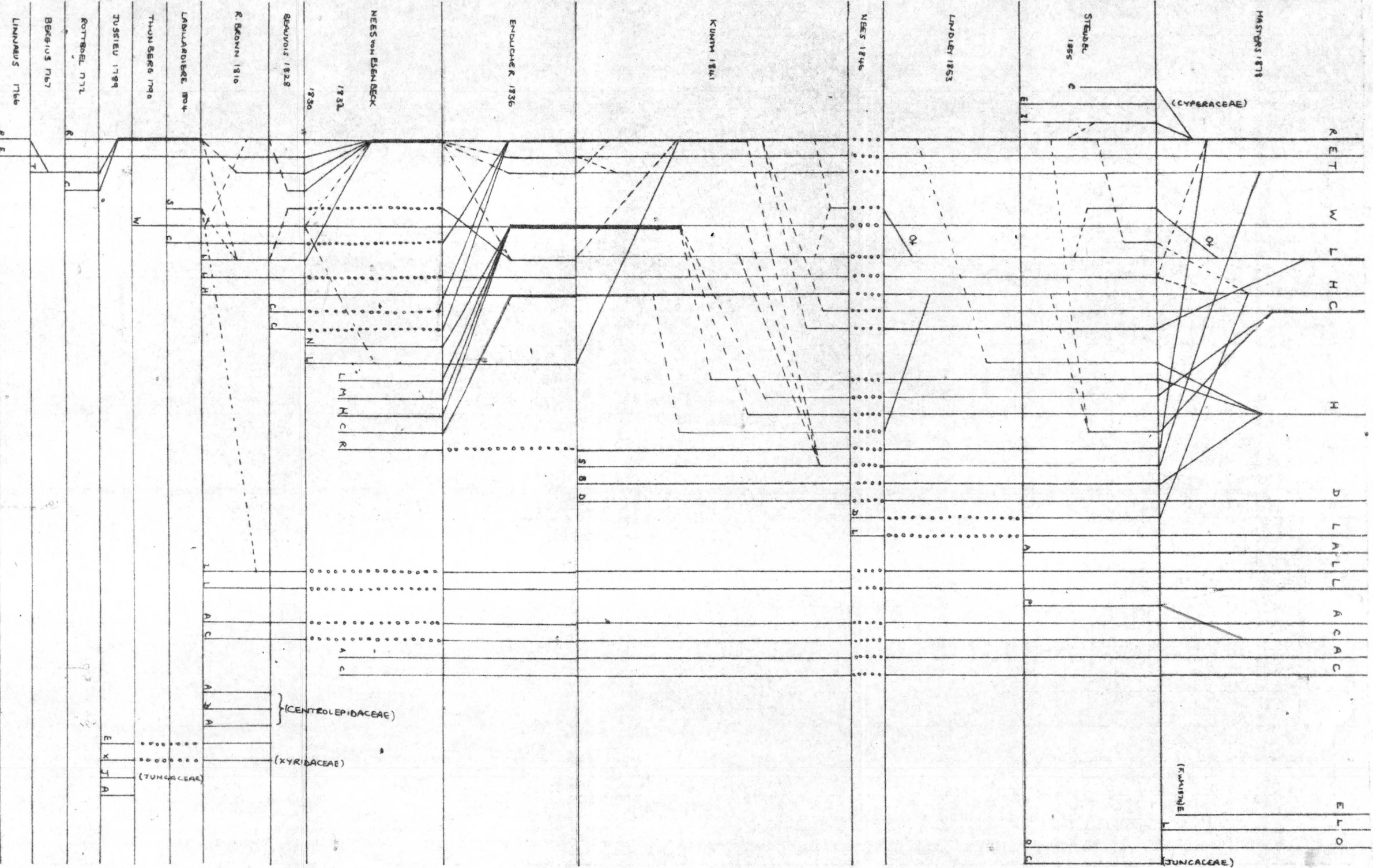
Suggestions of other possible revisions are made in the hope that the anatomical evidence will eventually be integrated into the totality of evidence required to obtain a satisfactory classification of the family.

### Explanation of Taxonomic Trends Table

Generic names are listed in the left-hand column and authors and dates of publication are given at the head of the columns across the top of the diagram. The constitution of a genus, according to a given author, in relation to that of any previous author, can be seen at the right-hand side of the column devoted to his work. Solid lines joining an obsolete genus into a new generic grouping denote the transference of the work of that genus into the new complex. Broken lines joining one genus to another indicate that some species only, and not the entire genus have been assimilated into a new combination. Genera joined by a row of circles indicate that the author through whose name such a row passes did not mention the genus, but, on the other hand, did not reject it.

The diagram indicates the direction and extent of the movements of genera made during the period 1766 - 1878, without reference to the species involved.

Craspedolepis  
 Eurostorhiza  
 Ischyrolepis  
 Restio  
 Elefia  
 Thamochoortus  
 Chondropetalum  
 Schoenodum  
 Willdenowia  
 Calororhus  
 Leptocarpus  
 Loxocarya  
 Hypolaena  
 Cannomois  
 Calopsis  
 Nematanthus  
 Lepidanthus  
 Leucoploeus  
 Mesanthus  
 Hypodiscus  
 Cucullifera  
 Rhodocoma  
 Stebercha  
 Boeckhia  
 Dovee  
 Desmocladius  
 Lepidobolus  
 Askidiosperma  
 Lyginie  
 Lepyrodia  
 Prionosepalum  
 Anerthria  
 Chaetanthus  
 Anthochortus  
 Ceratocaryum  
 Aphella  
 Desvauxia  
 Alepyrum  
 Ericcaulon  
 Xyris  
 Juncus  
 Aphyllantes  
 Ecdeiocolea  
 Lamprocaulos  
 Onychosepalum  
 Chaetodiscus



x

(JUNCACEAE)

## 2.2. THE NATURE OF THE PROBLEM.

The historical account shows some of the difficulties that have been experienced by taxonomists using only exomorphological characters in classifying members of the Restionaceae. Changes in emphasis given to particular characters by different authors have lead to many different combinations of genera and species. Some species now have many synonyms, e.g. Cannomois virgata Steud. which is quoted by Pillans (1928) as having 12 synonyms and includes names from 8 different genera. An examination of diagram will give an indication of the way in which the individual genera have stood the test of time. Not many have been left unaltered.

It is apparent that there are too few reliable exomorphic characters available on which to base a satisfactory classification. When keys have been constructed, they can often only be used with plants of one sex. Most male plants are quite unlike the female of the same species; they are often more like the males of other species.

Since anatomical evidence has been used so successfully in recent years to help to solve many problems of taxonomy (Metcalf, 1961, 1962) it was thought that a comprehensive survey of the anatomy of the Restionaceae might yield useful information to aid the taxonomist.

As indicated in section 2.1.2., E. Gilg (p.23 ) and C. Gilg-Benedict (p.31 ), among others, have shown the potential taxonomic value of certain anatomical characters.

Only a general statement could be given by such taxonomists, because they did not have sufficient information to be able to go into detail. The genus Restio has been neglected, and only a few 'representative' members of each of the other genera were examined. The time was ripe for a study of the anatomy of a very much larger number of species in the family.

The present work was started in an attempt to find out the taxonomic significance of the anatomy in the classification of the Restionaceae. From the observations which follow, it would appear that certain anatomical characters do have very considerable taxonomic significance. Many problems in classification in the Restionaceae can be solved to a greater or lesser extent by a few simple observations of the anatomy of the culm.



## 2.3. MATERIALS AND METHODS.

MATERIAL

The bulk of the material examined came from herbaria since living, correctly identified material was very difficult to obtain.

One living species only was growing at the Royal Botanic Gardens, Kew at the time that this work was started. A sample of 14 living plants sent by air from Sydney, Australia was potted out at Kew, but of these, only 5 survived. Seeds of two species were sent, freshly collected, from Sydney. These were put in a germinating tank at Kew. After 5 weeks one seed began to germinate, but the seedling died after a few days. Other seed sown under glass failed to germinate.

Reports on the difficulty of propagation of material, particularly by rhizome, came from contacts in both South Africa and Australia.

It was obvious that, in order to complete the work in a reasonable period of time, herbarium material would have to be used. The xeromorphic nature of the species prevented damage by drying to delicate anatomical structures. Since material from the herbarium could be revived readily it was quite suitable for anatomical study.

The collections at Kew and the British Museum (Natural History) were both consulted. Most of the Kew material from S. Africa had been examined by N.S. Pillans, during the course of his investigations proceeding to the production of his 1928 monograph. These sheets bear a determinavit slip and his initials; his identifications were taken to be

authoritative. It was the author's good fortune to have the advice of L. A. S. Johnson, the Australian Herbarium Liaison Officer at Kew for 1962-3. He kindly assisted in the identification of much of the Australian material. Thus the Kew herbarium provided a reliable source of accurately named specimens.

J. Lewis of the British Museum (Natural History) also assisted in the work by his kind observations and advice regarding the restionaceous material under his supervision. Although greatly impoverished by fire during the war, this collection added specimens of value and interest.

Other herbarium material came from the Sydney Herbarium by arrangements made by R. Carolin and L. A. S. Johnson.

Preserved material was sent from New Zealand by Moore. This included specimens of great taxonomic interest.

A large quantity of preserved material had very kindly been collected by V. I. Cheadle from Australia and South Africa.

Other material used was that from the Museums at Kew. Much of this had been collected by Burchell in the C19., in South Africa.

The quantity and quality of material obtained from the above sources made it unnecessary to attempt to examine material from other herbaria.

In order to preserve the value of a specimen only small samples from any given herbarium sheet could be taken.

A culm sample about  $\frac{1}{2}$ " to 1" could usually be removed

from a sheet without damage to the specimen. Care was taken to ensure that, <sup>as</sup> far as possible, samples were taken from a comparable position from each specimen. This was normally from a point roughly half way up the length of the culm. If, for any reason, such a sample could not be removed, a note was made indicating where the material had come from. In most cases the sample included a node. Sections were prepared from the mid-point along an internode.

Leaf samples were more difficult to obtain; the leaves themselves are so reduced in most species, and are sometimes deciduous. Consequently leaves have been examined in far fewer specimens than have culms. Leaf transverse sections are described for the central portion of a lamina (or sheath).

Root and rhizomes were obtained for relatively few species. Many early collectors took only aerial parts. If roots were present on specimens, they had frequently become damaged. It is more difficult to remove rhizome from a herbarium sheet than culm without leaving an obvious gap.

Herbarium material from Kew was removed under the kind supervision of R. Melville. All microscope slides prepared from this material are now housed at the Jodrell Laboratory, Royal Botanic Gardens, Kew.

Data referring to individual specimens (collector's name and number etc.) are given with the anatomical descriptions in section 3.2.

#### METHODS

Fixed material was preserved in Formalin Acetic Alcohol

mixture (F.A.A. 85% of 70% MeOH. + 10% of 40% Formalin + 5% of glacial acetic acid). Fresh material was killed, fixed and stored in F.A.A. Herbarium material was boiled in water for 10-15 mins. or until it ceased to float. After cooling, it was transferred to F.A.A. in which it remained for at least 48 hours to ensure adequate hardening.

In preparation for sectioning, the material was removed from the F.A.A. and washed in running tap water for a minimum of 30 mins. It was then placed in 50% methyl alcohol.

Various mounting materials were tried in the clamp of the Reichert sledge microtome, and bottle cork, specially shaped, was found to be the best, pith being too soft. The cork was prepared by cutting discs from a selected cork bung. The discs were best if about 3-4 mm. thick and 20 mm. in diam. An individual disc was cut down its diameter and the two halves placed one on either side of the specimen to be sectioned. The straight edge of the semicircles thus formed was arranged uppermost in the clamp. The corks chosen for disc making were even-textured and without sclereids.

Sections were cut at 18-22 $\mu$ . The knife (wedge section) was irrigated with 50% alcohol from a camel hair brush. Sections were brushed off and placed in the dish of 50% alcohol. Water irrigation was found to be unsatisfactory; alcohol has a better wetting and spreading effect.

Sections were examined uncleared, cleared and cleared followed by staining.

Clearing was carried out in undiluted 'Parozone' a domestic hypochlorite bleach. The time required for clearing

varied with the specimens; normally 5 mins. was required. Visual assessment was necessary. Sections were removed when clear, using forceps, and were washed in tap water, in a petri-dish.

Temporary preparations were stained on the slide, using either methylene blue or chlor-zinc-iodine. Any excess stain was removed, and the sections mounted in 50% glycerine. If kept flat and protected, such slides remained in good condition for several months.

Methylene blue staining was accomplished by mixing a very small quantity of 1% aqueous methylene blue with the glycerine before introducing the section. Careful regulation of the quantity of stain used eliminated the need for removing excess.

Carbolic acid solution was also used for staining temporary mounts. Silica bodies turn pink in the acid. This provided information additional to that obtained by an examination of the specimen under polarised light, when silica bodies do not shine between crossed polars.

Permanent mounts were prepared in the following way. Sections were cleaned in parozone, washed in tap-water and placed in an excavated glass block containing the stain. A lid was placed over the stain to prevent evaporation. By experiment it was found that a stain mixture of 80% safranin and 20% matured Delafield's haematoxylin would give consistent results after immersion for 2-6 hours. If the staining was to be done overnight, the well tried safranin/haematoxylin 96%/4% mixture was used. Sections were removed

from the stain using forceps, and placed in a petri-dish containing 50% alcohol and 2-3 drops conc. HCl. The sections were watched and removed as soon as the right colour balance was observed. They were washed in 95% alcohol for about 5 mins. then transferred to a covered petri-dish of absolute alcohol. After a further 5 mins. they were placed in xylol to complete dehydration. Sections were left in the xylol for about 5-10 mins only. Longer periods rendered them brittle and inflexible. They were mounted in neutral Canada balsam and baked in an oven at 58°C for 3-10 days before use.

Baking the slides ensured that they were dry before storage. This was essential, because the slides were filed upright, in aluminium containers.

The stain mixture used was found to be the best for all purposes. Chlorazol black gave very good results for wall pittings, but specimens had an overall dirty appearance. 'Reactive Genevois', a mixture of congo red and chrysoidin, gave pleasing results. The specimens stained orange and red, but the contrast between the colours was not sufficient for photographic purposes. Safranin/fast green staining was similarly unsuitable since green stains did not register well on the photographic plate or film used. (Selection of plate and film was based on other requirements; see below)

The contrast given by safranin/haematoxylin double staining was good. Thin-walled and cellulosic tissues stained purple, phloem blue or almost black, and thickened and lignified tissues red. Whilst being translucent, the colours are strong and positive. They photographed well, without the use

of colour filters.

Experience at the Jodrell Laboratory, Kew, has shown that the stain combination gives long-lasting results.

As alluded to above, polarised light techniques were used to study certain characters. There <sup>were</sup> / particularly useful when searching for crystals and examining silica bodies.

Phase contrast microscopy added little information to that obtainable by normal and polarised light. This is probably due to the thickness of the sections.

Photographic materials were selected for their fine grain and contrast characteristics. Kodak O250 plate was used for the  $\frac{1}{4}$  plate camera, with the occasional use of very high contrast B40 plates. Microfile film gave good results in the 35 mm. camera. The films were processed by R. Zabeau, chief photographer at the Royal Botanic Gardens, Kew.

Transverse, tangential longitudinal and radial longitudinal sections of the culm were prepared. Epidermal tissues were removed by careful adjustment of the first tangential longitudinal cut. Leaves were sectioned transversely; only a few longitudinal sections were prepared. The epidermis was removed as above or by peeling or by scraping tissues away from behind using a safety razor blade held at  $90^{\circ}$  to the specimen, which was resting on a formica bench top, whilst the blade was irrigated with Parozone. Roots were sectioned transversely. Very occasionally longitudinal sections could be obtained. Rhizomes were sectioned transversely and longitudinally.

Wax embedding was employed for the preparation of the shoot apex of ~~one~~ species. The normal embedding procedure was followed for material of this type.

In the initial stages of the work macerations were made of portions of several species. Information yielded by this technique was valuable in ascertaining the nature of cell types. It soon became apparent that similar cell types were present in most species, and that they could be readily recognised in sectioned material.

A 50/50 mixture of concentrated nitric acid/chromic acid was used for maceration. The length of time required for separating the cells varied from species to species, and had to be determined by inspection. The macerate was washed in water, centrifuged in a hand centrifuge and re-suspended in water repeatedly, until all traces of acid were removed. Water was then replaced by 95% alcohol for 2 washes, and finally 98% alcohol for 2 washes. Small samples of the final pellet were mounted in euparal containing 2-3 drops of fast green per 10 cc. Cells took up the green stain as the slides dried. The slides were ready for observation after 14 days in the oven at 58°C.

In addition to the routine sections made of internodal material, some species were selected for a study of the nodal structure. Owing to the complex nature of the nodal plexus, the nodes studied were taken from as near to the culm apex as was practical, bearing in mind the diameter of the culm. In one sample an Indian ink groove was made in the culm to facilitate the orientation of sections. This was unnecessary



in the species described later, since the outline of the leaf insertion made orientation straight forward. Unstained, serial sections were mounted in rows on microscope slides. Drawings were made of selected sections using a prismatic camera lucida. Three dimensional drawings were constructed from these data.

Stomatal development was studied in the leaves of Lepyrodia scariosa. Leaves developing at the apex of living material growing at Kew were removed with a scalpel. Those leaves less than 3 mm. long were suitable for staining in acetocarmine. The whole leaf was gently warmed in the stain and left for 10 mins. It was then washed in 45% acetic acid and examined. Suitable samples were split down the middle of the long axis and each half was mounted separately, freeze dried and mounted in balsam. The author is indebted to C. Marchant of the Cytology Department, Kew, for his help and advice with this technique.

When the slides had dried and were labelled, they were examined microscopically. Punched index cards were used to record the presence or absence of a large number of characters.

The face of each card was recorded with the author's reference number, a composite figure including the date and a serial number for that particular collection. Specimens collected during 1962 and 1963 bear day and month figures and a serial number, those for 1964 bear also the letter A, and B follows those collected in 1965. For example, specimen 7 collected on May 12th 1964 would be coded 12.5.7A. It is important to know the date of collection of some specimens,

because as the work progressed fresh characters were recorded. With a note indicating when the new character was first recorded it was possible to see which species should be re-examined for that character. The card face also includes the species name and authority, as on the herbarium sheet, and the geographical locality. Notes from the herbarium sheet are also included e.g. collector's name and number and any relevant information about locality, ecology etc. Sometimes it was necessary to record the nature of the specimen collected, whether stem or leaf, root or rhizome.

The cards have perforations numbered from 1-124. A glossary describing each character is given in the appendix. A brief introductory account of the characters follows. Numbers 1-70 cover culm characters, 71-89 leaf characters and 90-102 rhizome characters. The root is covered by 103-111. If root, rhizome, leaf or epidermis had not been seen, this was recorded using numbers 112-115. This is a time-saving device to speed up sorting analysis. Unrecorded cards can thus be rapidly excluded from the sorting procedure. Perforations 121-124 were coded for resorting the cards into genera. The genera were divided into 16 groups, and by using different combinations of the four numbers 121-124, the groups could be defined and sorted.

When extra characters were recognised it was not always possible to fit them into the section of the card where they logically belong, and they had to take up vacant spaces where these were available.

As each specimen was examined, the possession of a recordable character was indicated on the card by clipping at the appropriate number. If the character observed varied at all from the definition given in the glossary, a note was made opposite the number on the card.

Camera lucida drawings were made, on the blank reverse of the card, of a low power plan of culm T.S. (X100); any striking high power details were also recorded (X425). Additional drawings of characters of tissues of the other organs were also made on the cards where necessary.

A duplicate set of cards was cut without drawings. It was used in the sorting processes in order to protect the master set drawings from possible damage.

At the outset of the work, it was not known which anatomical characters would be of taxonomic value. After an examination of a number of specimens it became apparent that the culm showed the greatest degree of variation, and was the most readily available organ. Therefore the card was planned giving the largest proportion of holes to culm characters. Individual tissues were taken in turn and holes allotted to all observed variations; if there was a possibility of there being other variations, several adjacent holes were left vacant. For some cell types, for example, vessels, the variations usually found in other groups were all allocated spaces, with the risk of some holes being redundant. As new characters were observed, they were given holes. Measurements of cell dimensions are given in the descriptions

only when relative width to height of individual cells, or the relative heights or thicknesses of cell layers could not be expressed by simple proportions or fractions. Because in most cases it was possible to examine only 1 or 2 specimens of a given species, definite measurements could be misleading. Some species were examined more extensively in order to determine the reliability of various characters for taxonomic purposes. It was borne in mind that anyone wishing to use these data to identify material may only have a single specimen at hand, so characters exhibiting the least variation were concentrated on in the descriptions. For this reason a statistical analysis of sizes and dimensions was not undertaken.

### 3. DESCRIPTIONS

### 3.1 General Description of Anatomy of Family

The family shows relatively little variation in exomorphic characters. The vegetative anatomy shows far more variation. Whilst some genera are more or less uniform, others contain more than one anatomical type. The following description of the anatomy of the family gives a general account of the range of variation to be found in individual tissues. The generic and specific descriptions which follow this general account are more precise.

Abbreviations used in the descriptions are as follows:-

#### Vascular bundles:

mvb.	=	medullary vascular bundle
pvb.	=	peripheral " "
mx.	=	metaxylem
px.	=	protoxylem

#### Sheaths to vascular bundles:

O.S.	=	outer sheath
I.S.	=	inner sheath

#### General:

v.	=	very
T.S.	=	transverse section
L.S.	=	longitudinal section
T.L.S.	=	tangential longitudinal section
c.	=	circa, about

#### Orientation:

The following terms have a particular meaning in this work:-

Height, high - refer to anticlinal walls

Width, wide - refer to the length of periclinal walls.

Where numbers are given, for example 1-2(3), the number in brackets indicates an infrequent situation. The numbers outside the brackets represent the normal situation.

The term 'As high as wide' is used to describe a cell whose height is approximately equal to its width; 'slightly higher than wide' describes a cell whose height is greater than its width, but does not reach  $1\frac{1}{2}$  times higher than wide.

Measurements: The following relative terms are used with particular meanings: (Note that the meaning of a term is conditioned by the type of cell to which it refers)

<u>Walls:</u>	Very thick	>8 $\mu$
	Thick	6 - 8 $\mu$
	Moderately thickened	2.5 - 6 $\mu$
	Slightly thickened	1 - 2.5 $\mu$
	Thin	<1 $\mu$

Sclerenchyma fibres:

	Wide	20 - 25 $\mu$
	Medium-sized	15 - 20 $\mu$
	Narrow	<15 $\mu$

Tracheids in peripheral vascular bundles:

	Wide	>15 $\mu$
	Medium-sized	8 - 15 $\mu$
	Narrow	<8 $\mu$

Metaxylem vessels in medullary vascular bundles and cells of central ground tissue:

	Wide	>30 $\mu$
	Medium-sized	15 - 30 $\mu$
	Narrow	<15 $\mu$

The range of vessel diameters given by Chalk in *Anatomy of Dicotyledons*, Vol. I, p. <sup>xxii</sup> is outside that encountered in the Restionaceae, and is therefore inapplicable.

Dimensions of cells and thickness of cell walls were assessed visually, after a preliminary period of measurement by eyepiece micrometer. The actual dimensions of cells are rarely given as numbers, because the low sample number does not warrant it (see p. 50 ).

Each species description includes a list of numbers denoted "card characters". Each number refers to a specific anatomical character and a full explanation of these characters is given in Appendix II . Anyone wishing to make full use of this condensed form of information can readily reproduce a pack of suitably punched index cards.

The variability of stomatal structure is such that, for clarity of description, subsidiary cells, guard cells, apertures and lumina are divided into several types; full, illustrated descriptions of these types are given in a fold-out sheet in Appendix III.

Culm and leaf surface and T.S., and rhizome and root T.S., are described where available. In transverse section tissues are described working from the outside inwards. Details of cell structure which can only be seen in L.S. or T.L.S. are included in the account of transverse sections, when necessary.

#### Culm surface

Hairs; present in some species in several genera; unicellular or multicellular, ranging from simple or branched



filaments to flattened, fan-shaped hairs closely applied to epidermis. Papillae; short, rounded, frequent in few species. Epidermal cells; arranged in longitudinal files, exhibiting a wide range of outline; 4-, 5- or 6-sided, all of similar size or some longer than others; ranging from as long as wide to 7-8 times longer than wide, occasionally wider than long; walls straight or wavy, or wavy at surface only and straight at lower focus, thin to very thick. See figs. of main types in Appendix **II**. Epidermal cells with rounded or oval gaps between transverse walls in some genera (e.g. Chondropetalum), with cells of inner epidermal layer visible through such gaps. Stomata; paracytic, of the graminean type; long axis of stomata parallel to that of culm; guard cells and subsidiary cells showing a wide range of form, see figs. in Appendix **III**. Silica; present as spheroidal-nodular bodies or as granular material in some epidermal cells in some species of the genus Lepyrodia. Crystals; absent. Tannin; present in epidermal cells of many species. Cuticular marks; frequently granular, sometimes with longitudinal striations; wavy lines sometimes present above anticlinal walls of epidermal cells; short lines rarely present above, and at right angles to, anticlinal walls of epidermal cells.

Culm T.S. The tissues are arranged in the following sequence: epidermis; chlorenchyma; parenchymatous sheath; sclerenchymatous sheath (enclosing pvb's); mvb's, all, some or none embedded in sclerenchyma sheath, if free, then scattered throughout entire ground tissue. Inner part

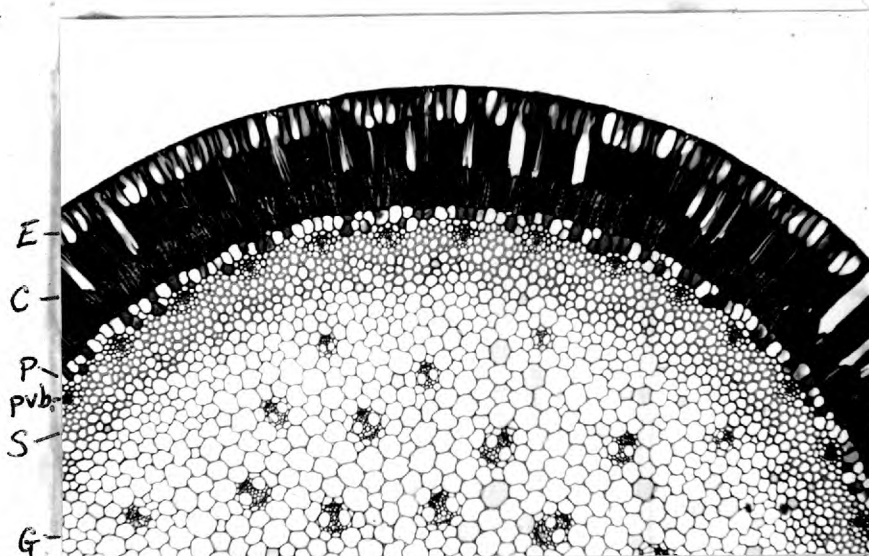


Fig. 1. General plan culm T.S. E-epidermis; C-chlorenchyma p-parenchyma sheath; S-sclerenchyma sheath; pvb-peripheral vascular bundle; m vb-medullary vascular bundle; G-central ground tissue (Chendropetalum paniculatum).

of ground tissue, if free from bundles, normally very thin-walled. (See fig. 1 showing general plan.)

Culm T.S. Details of tissues. Outline; rounded, oval or kidney-shaped, 4-sided or polygonal, or rounded or oval with low, dome-shaped or flat-topped emergences, or rounded and grooved. Solid or hollow at internodes, solid at nodes. Cuticle; thin to very thick; clear, or with granular inclusions; smooth, or granular, or with small ridges; usually continuous over guard cells and often produced into cuticular lips at outer and inner apertures of guard cells (see figs. in Appendix III); thin cuticular covering also present as lining to substomatal tube formed by protective cells (see fig. 4 ). Hairs; papillae; see culm surface. Epidermal cells; normally 4-sided; usually present in one, sometimes in two, or occasionally in 3(4) layers; cells wider than high, as high as wide, or up to 8-9+times higher than wide; all of the same height or some taller than others. Taller cells present (i) next to stomata, raising them up above culm surface (see fig. 2 A), or extending into chlorenchyma and lining substomatal tube (see fig. 2 C), or (ii) between stomata (see fig. 2 B), or (iii) opposite to pillar cells (see fig. 2 D). Occasional cells shorter than others in some species. When present in 2 layers, cells of outer layer sometimes with gaps between them, outer walls of some cells of inner layer then becoming superficial (see fig. 2 E); in one species (Elegia neesii), cells of outer layer reduced to small areas, the outer surface of culm made up largely of outer walls of cells of inner epidermal

no cuticle  
shown in fig. 4

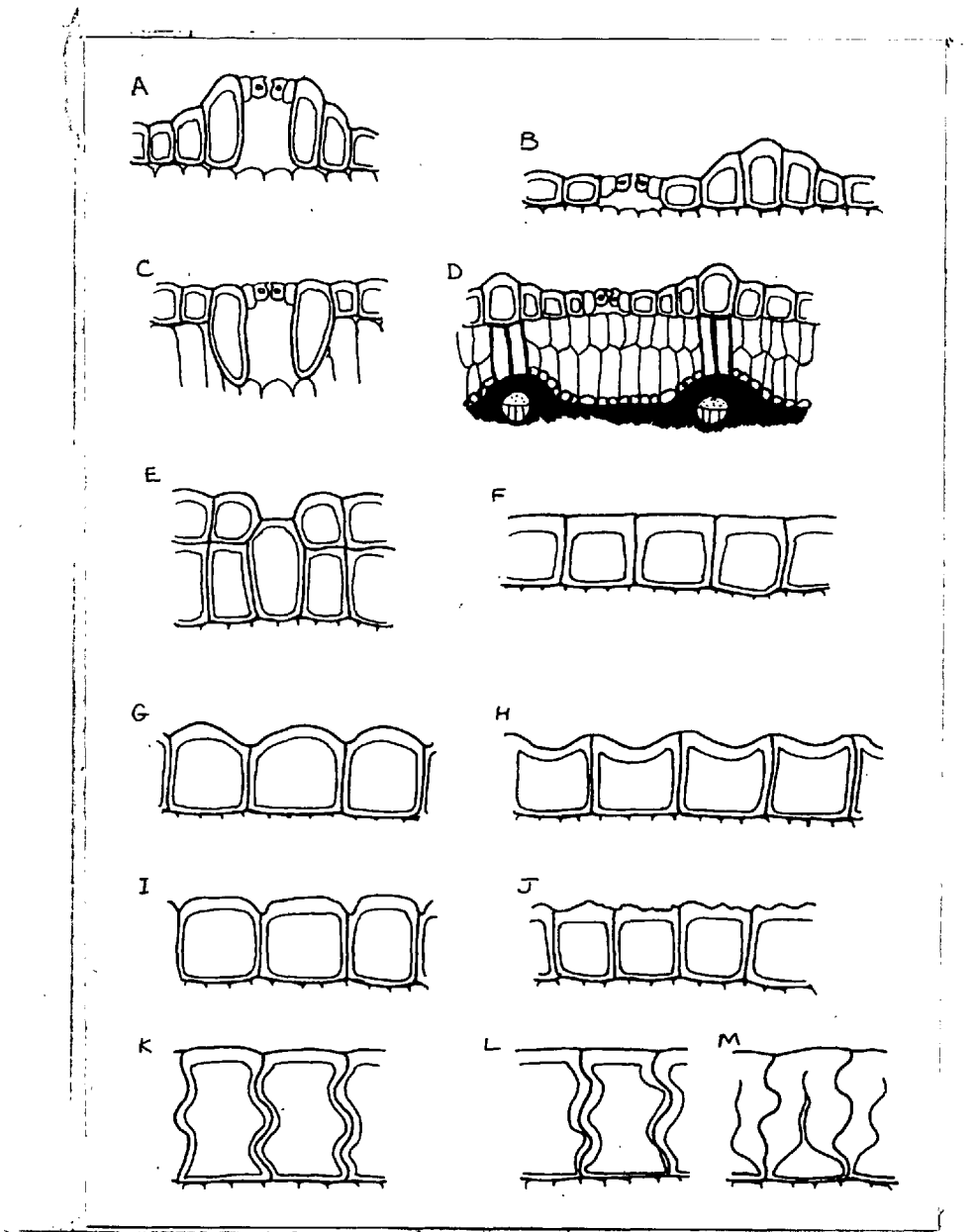


Fig. 2. Types of epidermal cell; see text.

layer. Cells of grossly unequal sizes in Dielsia and Restio leptocarpoides. Cells overarching stomata in some species, notably Sporadanthus. Outer walls slightly thickened to very thick; straight, convex or concave, curving inwards at margins or irregular (see figs. 2 G-J); anticlinal walls straight or wavy, thin to thick, evenly thickened (fig. 2 K) or with tapering thickening, thick at outer end, thickening tapering gradually to inner end, or thick for part of length and thickening tapering rapidly, inner part of wall less heavily thickened (see fig. 2 M); inner walls usually slightly or moderately thickened, occasionally thick. Stomata; superficial or sunken, raised onto mounds or ridges or sunken in grooves. Subsidiary cells normally thin-walled, sometimes with slightly or moderately thickened walls (see figs. in Appendix III); guard cells sometimes with lips at either inner or outer apertures or both, or with ridge on inner walls (see figs. in Appendix III); lumina variable, ranging from narrow-lenticular to broad, triangular (see figs. in App. III). Note: stomata are described for all species as seen in median T.S. Chlorenchyma; normally composed of 1, occasionally of 2 or 3 layers of thin-walled palisade cells; layers uninterrupted, or divided into sectors by other tissues. Palisade cells of variable height, anticlinal walls straight, or with peg-like processes (when termed 'peg-cells'), characteristic of many species of the family (Cutler, 1964), each peg-cell having (1-) 6-12(-20+) tubular peg-like outgrowths or projections from each of the 2-6 anticlinal walls, the pegs

being arranged in longitudinal files; pegs of adjacent cells opposite and apposed; some pegs with conspicuous pits in their mutual end walls. Pegs varying in length from half to about twice as long as wide. Cells with pegs: normally arranged in close lattice as seen in T.L.S., each cell normally joined to its neighbours by (4)-6 files of pegs (see fig. 35c ); cells without pegs or with very few pegs: normally arranged in transverse plates, or chequerboard pattern, or in longitudinal plates as seen in T.L.S. (see fig. 47B ). Protective cells; present in many species, particularly those from South Africa; consisting of modified palisade cells or peg-cells, normally with slightly to moderately thickened (lignified) walls, sometimes only those walls bordering onto substomatal cavity with thickening; cells surrounding substomatal cavity, and forming substomatal tube; walls of tube normally 1 cell-layer thick, tube composed of 1, 2 or 3 layers of palisade cells extending either from part way up substomatal cavity lined by epidermal cells, or from inner walls of epidermal cells, to parenchyma sheath, or only part way into chlorenchyma. Substomatal tube frequently closed at inner end. Closure brought about by a curving together of inner ends of protective cells; tube opening to chlorenchyma by pores or apertures between anticlinal walls of adjacent protective cells. Apertures rounded, oval, lenticular or very elongated, present at inner or outer ends of substomatal tube, junction between layers of protective cells, or present at intervals throughout whole length of tube; cells forming tube occasionally only

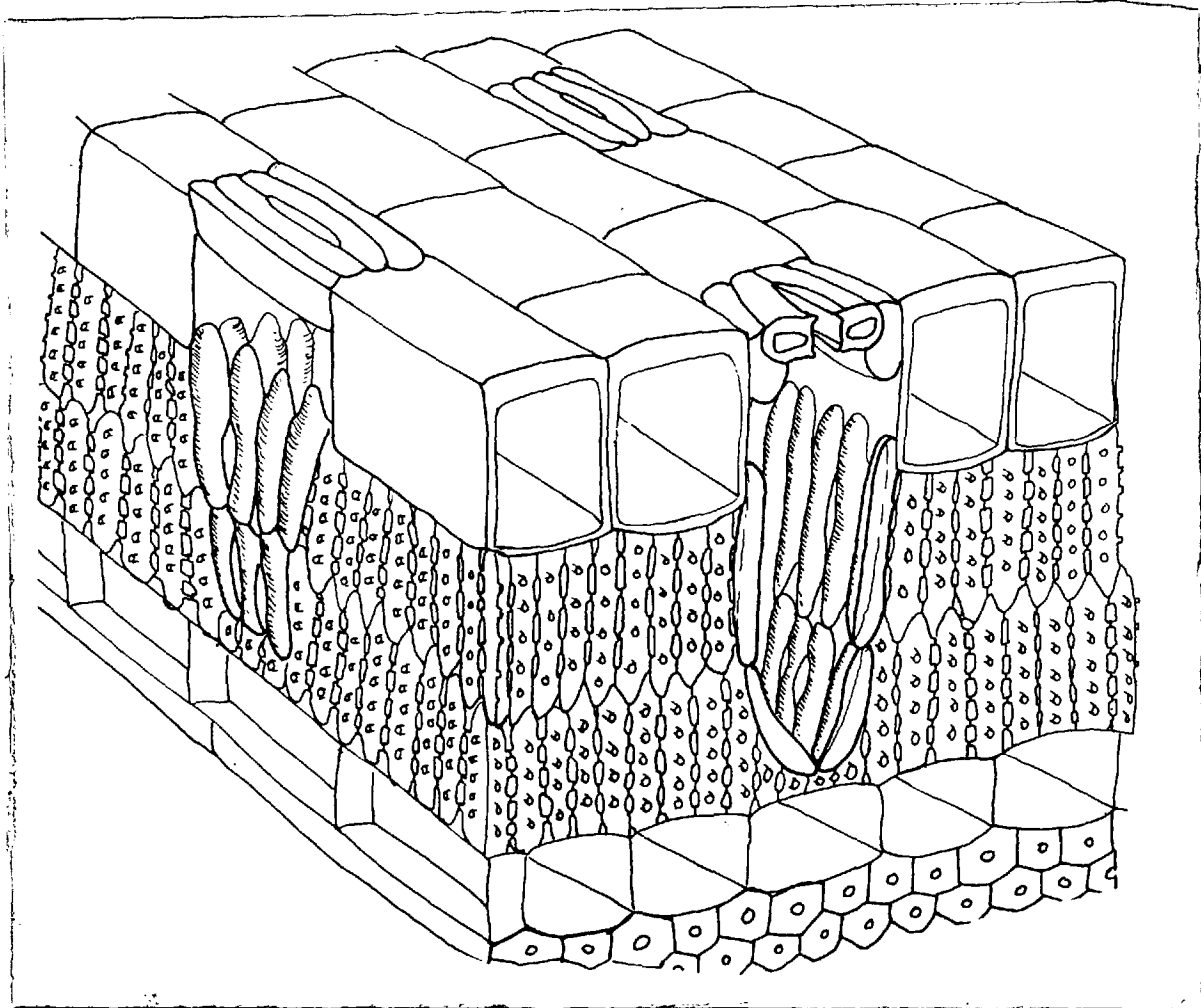
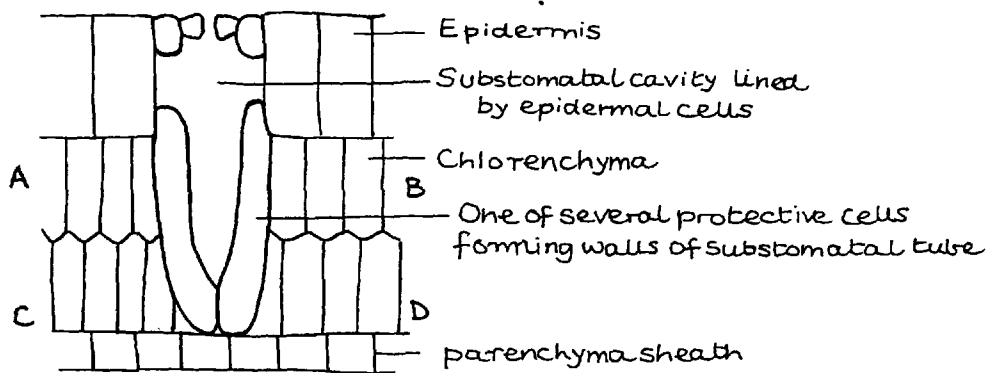


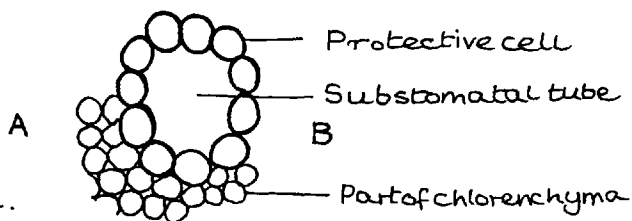
Fig. 3. Peg cells and protective cells; see text.

PROTECTIVE CELLS

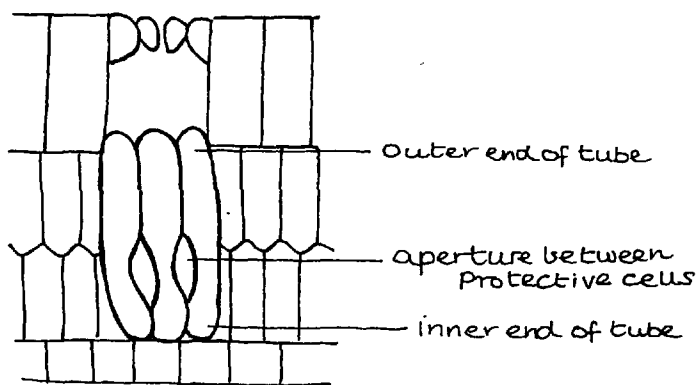
1. TS. outer part of culm



2. TLS of 1. at A-B



3. TLS of 1 at C-D



4. as 1 but at lower focus

Fig. 4. See text

no cuticle in figure



in contact with one another at outer and inner ends (see figs. 3 and 4 ). Parenchyma sheath; composed of 1, 2, 3 (several) layers of parenchymatous cells, bordering onto chlorenchyma to outside and sclerenchyma sheath to inside. Cells either: (i) all 4-6-sided, with rounded corners, as high as wide, or up to 2-(3) times wider than high or higher than wide (rectangular, normally  $1\frac{1}{2}$ -4 times or up to 7 or 8 times longer than wide with simple, rounded pits as seen in L.S.), all of more or less uniform size, or some larger than others, walls usually thin or slightly thickened, sometimes moderately thickened, thickening cellulose (becoming more <sup>heavily</sup> thickened in basal culm material), or (ii) in certain genera, of 2 different types; (a) as those in type (i), (b) 'pillar cells' (Cutler, 1964), elongated, palisade cells, normally 3-4 but sometimes up to 10 times higher than wide, usually with moderately thickened walls (lignified), infrequently with slightly thickened or thick walls; pillar cells radiating, singly or in groups of 2 or 3, from ridges or girders from sclerenchyma sheath to epidermis, dividing chlorenchyma into longitudinal canals; most pillar cells nearly parallel-sided, some with slightly expanded ends (see fig. 27A ). Parenchyma sheath including stegmata in some species; stegmata consisting of short cells with U-shaped thickenings, (lignin) on inner and anticlinal walls and with thin outer walls, each cell containing a single spheroidal-nodular silica-body (fig. 86, <sup>Appendix II</sup> ).

Sclerenchyma sheath; developed in all genera; present to

inner side of parenchyma sheath, and bordering directly onto it. Outline of sheath frequently following that of culm surface, with low, dome-shaped ridges opposite to small peripheral vascular bundles; girders or ridges present in some species, opposite to or alternating with pvbs.; girders wedge-shaped or more or less rectangular, extending from sclerenchyma sheath into chlorenchyma, sometimes reaching to epidermis, e.g. Dielsia, Restio leptocarpoides, or joined to epidermis by pillar cells (see above), e.g. some Leptocarpus and Willdenowia species; T-shaped, reaching epidermis in Anthochortus. Sheath varying in thickness in different species (or different specimens of same species), ranging from 2-3 layers in some to about 25 layers in others, but normally 6-8-layered. Fibres of girders and outer layers of sheath frequently narrow, with thick or very thick walls and narrow lumina; those of inner layers often wider, with thick or moderately thickened walls and wider lumina; fibres to outer side of pvbs. in some species with moderately thickened walls. Inner boundary of sclerenchyma sheath distinct or indistinct from ground tissue. Outline of fibres usually hexagonal, sometimes slightly rounded and with intercellular spaces filled with extracellular substances; fibres elongated, often many times longer than wide, frequently with square (transverse) end walls, or end walls oblique, or fibres pointed as seen in L.S.; wall pitting simple, pits oblique, slit-like. Sheath enclosing all pvbs. in all species except Lepyrodia graminifolia;

see species descriptions. Some, all, or no medullary bundles enclosed by sheath; medullary bundles sometimes attached to sheath by fibres at phloem pole. Vascular bundles; collateral; of 2 distinct types: (i) peripheral; confined to outer ring, enclosed in sclerenchyma sheath, more or less evenly spaced; each with small, sometimes poorly developed xylem pole consisting of <sup>1-</sup>a/or several-layered arc or horse-shoe of tracheids (narrow vessels noted in very few species); all tracheids of similar size (narrow to wide), or central ones widest, or flanking ones wider than the rest; phloem pole small, composed of sieve tubes and companion cells, rounded, or radially- or tangentially-oval, situated in concavity of arc formed by xylem, facing outer surface of culm; phloem occasionally separated from xylem by 1 layer of narrow cells with slightly or moderately thickened walls; (ii) medullary; present to inner side of ring formed by pvbs.; all, some or none enclosed in sclerenchyma sheath; if free, then scattered throughout central ground tissue or confined to outer region. Outermost bundles smallest, innermost bundles largest, with intermediate sizes between the two. Outline of bundles round, radially- or tangentially-oval (see Appendix II for illustrations). Bundles most frequently with 1 conspicuous metaxylem vessel on either flank; mx. vessels narrow, medium-sized or wide, rounded, angular or many-sided (see figs. in Appendix II), walls slightly thickened to thick, occasionally very thick; narrowest mx. vessels usually found in outermost bundles; vessel wall pitting usually scalariform, sometimes alternate,

occasionally reticulate; pits simple or bordered (usually bordered in thick-walled vessels); perforation plates oblique or transverse, simple, scalariform (with few or many bars), scalariform-fenestrate or reticulate (figs. in appendix II ). Flanking mx. vessels sometimes close together, characteristically widely separated by several rows of narrow cells (xylem parenchyma) in some species. Protoxylem present in most larger, inner bundles and absent from smaller, outer bundles; vessels with annular or spiral thickenings; lysigenous cavities rarely present at px. pole. Phloem poles rounded, tangentially or radially oval, or over-arching flanking mx. vessels; abutting directly onto xylem in certain species, or, more usually, separated from xylem by 1 layer of narrow cells; narrow cells usually with thin walls next to phloem and other walls slightly or moderately thickened. Phloem composed of sieve tubes and companion cells; some sieve tubes wide in certain species, all narrow in others; sieve tube elements short or elongated, sieve plates oblique in narrower elements, nearly transverse in wider ones; narrow sclereids present in phloem of some species. Bundle sheaths; sclerenchymatous, variable in thickness, but normally with more fibre-layers at poles than on flanks; fibres at phloem pole normally with thickest walls, often narrow, arranged in 1, 2 or 3(4) layers; those on flanks narrow or medium-sized, with slightly or moderately thickened or, occasionally, thick walls, usually arranged in 1, occasionally in 2 layers; fibres at xylem pole

often narrow, sometimes medium-sized, usually with moderately thickened or thick walls, arranged in 1 or 2(3) layers, Thickness of walls variable; normally thickest in specimens with numerous layers of very thick-walled fibres in sclerenchyma sheath. Fibres of bundle sheaths distinguishable from those of sclerenchyma sheath by their higher **birefringence** when viewed in T.S. between crossed polars. Central ground tissue; parenchymatous, cells usually hexagonal in T.S. (with transverse end walls, usually from 4-8 times longer than wide as seen in L.S. with round, simple pits in thin-walled cells, pits often elliptic, oblique in cells next to sclerenchyma sheath). Cells of outer layers, nearest to sclerenchyma sheath and often surrounding mvbs., frequently with moderately thickened (partly lignified) walls (cells of outermost layers sometimes with very thick (lignified) walls); inner cells wider than outer, sometimes with slightly thickened (cellulose) walls; central cells, free from vascular bundles in most species, thin-walled, often breaking down to form central cavity; central cells cut off from other cells by single ring (sheath) of fibres in some Leptocarpus and 1 Restio species. Some species, notably Thamnochortus, with scattered areas of thin-walled cells amongst those with moderately thickened walls in outer layers. Crystals; rhombic, present in Lyginia barbata only, in cells of parenchyma sheath. Silica; present in 2 forms; (i) silica-bodies, spheroidal-nodular, present in certain species in some unspecialised cells, or

stigmata in parenchyma sheath, or in stigmata in outer layer of sclerenchyma sheath, or in special epidermal cells in some Lepyrodia species, occasionally present in some pillar cells, protective cells or cells of inner chlorenchyma layer but usually then with irregular outlines; (ii) granular material (silica sand) present in certain species in occasional cells of central ground tissue, parenchyma sheath, and infrequently in pillar cells, protective cells or chlorenchyma cells, usually filling lumen. Tannin; dark-brown, refractive, hard material, of uncertain chemical composition, frequently found in some epidermal cells, occasionally found in cells of parenchyma sheath or central ground tissue, and occasionally present in phloem and xylem of pathological material.

### The Leaf

Leaf blades are rarely present, but are described in T.S. when suitable material was available; descriptions given here frequently refer to the sheathing leaf base, which is more readily available. The base of the leaf overlaps and encircles the culm by  $1\frac{1}{3}$  -  $1\frac{1}{2}$  times at its region of fusion with the culm.

### Leaf surface

Hairs; uncommon; if present uni- or multicellular. Papillae; more frequent than hairs, often occurring in species with papillate culms. Individual papillae short, rounded, usually 1 to a cell. Epidermis; leaf blade, abaxial and adaxial surfaces sometimes similar; leaf base

material surfaces usually dissimilar; (i) abaxial; cells exhibiting same range of variation as found in culm, often similar to those of culm of same species, but sometimes shorter in axial direction; (ii) adaxial; 4, 5 or 6-sided, frequently very elongated, sometimes hexagonal and 2-3 times wider than long, walls straight or wavy, thin to thick, usually thinner than those of abaxial cells. Stomata; paracytic, arranged with long axis parallel to that of leaf; exhibiting same range of variation as found in those of culm; frequently present on both surfaces of leaf blade material, normally present only on abaxial surface of sheathing leaf base material. Often similar to culm stomata of same species. Silica; spheroidal-nodular bodies present in occasional epidermal cells of some species of Lepyrodia. Tannin; frequently present, particularly in epidermal cells of sheathing leaf bases. Cuticular marks; frequently granular, occasionally with longitudinal striations.

Leaf T.S.

Flattened dorsiventrally, leaf blade usually with parallel faces and rounded margins (fig. 5 (i)), leaf bases usually with parallel faces in central region, but tapering gradually to margins; sections are described as seen in thicker part of leaf (Section A-B, fig. 5 (ii)). The leaf base T.S. sometimes has ridges opposite to vascular bundles on the abaxial side. Veins run longitudinally in both blade and sheathing base; they are thus cut transversely in transverse sections. Hairs, papillae; see leaf surface. Cuticle; normally thin, sometimes slightly

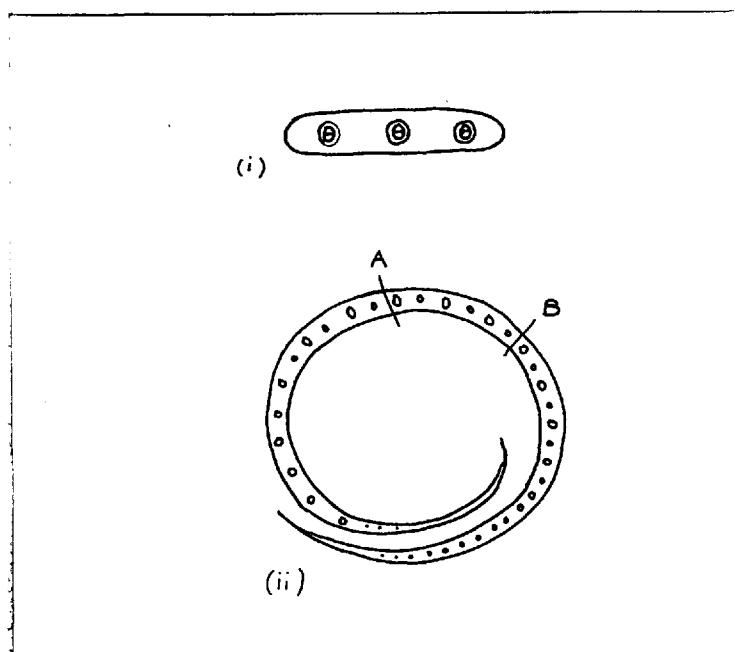


Fig. 5. Leaf blade and leaf base T.S. see text.



thickened. Epidermis; (i) abaxial; cells showing range of outline and wall thickness as described for culm, cells frequently similar to those from culm of same species; (ii) adaxial; cells in leaf blade similar to those of abaxial; in sheathing base frequently unlike those of abaxial, cells normally ranging from 2-4(5) times wider than high, 4- or 5-sided, thin to thick-walled, usually about  $\frac{1}{4}$  -  $\frac{1}{3}$  of height of abaxial cells. Stomata; present in both surfaces of leaf blade; normally absent from adaxial surface of leaf sheath; superficial or sunken, showing same range of variation in guard cells and subsidiary cells as occurs in culm stomata. Chlorenchyma; composed of palisade or more or less isodiametric cells, frequently with pegs (see culm chlorenchyma); cells occupying all space between vascular bundle-sheaths and epidermis in most leaf blades, but present in 1 or 2(3) layers next to abaxial epidermis in sheathing leaf bases; layers interrupted by bundle sheaths in leaf bases of some species. Protective cells sometimes present in species having them in culm chlorenchyma. Vascular bundles; (a) in blade, usually 3, but sometimes up to 12-15, arranged in 1 row, all orientated with phloem poles facing abaxial surface; (b) in sheathing base, 14-30 (40), in 1 row, frequently alternating small and medium-sized (or large), orientated as in blade. Bundles usually with small phloem and xylem poles; tracheids of xylem all narrow or medium-sized in smaller bundles, sometimes wide on flanks in larger bundles; vessels not seen; phloem composed of narrow sieve tubes

and companion cells. Bundle sheaths; l. S. sclerenchymatous, fibres usually narrow or medium-sized, rarely wide, usually thick- or very thick-walled, arranged in 1-3(4+) layers, sometimes continuous on flanks with sclerenchyma of ground tissue; O.S. parenchymatous, present as complete, usually 1-layered sheath round leaf blade bundles, often reduced to 1-layered cap at phloem pole or continuous in 1 layer between bundles to abaxial side of ground tissue sclerenchyma in leaf sheaths. Sclerenchyma; confined to bundle sheaths and sometimes also as 2-3 layers of ground tissue between bundles in leaf base material of certain species. Ground tissue; chlorenchymatous in leaf blades, either all parenchymatous or partly sclerenchymatous (see above) in sheathing leaf bases; when partly sclerenchymatous, sclerenchyma often separated from adaxial epidermis by 1 or 2 layers of parenchyma cells. Parenchyma cells usually hexagonal in outline (3-6 times longer than wide, with transverse end walls as seen in L.S.), or lobed and aerenchymatous; occupying all space not filled by other tissues except where air cavities are present. Air-cavities; rare, present in occasional Thamnochortus species, formed by breakdown of parenchyma cells between vascular bundles. Silica; present as (i) granular amorphous deposits in various tissues of occasional species; (ii) spheroidal-nodular bodies in cells of outer bundle sheath or in stegmata in outer layer of inner sheath at phloem pole in some species; also present in some epidermal cells in certain Lepyrodia species. Tannin; frequent, particularly in epidermal cells of sheathing leaf

bases.

T.S. Rhizome

Usually sectioned in region between buds or culm bases. Hairs; present in certain species; usually multicellular, short uniseriate filaments. Epidermis; cells  $1\frac{1}{2}$ -2-3 times wider than high, normally 4-, sometimes 6-sided; walls usually all of similar thickness, ranging from thin to thick. Stomata; infrequent; superficial; showing range of variation as in culm. Hypodermis; occasionally distinct, <sup>present</sup> as 1 or 2 layers of cells, but normally either absent or indistinguishable from cells of outer cortex. Cortex; variable in composition; all cells parenchymatous, or mainly parenchymatous with areas of several layers of sclereids, or occasionally composed almost entirely of sclereids; inner layers often aerenchymatous. \*Endodermoid sheath; often distinct as 1-2-(3) layers of cells with all walls thick or very thick, or with thin outer walls. Vascular bundles; all amphivasal, or outer, smaller bundles collateral; vessels sometimes narrow, more often medium-sized or wide, angular or sometimes round or oval, with scalariform wall pitting and simple, more or less transverse perforation plates; phloem pole rounded, composed of sieve tubes and companion cells. Bundles scattered throughout all of central ground tissue, or absent from small, central region. Bundle sheaths; sclerenchymatous, occasionally distinct from ground tissue; 2-3-layered, fibres with

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\* Sensu Tomlinson, 1964: there is no apparent evidence that this is a true endodermis.

moderately thickened or thick walls. Central ground tissue; composed of 2 sorts of cell, (a) those next to bundle sheaths, sclerenchymatous, with moderately thickened or thick walls; (b) in gaps or canals scattered amongst thickened cells and often at centre of rhizome, parenchymatous, often aerenchymatous, thin-walled, lobed, more or less isodiam<sup>e</sup>tric cells. Silica; present in granular material in some parenchyma cells in occasional species, or as spheroidal-nodular silica-bodies in some cells of inner cortical layers. Crystals; none seen. Tannin; present in some cells of parenchyma of cortex or ground tissue or epidermis in some species.

#### Root T.S.

Root hairs; developing from hairs similar in size to those making up remainder of epidermis; basal part of hair normally 2-3 times wider than shaft. Epidermal cells; 4-(6-) sided, as wide as high to 2-3 times wider than high, normally with slightly thickened walls. Hypodermis; 1-2-layered, parenchymatous, cells similar to those of epidermis; present in few species. Exodermis; rarely present, composed of 1-2 layers of cells with thickened inner and anticlinal and thin outer walls. Cortex; either all parenchymatous (cells of outer layers occasionally with slightly thickened walls), or divided into 3 regions: (i) outer, composed of several layers of parenchymatous, 4- or 6-sided cells with slightly or moderately thickened walls; (ii) middle, composed of radiating plates of parenchyma cells; plates normally 1 cell wide and up to 20 cells high,

with air spaces between them; (iii) inner, composed of 2-3 layers of parenchymatous cells, individual cells normally narrower than those in plates. Endodermis; frequently 1-, occasionally 2-layered; cells usually with thick or very thick inner and anticlinal walls and thin outer walls; passage cells present in some species, wall pitting simple, often branched. Pericycle; normally 1- or 2- layered, but sometimes up to 6-layered, cells thin or moderately-thick-walled (occasionally thick-walled). Vascular tissue; region immediately inside pericycle composed of alternating strands of px. and phloem surrounded by cells of ground tissue; mx. vessels present (i) in 1 ring, to inner side of px. and phloem or (ii) in 2 rings or (iii) in 1 outer ring and scattered in central ground tissue; individual mx. vessels rounded, oval or angular, usually with scalariform wall pitting and simple, transverse perforation plates. Unusual phloem distribution noted in some species; strands of phloem associated with central mx. vessels, or scattered in central ground tissue. Central ground tissue; parenchymatous, all cells with slightly-, moderately thickened or thick walls, or, in some species, central cells thin-walled. Silica; none seen. Crystals; none seen. Tannin; present in occasional ground tissue cells or vessels in some species; possibly pathological.

### 3.1.1. NODAL ANATOMY

The course of vascular bundles through a node has been examined in detail in Leptocarpus tenax R.Br. and Restio sieberi Kth. var. venstulis Pill. The pattern found in these species is similar to that in others which have been examined briefly, and it is probable that it is fairly typical for the family.

Vascular bundles in the culm of a restionaceous plant anastomose and redivide at each node. They are joined at each nodal plexus by leaf bundles from the leaf insertion of the next highest node. When leaf bundles enter a culm at a node, some may join onto the nodal plexus at that node, but the majority of them bypass the node and pursue a vertical course through the periphery of the internode below as 'peripheral bundles' and join culm bundles as they enter the next lower node where they lose their individual identity.

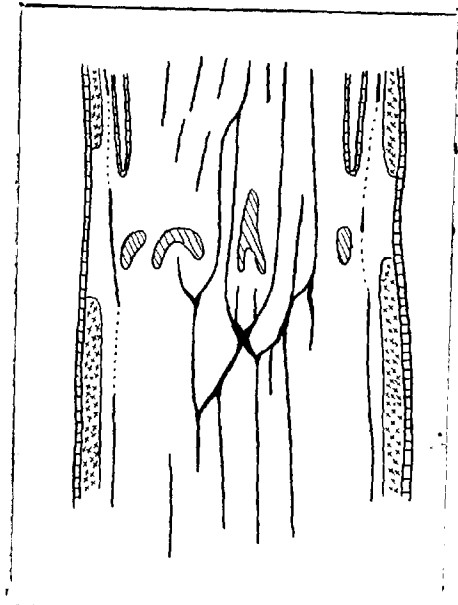
At the node, the peripheral and medullary bundles from the internode above converge and fuse into the nodal plexus. Although many divisions and refusions occur in this plexus and vessels, tracheids and phloem appear to run in random directions, 3 main phases are discernible. Firstly, most individual bundles fuse with their neighbours, secondly most fusion bundles divide again only to fuse once more with different partners in the third phase. The bundles which emerge from the proximal side of the node are other fusion products of the third phase, and they are recognisable as the medullary bundles. As noted above, the peripheral

bundles are leaf trace bundles, most of which have bypassed the nodal plexus and all of which will fuse into the next lower nodal plexus.

Although the leaf base has a spiral insertion, the leaf bundles opposite one another at the region of overlap fuse and enter the culm as a single strand.

Fig. ~~over page~~, Restio sieberi Kth., var. ven<sup>u</sup>stulis Pill. shows a camera lucida drawing of an R.L.S. of a node. The chlorenchyma (marked with crosses) is discontinuous, the epidermal cells are flattened, and the parenchyma sheath is lacking in the region between the leaf and culm. Aerenchymatous tissue is cross patched; vascular bundles are indicated by solid black lines, the dotted lines indicate their course when they deviate from the plane of the section. The region not occupied by aerenchyma is sclerenchymatous at the node. The particular leaf bundles illustrated bypass the node and take their position in the periphery of the culm. The various fusions and re-divisions of the medullary bundles are shown, and on the right, a peripheral bundle from the upper internode can be seen to be joining the nodal plexus.

Diagram 1 illustrates some of the possible courses of vascular bundles entering the node in Leptocarpus tenax R. Br. It was compiled from serial transverse culm sections. The scale is exaggerated in the axial direction. The appearance at different levels is explained as follows:  
A Base of leaf joins culm; the leaf margins overlap for half the circumference of the culm.



RESTIO SIEBERI VAR. YENUSTALIS

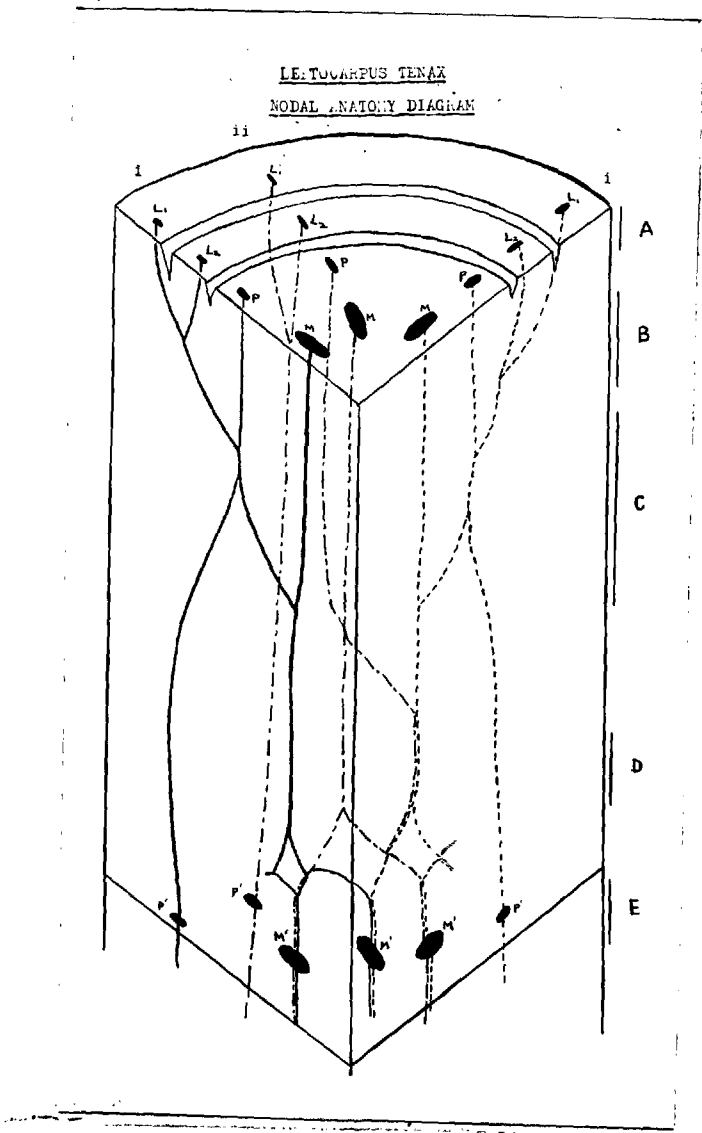


DIAGRAM 1



B Leaf bundles  $L_1$  and  $L_2$  of each opposite pair fuse.

C The fusion bundle from (B) either (i) swings towards the culm centre and joins the nearest peripheral bundle P from the internode above and leaves it again a little lower down (probably in composite form) or (ii) passes directly by the plexus and emerges as  $P^1$  in the internode below.

In case (i) the bundle  $P_1$  probably with part of  $L_1$  +  $L_2$ , joins the medullary bundle M. In case (ii) P alone joins M. The  $(P - L_1 - L_2 - M)$  and  $(P - M)$  bundles may divide and fuse again in different combinations before level D.

D General fusion of the  $(P - L_1 - L_2 - M)$  and  $(P - M)$  bundles into a plexus. Bundles emerging from this complex in the internode below are all medullary ( $M^1$ ) bundles.

E The emergent bundles are clearly separated into 2 groups, peripherals,  $P^1$  and medullaries,  $M^1$ .

The results of this study indicate that the peripheral bundles of the culm, and possibly the tissues to their outer side, can be interpreted as being closely related to 'leaf' and the central portion of the culm only can be interpreted as 'stem'.

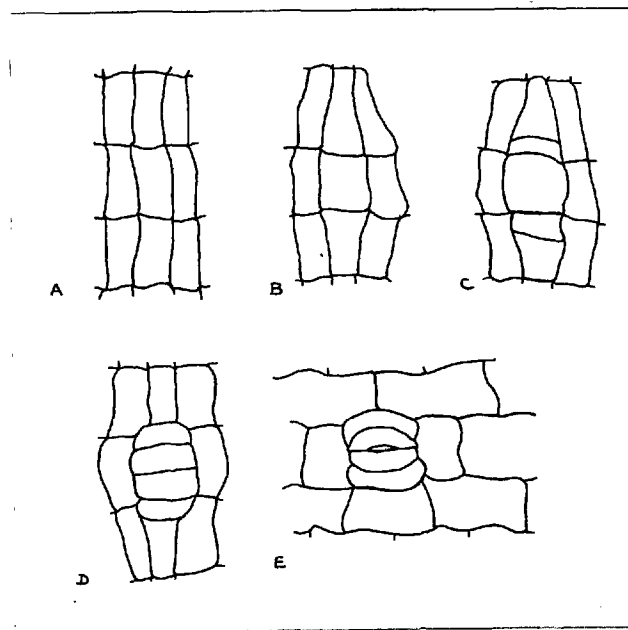
The structure of the culms of the Restionaceae provides a good illustration of the shoot concept, since they are clearly of composite leaf-stem construction.

### 3.1.2. DEVELOPMENT OF STOMATA

The development of stomata was studied in leaf material of Lepyrodia scariosa R.Br. grown at Kew. No other material was available for this purpose. The sequence of events detailed below is summarised in figs. A-E, prepared from camera lucida drawings (over leaf).

The leaf blade examined was 3 mm. long. Stomatal development takes place very rapidly; almost mature stomata were present only 0.05 mm. from the meristem at the leaf base. In surface view the epidermal cells of the abaxial surface 0.01 mm. from the basal meristem are rectangular, 2-3 times wider than long, and are arranged in longitudinal files. As the cells develop, they first become square, and then rectangular in the axial direction. During the initial stages of this process certain cells become square more rapidly than the others. They are the potential guard-cell-mother-cells. It was not possible to determine whether these cells had been derived by division from other epidermal cells, as is the case in many other monocotyledonous plants, for example Juncus effusus (Stebbins and Khush, 1961). The guard-cell-mother-cells are bordered on either flank by a single epidermal cell; the wall of these cells next to the guard-cell-mother-cell expands at the same rate as the mother-cell (fig. B). Each of these flanking cells cuts off a narrow cell next to the guard-cell-mother-cell by unequal division (fig. C). Each of these narrow cells is a subsidiary

cell in the paracytic stomatal apparatus; following on their formation the guard-cell-mother-cell divides down its length parallel to the subsidiary cells into 2 equal parts (fig. D). The subsidiary cells remain thin-walled, expanding slightly to attain their final shape, but the guard cell walls become thickened during the expansion phase, and the mutual wall between the guard cells separates along its middle region to form the stomatal pore (fig. E).



### 3.2 Generic and specific descriptions.

Genera and their species are arranged in alphabetical order; if a genus is divided into groups (for clarity of description) the species in each group are arranged alphabetically.

- Anthochortus Nees P. 84-  
in Lindl. *Introd. Syst.* ed. II (1835)
- Calorophus Labill. P. 89  
Pl. Nov. Holl II (1806) 78, t.228
- Cannomois Beauv. P. 101  
in *Ann. Sc. Nat. Ser. 1*, XIII (1828) 43, t.3 f.1
- Chaetanthus R.Br. P. 123  
Prodr. (1810) 251.
- Chondropetalum Rottb. P. 126  
Progr. 12 (1772) *Descr. et Ic. Pl.* (1773) 10,  
t.3. f.2.3.
- Coleocarya S.T. Blake P. 157  
Proc. Roy. Soc. Queensland 54 (1943) 75-77.
- Dielsia Gilg P. 160  
in *Engl. Bot. Jahrb.* XXXV (1904) 88, Fig.6 A-L.
- Elegia L. P. 164  
Mant. II (altera) (1771) 162, 297.
- Harperia Fitzgerald P. 207  
in *Journ. West Austral. Nat. Hist. Soc.* n.1  
(1904) 34-
- Hopkinsia Fitzgerald P. 210  
in *Journ. West Austral. Nat. Hist. Soc.* n.1  
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- Hypodiscus Nees P. 214  
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p.450
- Hypolaena R.Br. P. 241  
Prodr. (1810) 251.
- Lepidobolus Nees P. 262  
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- Leptocarpus R.Br. P. 271  
Prodr. (1810) 250
- Lepyrodia R.Br. P. 314  
Prodr. (1810) 247
- Loxocarya R.Br. P. 348  
Prodr. (1810) 249
- Lyginia R.Br. P. 366  
Prodr. (1810) 248
- Mastersiella Gilg Benedict P. 313  
in *Engler Pflanzten Fam* 2. Aufl (1930) 25

- Meeboldina Suess. p. 389  
 in Boissiera 7, (1943) 20-26.
- Onychosepalum Steud. p. 393  
 Syn. Pl. Glum. II (1855) 249.
- Phyllocomos Mast. p. 395  
 in Engl. Bot. Jahrb. XXIX, Beibl. 66 (1900) 19
- Restio Rottb. p. 399  
 Desc. Pl. Rav. Progr. 9 (1772)
- Sporadanthus F.v. Mue l. ex J.Buch. p. 585  
 in Trans. N.Z. Inst. VI (1874) p.340.
- Staberoha Kth. p. 593  
 Enum. Pl.III (1841) 442
- Thamnochortus Berg. p. 607  
 Desc. Pl. Cap. (1767) 353
- Willdenowia Thb. p. 644  
 in Vet. Akad. Handl. Stockh. XI (1790)  
 26 t.2, f.2.

Anthochortus NeesGeneric and specific descriptionCulm surface

Fig. 6

Hairs and papillae; none seen. Epidermal cells; ~~more~~ or less square to 2-3 times longer than wide; all walls wavy but longitudinal walls more wavy than transverse walls. Stomata; c.2/3 length of epidermal cells; subsidiary cells mostly equal in length to guard cells, with parallel or slightly wavy long anticlinal walls; end walls angular or nearly perpendicular (xi,xiii,xvii); guard cells with parallel long walls, and rounded ends (ix); apertures long, with parallel sides (ii). Silica; bodies absent. Crystals; absent. Tannin; present in some cells. Cuticular marks; granular.

Culm T.S.

Outline; sub-terete, slightly flattened on one side and tending to be polygonal. Epidermal cells; square to  $1\frac{1}{2}$  times higher than wide. Outer walls moderately thickened, other walls slightly thickened. Anticlinal walls straight. Stomata; superficial; subsidiary cells of types (b) and (c), walls slightly thickened; guard cells having lips at inner and outer apertures (7,8), lumina triangular, wide (3). Hypodermis; absent. Chlorenchyma; divided into 5 longitudinal chambers. Cells of 2 types: (i) lobed, more or less isodiametric to slightly higher than wide, walls slightly thickened (staining light pink with safranin); in 1 outer layer; with large, intercellular air-spaces; (ii) palisade, mostly c.4-5 times higher than wide, walls thin (staining

blue with haematoxylin); present in 1-2 inner layers; air-spaces very infrequent. Parenchyma sheath; cells in 1 (occasionally 2) layer(s), largest next to sclerenchyma sheath, smallest next to girders. Sclerenchyma sheath; poorly developed, cells in 1-3 layers; walls moderately thickened or thick. Sheath produced at regular intervals into strong girders extending outwards to epidermis (5 present in specimen examined). Individual girders 'T'-shaped, the column having concave sides and being from 4-7 cells wide, the bar being 1 cell thick and 12-15 cells wide. Vascular bundles: (i) peripheral; well developed, each having 1 medium-sized, angular tracheid on either flank, phloem abutting directly onto xylem; (ii) medullary; radially elongated; each with 1 medium-sized/wide, many sided mx. vessel on either flank; vessel wall-pitting opposite-scalariform; perforation plates oblique, many-barred, scalariform-reticulate; px. vessels and tracheids medium-sized to narrow, enclosed in xylem parenchyma; phloem poles abutting directly onto xylem, over-arching and extending between flanking mx. vessels. Bundle sheaths; sclerenchymatous; fibres at bundle poles thick-walled, arranged in 1-2 layers; those on flanks moderately thick-walled, arranged in 1 layer; fibres at xylem pole very narrow with slightly thickened walls. Central ground tissue; parenchymatous, walls of central cells thinnest, often breaking down to form cavity. Silica; bodies spheroidal-nodular, present in some cells of parenchyma sheath. Crystals; none seen. Tannin; present in some epidermal cells.

Leaf surface not seen

Leaf T.S.

Outline; enclosing culm in  $1\frac{1}{2}$  turns, central region thick, with deep, widely spaced longitudinal grooves in abaxial surface, leaf c.  $\frac{1}{2}$  as thick at grooves as between them (fig. 6D). Epidermis: (i) abaxial; cells 4-sided, of 2 main sizes: (a) between grooves more or less square to slightly higher than wide; outer walls moderately thickened, anticlinal and inner walls slightly thickened, not wavy; (b) at base of grooves cells c.  $\frac{1}{2}$ - $\frac{1}{3}$  as wide and high as type (a), all walls thin; (ii) adaxial; cells 4-5-sided, c.  $\frac{1}{3}$  as wide and  $\frac{1}{5}$  as high as those of abaxial surface; walls slightly thickened. Stomata; present in abaxial surface only, among cells of type (a), superficial, as in culm. Hypodermis; absent. Chlorenchyma; confined to thicker parts of central part of leaf; composed of 2-3 layers of cells situated below abaxial epidermis; cells of outer layer lobed, as wide as or  $1\frac{1}{2}$  times wider than high, walls slightly thickened (as in culm); cells of inner layers palisade, ranging from twice to 7 times as wide as high, walls thin. Vascular bundles; of 2 main sizes; (i) larger, in grooves; tracheids all narrow, arranged in an arc, or flanking tracheids medium-sized, phloem partially enclosed by arc; (ii) smaller, opposite chlorenchyma in wider parts of leaf; all tracheids narrow. Bundle sheaths; O.S., if present, not distinguishable from ground tissue; I.S. sclerenchymatous, fibres 1-layered round smaller bundles, thin-walled, fibres in 1-2 layers at phloem poles of larger bundles, with thick walls,

counted



those on flanks and at xylem pole present in 1 layer, with thin walls. Sclerenchyma; present only as bundle sheaths. Ground tissue; parenchymatous, in 3-4 layers occupying all space between vascular bundles, chlorenchyma and adaxial epidermis. Air-cavities; absent. Silica; spheroidal-nodular bodies present in some cells situated between larger vascular bundles and abaxial epidermis. Crystals and Tannin; none seen.

Rhizome and root not seen.

Material examined

A. ecklonii Nees                      Esterhuysen 10901 S. Afr.                      (K)

Card characters:

Culm diameter: 1 by 0.75 mm.

2,7,9,11,15,20,22,26,33,34,42,43,49,50,52,53,  
54,55,56,60,68,71,72,73,78,81,88,110,112,115,  
121,122,123,124.

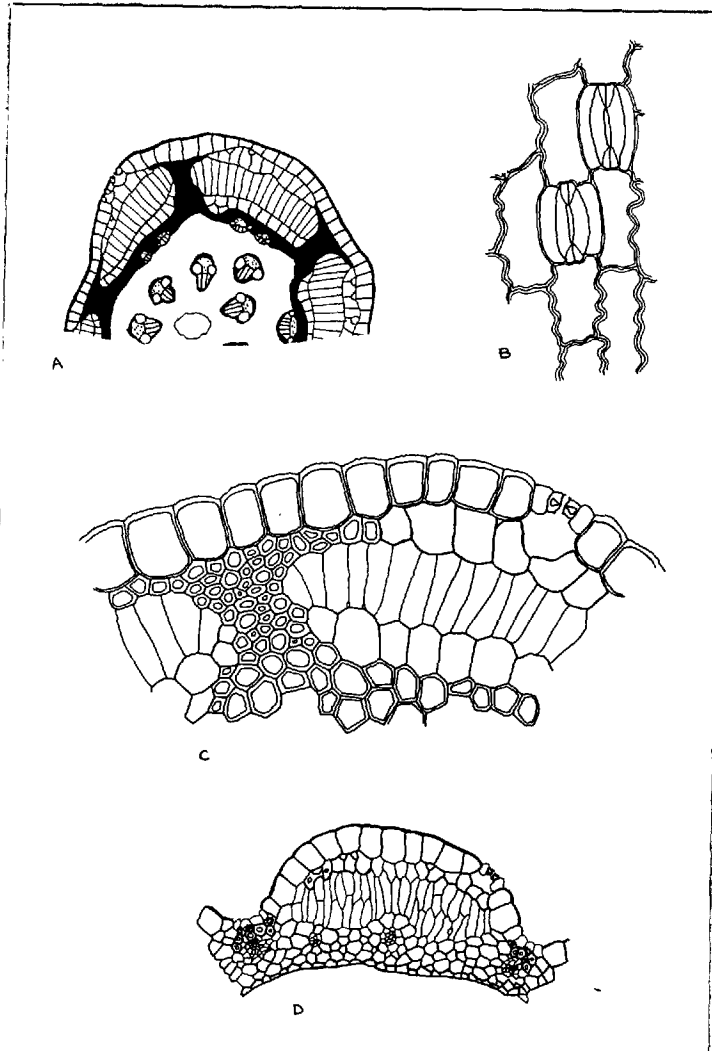


Fig. 6. Anthechertus ecklonii. A. culm L.P., T.S. (x50);  
 B. culm epidermis surface view (x185); C. culm H.P., T.S.  
 (x185); D. part of leaf T.S. (x50).

Calorophus Labill.Generic description.Culm surface:

Fig. 7

Hairs; absent. Epidermal cells; rectangular, long axis parallel to that of culm, walls moderately thickened, wavy. Stomata; subsidiary cells of 2 main types: (i) outer, axial, anticlinal walls wavy (xvii); (ii) centre compressed almost to exclusion of lumen, but ends uncompressed and bulbous (xx); guard cells thick-walled, ends rounded (ix), frequently shorter than subsidiary cells. Silica; none seen. Tannin; none seen. Cuticular marks; granular; longitudinal striations present in one specimen.

Culm T.S.

Outline; terete, or terete and with one flattened side (latter normal condition of side branches). Epidermal cells; square to slightly higher than wide; outer walls thick, other walls thin or moderately thickened. Stomata; superficial; subsidiary cells frequently compressed, lumina either wider above and below (s), or only below guard cells (r); guard cells frequently with cuticular lips at outer aperture (5). Hypodermis; absent. Chlorenchyma; composed of peg-cells in 1, 2, or 3 layers. Protective cells when present unusual, being palisade, equal in height to cells of outer chlorenchyma layer; each protective cell with short arms on outer end (immediately below subsidiary cells), each arm arranged at about 90 degrees to long axis of cell and equal to it in width; adjacent arms touching; tube formed by ring of such cells thus complete at outer end only, the main,

palisade axes being well separated from one another; walls moderately thickened. Parenchyma sheath; 1-or several-layered, continuous round culm. Sclerenchyma sheath; well developed, enclosing peripheral and all or some medullary bundles; outline either circular, or with rounded ridges opposite to and including peripheral vascular bundles.

Vascular bundles: (i) peripheral; phloem pole small, rounded, partially enclosed by arc of tracheids; tracheids medium-sized and narrow; tracheid end walls oblique, scalariform, side walls with scalariform pitting; (ii) medullary; metaxylem vessels wide or medium-sized, angular, (i) 1 on either bundle flank, widely spaced or close together, or (ii) single and central. Wall pitting alternate or opposite scalariform; perforation plates simple, transverse to slightly oblique; phloem abutting directly onto xylem, with strands of fibres in C. gracillima. Bundle sheaths; sclerenchymatous; fibres in 1 or 2 layers at poles, 1 layer on flanks. Central ground tissue; parenchymatous, cells frequently breaking down to form central cavity. Silica; bodies spheroidal-nodular, present in some cells of parenchyma sheath.

Crystals; absent. Tannin; none seen.

Leaf surface:

Hairs; absent. Epidermal cells; square to oblong, anticlinal walls wavy. Stomata; paracytic, subsidiary cells with wavy outer axial walls and obtuse ends (xvii); guard cells thick-walled, of type (ix). Silica; absent. Tannin; none seen. Cuticular marks; longitudinal striations present in some species.

Leaf T.S.

Blade; seen in C. elongatus only.

Outline; oval. Epidermis: abaxial and adaxial; cells more or less square, c. 20 $\mu$  wide and to c. 25 $\mu$  high. Outer wall moderately thickened, inner and anticlinal walls thin. Stomata; superficial, as in culm of same species; subsidiary cells large, wider and deeper than guard cells, each being half as deep as epidermal cells, walls thin. Hypodermis; absent. Chlorenchyma; composed of palisade peg-cells and lobed cells in 2-3 layers, occupying all the volume round the vascular bundle sheaths and continuous to the epidermis; protective cells present, of same type as in culm. Vascular bundles; 3 present, all orientated with phloem poles facing abaxial surface; median bundle largest, with 1 angular, medium-sized, metaxylem tracheid on either flank and a central group of narrower tracheids; xylem of lateral bundles made up of narrow tracheids; cells of phloem abutting directly onto xylem. Bundle sheaths; O.S. composed of 2-3 layers of thin-walled parenchymatous cells, I.S. composed of 1 layer of narrow, thick-walled fibres. Sclerenchyma; represented by bundle sheaths only. Ground tissue; all chlorenchymatous. Air-cavities; none present. Crystals; absent. Silica; none seen. Tannin; none seen.

Leaf sheath; seen in C. minor (NzG 3616) only.

Encircling culm, with overlap of 1/3 turn; 220 $\mu$  at thickest part.

Epidermis; (i) abaxial; cells more or less square,

outer walls moderately thickened, inner and anticlinal walls thin; anticlinal walls straight, outer walls slightly corrugate; (ii) adaxial, cells 4 or 5-sided, slightly smaller than abaxial cells, walls slightly thickened.

Stomata; found on abaxial epidermis only, superficial; subsidiary cells narrow at top, ballooning out below (r); c.  $1\frac{1}{2}$  times higher than guard cells, the top being level with that of guard cell; guard cells with step on inner wall (see fig. 7B); lumina lenticular (l). Chlorenchyma; consisting of 1 layer of palisade peg-cells. Vascular bundles; <sup>in 1 row,</sup> /of 2 sizes, more or less alternating; (i) larger bundles, having numerous narrow tracheids at the xylem pole and 1,2 or 3 medium-sized, angular tracheids on either flank; (ii) smaller bundles, having only narrow tracheids. Phloem poles consisting of only 5-6 cells in smaller bundles and up to 25 cells in larger bundles; abutting directly onto xylem on abaxial side. Bundle sheaths; O.S. parenchymatous, present to outer side of phloem pole only, becoming continuous with parenchyma from adjacent bundles and forming a layer, 1 cell thick, immediately <sup>to</sup> /inside of chlorenchyma; I.S. sclerenchymatous, 1-2 cells wide, fibres narrower and having thicker walls at phloem than xylem pole. Sclerenchyma; as bundle sheaths and also as a layer, 2-4 cells wide, joining bundle sheaths laterally, occurring immediately to inside of parenchyma layer. Those cells closest to parenchyma most heavily thickened. Ground tissue; 1-2 layers of polygonal cells, occurring between sclerenchyma and adaxial epidermis.

Air-cavities; absent. Silica; present as spheroidal-nodular

bodies in specially thickened cells of parenchyma sheath; thickenings present in all but outer walls. Crystals; absent.

T.S. Rhizome.

Seen only in C. minor Hk. f. G3616. Diameter 3 mm. Hairs; multicellular, thin-walled; (i) unbranched filament, up to 4 cells long, cells 2-6 times as long as wide; (ii) bifurcating, stalk 2-celled, branches each 2 cells long. Epidermal cells; thin-walled, more or less rectangular, twice as wide as high. Hypodermis; absent. Outer cortex; cells parenchymatous, polygonal, more or less straight-sided, in up to 5 layers. Middle cortex; cells lobed, more or less isodiametric, with large intercellular spaces, in up to 7 layers. Inner cortex; (= endodermoid layer) composed of 1-2 layers of thin-walled, more or less isodiametric cells, some containing small, spheroidal-nodular silica-bodies. Vascular bundles; of 2 main types; (i) collateral, having arc of wide, thin-walled, angular metaxylem vessels partially enclosing phloem; (ii) amphivasal, having circle of wide, thin-walled, angular metaxylem vessels enclosing phloem. Central ground tissue; cells of 2 types; (i) angular, walls slightly thickened, surrounding vascular bundles; (ii) lobed, more or less isodiametric, thin-walled, occupying central region. Silica; bodies present in endodermoid sheath and central ground tissue. Crystals; none seen. Tannin; none seen.

T.S. Root

Seen in C. minor Hk. f. Cheadle CA331 and G3616.

Root hairs; sparse, arising from cells similar to those of remainder of epidermis; hair shaft half as wide as base. Epidermal cells; thin-walled, more or less square. Outer cortex; composed of 1 layer of thin-cellulose-walled cells outside 5-12 layers of angular cells with slightly lignified thickened walls. Inner cortex; consisting of 7-8 layers of square thin-walled cells diminishing regularly in size towards the centre of the root; arranged in radial files or plates. Small intercellular spaces occurring at angles. Endodermis; composed of 1 layer of large, thin to moderately thick-walled, lignified cells, up to twice as high as wide. Pericycle; cells very narrow, in a single layer about 1/6 height of endodermal cells. Vascular tissue; protoxylem and phloem poles alternating; metaxylem vessels large, thin-walled, rounded, arranged in a single ring to inner side of that formed by phloem. Central ground tissue; cells parenchymatous, polygonal, walls slightly thickened.

Material examined:

C. elongatus Labill.	Hinsby, W.M.C. Stranan,	
" "	Tasmania	(K)
" "	"	851 (K)
" "	"	852 (K)
" gracillimus F.v. Muell.	Drummond, Herb. Hook. An. 1867	
" "	Swan R., Australia	14119 (K)
" "	Andrews, C. Bayswater, Perth,	
" "	Australia	14118 (K)
" minor Hk. f.	Moore G3616, Salt marsh,	
" "	Moana Tua Tua, N. Zealand	(S)
" "	Cheadle CA331, Nr. Sydney,	
" "	Australia	(S)



C. minor Hk. f.	Drummond, Herb. Hook. An. 1867		
"	Swan R., Australia	14531	(K)
"	Hubbard, C.E. 4609, Fraser Is.		
"	Australia, An. 1930	14115	(K)
"	Cunningham, A. Austr. Herb.		
"	An. 1862, Australia	14113	(K)
"	? Port Jackson, 28, Australia	14111	(K)
"	Herb. Hook. An. 1867, 599		
"	Australia	14114	(K)
"	? Port Jackson, 49,		
"	Australia	14112	(K)

Species descriptions:

C. elongatus Labill. Culm diameter: 0.75-1.5mm.

Card characters: 2c, 5b, 5c, 6a, 7, 9, 15, 18, 19, 21, 26, 27, 28, 31, 37, 42, 44, 45, 47, 48, 50, 52, 54, 55, 60, 61, 70, 71, 78, 81, 88, 110, 112, 115, 118, 121, 123.  
 Hinsby  
 2c, 5b, 5c, 6a, 7, 9, 15, 18, 21, 26, 31, 37, 42, 44, 45, 47, 48, 50, 51, 52, 54, 55, 60, 70, 110, 112, 114, 115, 118, 121, 123.  
 851  
 2c, 5b, 5c, 6a, 7, 9, 15, 18, 19, 21, 26, 27, 28, 31, 37, 42, 44, 45, 47, 48, 50, 52, 54, 55, 60, 70, 110, 112, 114, 115, 118, 121, 123.  
 852

Culm surface:

Trichomes; absent. Epidermal cells; as long as or up to  $1\frac{1}{2}$  times longer than wide, walls wavy, moderately thickened. Stomata; subsidiary cells with wavy outer axial anticlinal walls (xvii); guard cells shorter than subsidiary cells, of type (ix). Cuticular marks; granular; thickenings present over transverse end-walls in 851.

Culm T.S.

Outline; rounded and slightly flattened. Epidermal cells; 4-sided; c.  $1\frac{1}{2}$  times as high as wide, (twice as high

as wide in 851). Anticlinal walls slightly to very wavy, moderately thickened; outer walls thick, corrugate (with slight papillae over anticlinal walls in 851). Stomata; superficial; subsidiary cells not compressed; outer wall produced into a ridge (k); guard cells with cuticular lips at outer and inner apertures (5, 8). Chlorenchyma; composed of 2-3 layers of peg-cells with few, large pegs, mostly on upper and lower faces; cells close together as seen in T.S., (well spaced as seen in L.S.); protective cells having lobed outer ends (see fig. 7A). Parenchyma sheath; cells thin-walled, polygonal (2-3 times as long as wide as seen in L.S.), present in 2-3 layers. Sclerenchyma sheath; well developed, 4-8-layered. Vascular bundles: (i) peripheral; with or without medium-sized flanking tracheids; (ii) medullary; of 2 main types, (a) having 1 large medullary vessel on either flank separated by 1-2 layers of narrow parenchyma cells, phloem closely applied to xylem; (b) with 1 large metaxylem vessel, capped by phloem. Px. pole opposite to the phloem in both types: consisting of annular and spiral vessels. Bundle sheaths; sclerenchymatous, 1-layered, cells at poles with thick walls, those at bundle flanks thinner. Central ground tissue; parenchymatous, cells round bundles with slightly thickened walls, central cells thin-walled, breaking down. Silica; bodies infrequent, present in some cells of parenchyma sheath.

### Leaf

See generic description.

C. gracillimas F. v. Muell.

Culm diameter: 0.6, 0.8 mm.

Card characters: 3,5b,7,9,15,19,21,25,26,27,28,31,42,43,49,  
50,51,52,54,55,56,60,68,110,112,114,115,121,  
14119; 123.  
5b,6,7,9,14,15,19,21,26,27,28,31,42,43,47,  
14118; 49,50,52,54,55,60,68,110,112,114,115,121,123

Culm surface:

Epidermal cells; very elongated, mostly 4-5 times longer than wide, walls wavy. Stomata; subsidiary cells slightly to much constricted in the middle, ends rounded or square to slightly obtuse(xx); guard cells with rounded ends, much shorter than subsidiary cells<sup>(ix)</sup>. Cuticular marks; granular.

Culm T.S.

Outline; terete, slightly flattened on one side.  
Epidermal cells; mostly twice as wide as high, outer walls thick, other walls thin; inner wall having several faces.  
Stomata; superficial; subsidiary cells wide below guard cells, narrow at outer ends (r); guard cells having cuticular lips on outer walls (5). Chlorenchyma; composed of peg-cells arranged in 1 layer; protective cells absent.  
Parenchyma sheath; cells in 1 layer opposite pvbs.; regions of numerous stegmata in between pvbs. Sclerenchyma sheath; circular in outline; fibres thick-walled, in 5-6 layers, widest towards centre of culm. Vascular bundles: (i) peripheral; with medium-sized to narrow tracheids arranged in shallow arc, partly enclosing phloem; (ii) medullary; of 2 types; (a) smaller, with 1 medium-sized metaxylem vessel on either flank, sheath attached to culm sclerenchyma cylinder; (b) larger, free, flanking mx. vessels wide, angular,

separated by 2-3 rows of tracheids, narrow parenchymatous cells, and narrow vessels; phloem containing longitudinal strands of narrow fibres with slightly thickened walls.

Bundle sheaths; sclerenchymatous, narrow fibres with slightly thickened walls occurring in 1 row on bundle flanks and wider fibres with thicker walls present in up to 2 layers at poles. Central ground tissue; parenchymatous, walls slightly thickened. Silica; bodies very frequent in stegmata of parenchyma sheath. Granular material present sporadically in most tissues.

C. minor Hk. f.

Culm diameter: 0.75-2.0 mm.

Card characters: 3,5b,7,9,14,19,20,21,22,26,27,28,31,42,43,  
47,49,50,51,52,54,55,60,68,71,73,80,81,88,  
G3616; 89,90,101,102,103,105,106,121,122,123.  
5b,6,13,19,20,21,26,27,28,30,31,42,43,49,50,  
52,55,60,70,71,73,78,81,88,112,115,121,122,  
14531; 123.  
5b,6,7,9,14,15,18,19,21,25,26,27,28,31,42,  
43,47,49,50,52,54,55,56,60,68,110,112,114,  
14115; 115,121,122,123.  
2,5b,7,9,14,19,20,21,22,25,26,27,28,31,42,43,  
47,49,50,51,52,54,55,56,60,68,110,114,115,  
14113; 121,122,123.  
3,5b,7,9,15,19,20,21,22,25,26,31,42,43,47,  
49,50,51,52,54,55,56,60,68,110,112,114,115,  
14111; 121,122,123.  
5b,6,7,9,14,19,21,26,27,28,31,36,42,44,47,  
49,50,52,54,55,56,60,68,110,112,114,115,121,  
14114; 122,123.  
3,5b,7,9,15,19,21,25,26,27,28,31,42,43,47,  
49,50,51,52,54,55,56,60,68,71,72,78,110,112,  
14112; 114,115,121,122,123.  
3,5b,7,9,15,18,19,21,26,27,31,36,42,43,49,52,  
CA331; 54,55,60,68,71,80,88,103,104,105,106,113,115,  
(basal) 121,122,123.

Culm surface:

Epidermal cells; oblong, 2-3 times longer than wide, walls sinuous. Stomata; subsidiary cells extending beyond guard cells at either end; long anticlinal walls wavy or much compressed in the centre (xx); guard cells with curved ends, outline of guard cell pair more or less circular (viii). Cuticular marks; granular, except in G3616, from New Zealand, where longitudinally striate.

Culm T.S.

Outline; terete, with one flattened side. Epidermal cells; as high as or slightly higher than wide; outer walls thick, other walls thin. Stomata; as for genus. Chlorenchyma; composed of peg-cells arranged in 1 layer (2 layers in No.14114), cells mainly 4-6 times higher than wide; protective cells, <sup>absent,</sup> see generic description. Parenchyma sheath; 1-layered, with occasional stegmata. Sclerenchyma sheath; mainly only 3-4-layered, outline rounded. Vascular bundles: (i) peripheral; each with a shallow arc of medium-sized to narrow, angular tracheids; phloem partially enclosed by the arc; (ii) medullary; mostly free, with 2 large, rounded-angular to -oval metaxylem vessels with slightly thickened walls, separated from one another by 1 or 2 files of narrow, flattened tracheids, or touching one another; each mx. vessel enclosed by a sheath of flattened parenchyma cells and tracheids; phloem pole abutting directly onto xylem, overarching the larger mx. vessels on either side of bundle; occasional, outer bundles with only 1 large, central, metaxylem vessel. Bundle sheaths; sclerenchymatous

1-layered, except at xylem pole, where 2-layered. Ground tissue; parenchymatous, cell walls slightly thickened; inner cells breaking down and forming a central cavity. Silica; present as (i) bodies, in stegmata of parenchyma sheath; (ii) granular silica, in some cells of ground tissue, and occasionally in some chlorenchyma cells. Leaf, Rhizome and Root. See generic description.

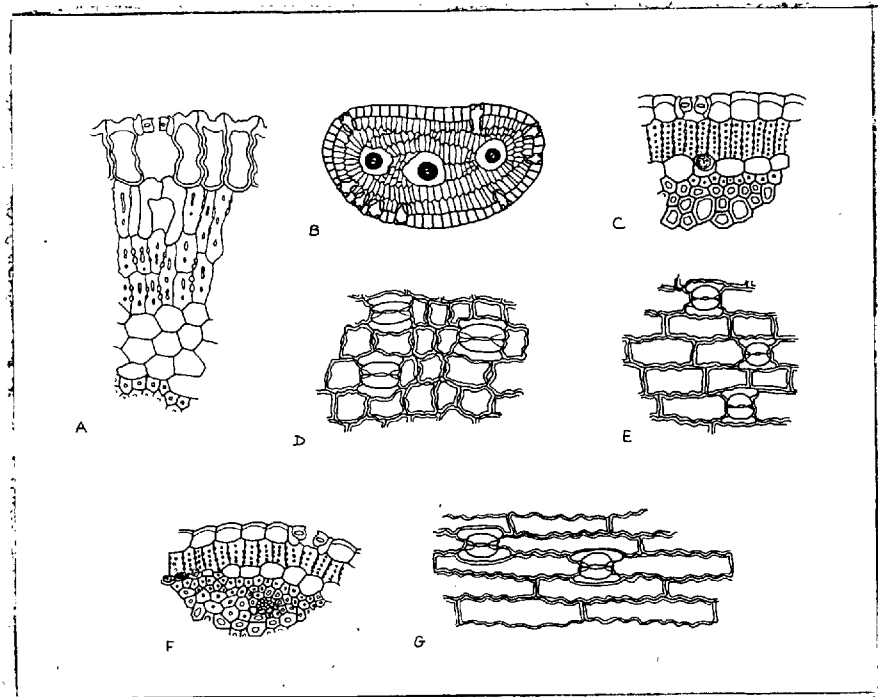


Fig. 7. Calerephus A. elongatus culm T.S. ; B. elongatus leaf blade T.S. ; C. minor culm T.S. ; D. elongatus culm epidermis; E. minor culm epidermis; F. gracillimus culm T.S. ; G. gracillimus culm epidermis. B x60, others x240.

Cannomois Beauv.

Generic description

Culm surface

Hairs and papillae; absent. Epidermal cells; 4-sided and as long as or up to 3 times longer than wide or 5-6-sided and up to twice as long as wide. Walls slightly or moderately thickened, or thick, straight or wavy. Stomata; subsidiary cells of types (xi), (xii), (xv) and (xviii); guard cells of types (vii) and (x); apertures of type (ii). Silica and Crystals; none seen. Tannin; present in epidermal cells in some species. Cuticular marks; granular, with or without longitudinal striations.

Culm T.S.

Outline; terete. Cuticle; thick or very thick. Epidermal cells; present in 1 layer; as high as to slightly higher than wide or 2-3 or 6-8 times higher than wide. Outer walls thick, frequently convex, other walls moderately thickened, anticlinal walls straight or wavy. Stomata; superficial in species with shorter epidermal cells, sunken in the others; subsidiary cells of types (g), (i), (k) and (o), outer wall frequently produced into a conspicuous ridge; guard cells with lip at outer aperture (7) in some species, and some species with ridge (9) on inner wall; walls to pore frequently convex (12); lumina of type (4), triangular, oblique. Hypodermis; absent. Chlorenchyma; composed of 2 uninterrupted layers of palisade peg-cells; protective cells present in all species, more strongly developed in some than others. Parenchyma sheath; mainly 1-layered, 2-layered

in places in some species; cells opposite pvbs. larger than the others. Sclerenchyma sheath; well developed in all species, particularly wide in some; outline rounded, with slight ribs between pvbs. in some species. Vascular bundles: (i) peripheral; unusually well developed; outline rounded, or radially or tangentially oval; xylem composed of wide, angular tracheids with slightly to moderately thickened walls, arranged in a single-layered arc or U; phloem pole situated in concavity of arc or U; (ii) medullary; outline rounded or tangentially oval, each with 1 or 2 narrow, medium-sized or wide, rounded-angular, thick-walled mx. vessels on either flank, these separated from one another by 2-3 files of narrow parenchymatous cells; phloem only occasionally abutting directly onto xylem, normally separated from it by a layer of narrow parenchymatous cells with thin or slightly thickened walls; protoxylem poles present in all but outermost smallest bundles. Wall pitting of flanking mx. vessels scalariform, perforation plates oblique, scalariform or almost transverse, simple. Many bundles free from culm sclerenchyma sheath in all species. Bundle sheaths; sclerenchymatous, fibres thick-walled, either completely encircling, 1-layered on flanks and 2-3-layered at caps, or present as 1-3-layered caps. Central ground tissue; parenchymatous, walls thin or slightly to moderately thickened; small, scattered groups of narrower, thin-walled cells present in some species. Central cells frequently thin-walled and breaking down to form central cavity. Silica; spheroidal-nodular bodies present in some smaller



cells of parenchyma sheath and some outer cells of ribs from sclerenchyma sheath. Crystals; none seen. Tannin; present in some epidermal cells of some species.

Leaf T.S.

Sheath only, seen in C. acuminata and C. virgata; overlapping culm by  $1\frac{1}{2}$  turns.

Hairs; none present. Epidermis: (i) adaxial; cells 5-sided, outer wall flat, anticlinal walls short, inner walls with 2 faces, all walls moderately thickened; (ii) abaxial; cells 4-sided, of unequal heights, 2-3 times wider than those of adaxial surface; individual cells either as high as wide, or  $1\frac{1}{2}$ -2 times higher than wide; all walls moderately thickened, outer walls convex or flattened-dome-shaped, anticlinal walls not wavy. Stomata; present in abaxial surface only; sunken; subsidiary cells of type (d), but guard cells mounted on inner ends (not centrally, as normal); guard cells with ridge on inner wall (9); walls to pore convex (12); lumina of type (4). Chlorenchyma; represent by more or less isodiametric, lobed cells in 2-4 layers restricted to small areas opposite to stomata and between sheaths of vascular bundles (i.e. in longitudinal channels below abaxial epidermis as seen in surface view). Protective cells absent.

Vascular bundles: (i) small; tracheids few, all narrow; phloem poles composed of 10-20 cells; (ii) alternating with (i), very small bundles consisting of 2-3 tracheids and 3-4 phloem cells. Bundle sheaths; O.S. parenchymatous, 1-layered, present on abaxial side and flanks of bundles; I.S. sclerenchymatous, completely encircling bundles, fibres

medium-sized and narrow, thick-walled, in 2-3 layers at phloem pole, 3-4 layers on flanks and 6-8 layers at xylem pole; outline of I.S. rounded, or laterally oval, with bundle positioned excentrically, near the abaxial surface. Sclerenchyma; represented by that of inner bundle sheaths and also present as ground tissue at narrowing leaf margins. Ground tissue; composed of wide-celled parenchyma, in 2-3 layers between vascular bundle sheaths and adaxial epidermis, and 3-4 layers between bundles, abutting onto chlorenchyma to abaxial side and adaxial epidermis to adaxial side. Air-cavities; absent. Silica; (i) spheroidal-nodular bodies, present in some cells of O.S. and some outer cells of I.S.; (ii) granular material, in some cells of ground tissue and occasional xylem and phloem cells. Tannin; none seen.

Rhizome T.S.

Seen in C. acuminata and C. virgata.

Epidermal cells; 4-sided, up to  $1\frac{1}{2}$ -2 times higher than wide; outer wall slightly to moderately thickened, other walls slightly thickened. Outer cortex; about 1<sup>0</sup>-layered in C. acuminata, composed of parenchymatous cells interspersed with tangential bands of sclerenchymatous cells; all parenchymatous in C. virgata, cells in about 20 layers.

Inner cortex; composed of 4-8 layers of lobed, more or less isodiametric, thin-walled cells. Endodermoid layer; cells with thin outer walls, other walls moderately thickened (C. virgata) or thick (C. acuminata). Vascular bundles; amphivasal and collateral; mx. vessels wide, angular, wall pitting scalariform, perforation plates simple, more or less

transverse; some outer bundles without wide mx. vessels; bundles scattered throughout ground tissue. Bundle sheaths; indistinguishable from ground tissue. Ground tissue; parenchymatous, cells either (i) angular, 6-sided, thick-walled (forming bulk of tissue) or (ii) thin-walled, lobed (in scattered strands). Silica; occasional granular bodies present in some lobed cells of central ground tissue.

Tannin; none seen.

Root T.S.

Seen in C. acuminata and C. virgata.

Epidermal cells; 4-5-sided, slightly wider than high, thin-walled. Root hairs; arising from cells similar to others in epidermis, shaft about  $1/3-1/2$  of width of base. Outer cortex; composed of 2-4 layers of 5-6-sided parenchyma cells with slightly thickened walls. Middle cortex; consisting of radiating plates composed of 1 or 2 layers of wide, rounded parenchyma cells with slightly thickened walls; air-spaces present between plates of cells. Inner cortex; made up of 1-3 layers of parenchymatous cells, individual cells rounded or slightly wider than high, with slightly to moderately thickened walls. Endodermis; 1-layered, cells with thin outer walls, all other walls very thick; lumina occluded in C. acuminata, very reduced in C. virgata.  
Pericycle; 2-3-layered in C. virgata, about 7-layered in C. acuminata; cells 4-6-sided, mostly as high as wide, with thick walls. Vascular system; phloem strands composed of 2-4 wide sieve tubes and several companion cells; strands arranged (i) in outer ring, immediately inside pericycle, (ii) to inner side of, but close to, mx. vessels

of outer ring, (iii) close to mx. vessels scattered in central region of root, 1-3 strands to each vessel or vessel multiple. Metaxylem vessels radially oval-angular, either solitary, or in tangential or radial multiples of 2 or 3, each vessel or multiple ensheathed by single or double layer of compressed tracheids. Mx. vessels arranged in outer ring and also scattered in central ground tissue. Central ground tissue; parenchymatous, all, except for few central cells in C. acuminata, thick-walled. Silica and Tannin; none seen.

Material examined:

<i>C. acuminata</i> (Thb.) Pill.	Univ. Cape Town 8735 ♂	
"	S. Afr.	10124 (K)
"	Acocks 14706 (in Kew Herb. as <u>C. simplex</u> Kth.)	
"	S. Afr.	10129 (K)
<i>C. drègei</i> Pill.	Nat. Herb. Pretoria 18266	
"	S. Afr.	10126 (K)
<i>C. nitida</i> (Mast.) Pill.	Esterhuysen 8382	S. Afr. 10128 (K)
"	10085	S. Afr. 10127 (K)
<i>C. parviflora</i> (Thb.) Pill.	Compton 2626	S. Afr. 10125 (K)
<i>C. scirpoides</i> Mast.	Burchell	S. Afr. 1111B (M)
<i>C. virgata</i> Steud.	Cheadle, V.I. CA742	
"	S. Afr.	1112B (S)
"	Burchell	S. Afr. 1113B (M)
"	Burchell	S. Afr. 1114B (M)

Species descriptions

<u><i>C. acuminata</i></u> (Thb.) Pill.	Culm diameter: 1.5, 2.4 mm.
<u>Card characters:</u>	3,5b,6,7,9,14,19,21,26,27,28,31,37,42,44,47,48,49,50,51,55,56,58b,68,71,73,74,81,87,88,89,90,93,94,99,101,104,105,108,110,116,117,121,122,123.
Acocks 14706	

3,5b,7,9,14,19,21,26,27,28,31,37,42,44,47,  
48,49,50,51,52,54,55,56,60,68,110,112,115,  
8735 117,121,122,123.

Culm surface

Epidermal cells; 14706: 4-sided, those next to stomata as long as wide, partly overhanging subsidiary cells, others 2-3 times longer than wide; walls moderately thickened, not wavy; 8735: 4-sided, those next to stomata as long as wide, others mostly 3 times, some up to 4 times longer than wide; walls slightly thickened, wavy. Stomata; subsidiary cells wide, predominantly of types (xiv) and (xvi) in 14706, and (xi) and (xii) in 8735; guard cells narrower than usual, of type (vii); apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; granular, with longitudinal striations.

Culm T.S.

Cuticle; thick, ridged. Epidermal cells; as high as wide to slightly higher than wide, some up to twice as wide as high in 14706, the shorter cells being next to stomata; outer walls thick, slightly convex in 8735, dome-shaped in many cells in 14706; other walls moderately thickened, anticlinal walls not wavy. Stomata; superficial in 8735, slightly sunken in 14706. Subsidiary cells of types (f) and (i), the inner end more bulbous than normal; guard cells with no lips in 8735, with slight lips at inner aperture in 14706; walls to pore of type (11); lumina of type (4a). Chlorenchyma; composed of 2 similar layers of peg-cells, individual cells mostly 4 times higher than wide, those opposite protective cells normally twice as high as wide;

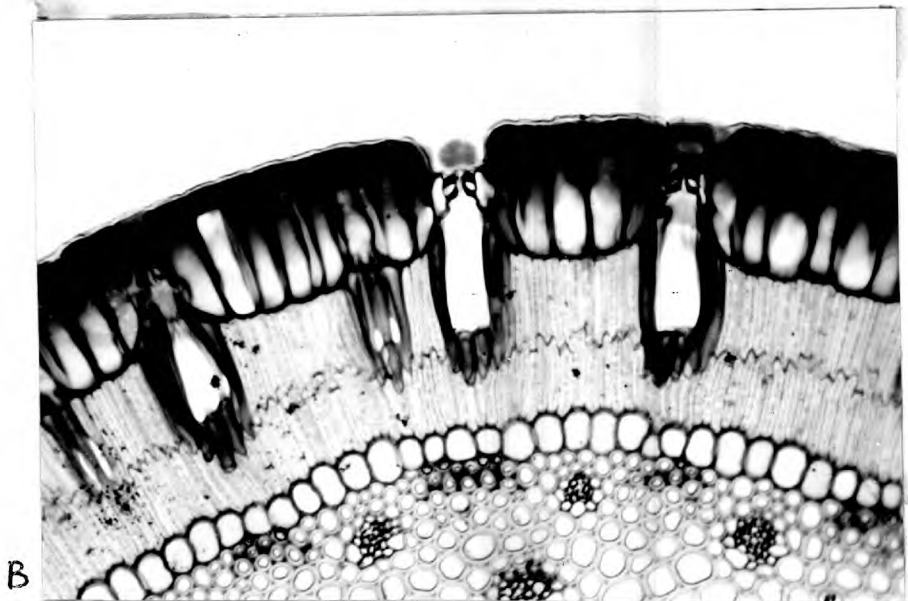
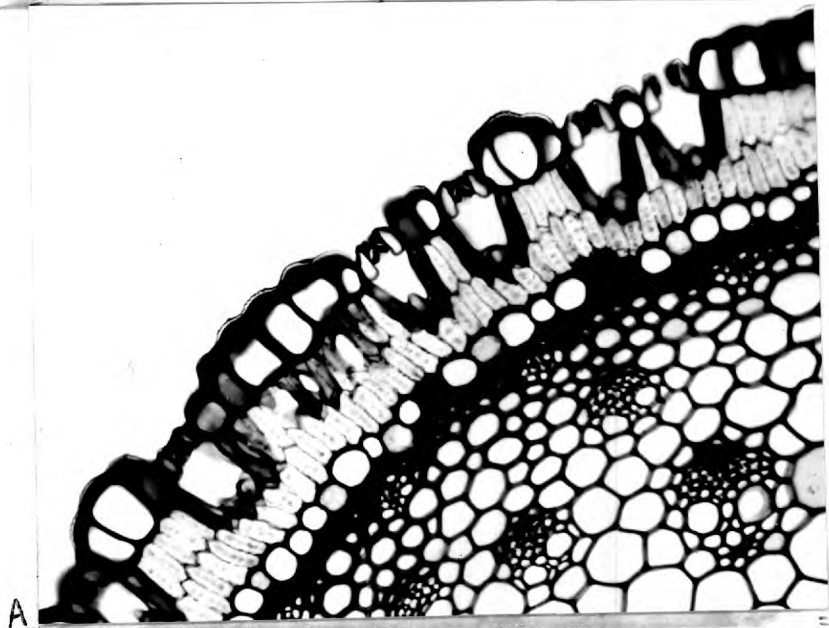


Fig. 8. A. Cannemopsis accuminata; B. C. nitida  
culm T.S. ; x200

pegs small, frequent. Protective cells with slightly to moderately thickened walls, cells extending in 1 layer from epidermis to about half way into inner chlorenchyma layer, each cell expanded at outer and inner ends, making contact with its neighbours, middle part of walls free, bordering wide, elongated apertures. Parenchyma sheath; cells mostly as high as or slightly higher than wide, arranged in 1 layer, being interrupted between pvbs. opposite to pvbs., by short, wide, rectangular girders of fibres from sclerenchyma sheath. Sclerenchyma sheath; 3-6- or 6-9-layered, outline rounded, with rectangular girders between pvbs., projecting into and interrupting parenchyma sheath; girders 2-3-layered and 5-9 cells wide in 8735, 3-4-layered and 2-4 cells wide in 14706. Fibres of girders and outer layers of sheath narrow, very thick-walled, those of inner layers wider, with thick walls. Vascular bundles: (i) peripheral; 2-6 medium-sized or wide, angular, thin-walled tracheids and several narrow tracheids arranged in shallow arc; phloem pole wide, tangentially oval, situated in concavity of xylem arc; (ii) medullary; 8735: outline tangentially oval, with 1 very wide, rounded, many-sided, moderately thick-walled mx. vessel on either flank, these separated by 2-5 rows of narrow tracheids and parenchyma cells; phloem separated from xylem by single layer of narrow cells with slightly thickened walls, extending partly between and overarching mx. vessels; px. absent from smaller, outer bundles; 14706: outline tangentially oval; flanking mx. vessels narrow in outer bundles, medium-sized in inner bundles, angular, moderately thick-walled; mx. vessels separated by 1-3 rows of narrow

cells; phloem as in 8735 but with occasional sclereids; px. absent from smaller, outer bundles. Bundle sheaths; sclerenchymatous; fibres at poles narrow, thick-walled, arranged in 2-3 (4) layers; those on flanks wider, with slightly to moderately thickened walls; arranged in 1 layer. Central ground tissue; parenchymatous, cells of outer layers with moderately thickened walls, those at centre thin-walled, breaking down to form cavity. Strands of thin-walled cells present amongst thickened cells in 8735. Silica; spheroidal-nodular bodies present in some cells of outer layer of sclerenchyma girders. Tannin; present in some epidermal cells. Leaf, rhizome and root T.S., see generic description.

C. drègei Pill.

Culm diameter: 3 mm.

Card characters: 5b, 6b, 7, 9, 15, 19, 20, 21, 22, 23, 25, 26, 27, 31, 37, 42, 44, 47, 48, 49, 50, 51, 52, 55, 56, 58, 60, 68, 110, 112, 114, 115, 117, 118, 121, 122, 123.

Culm surface

Epidermal cells; 4-5- or 6-sided,  $1\frac{1}{2}$ -2 times longer than wide, except round stomata, when about as long as wide; walls thick, wavy at surface, straight at lower plane of focus. Stomata; visible through rectangular aperture bordered by overhanging epidermal cells; opening thickly lined with cuticle. Subsidiary cells mainly of type (xviii), but with rounded ends extending beyond each end of guard cells; guard cells of type (vii); apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; granular. Culm T.S.

Cuticle; very thick. Epidermal cells; 5-6 times



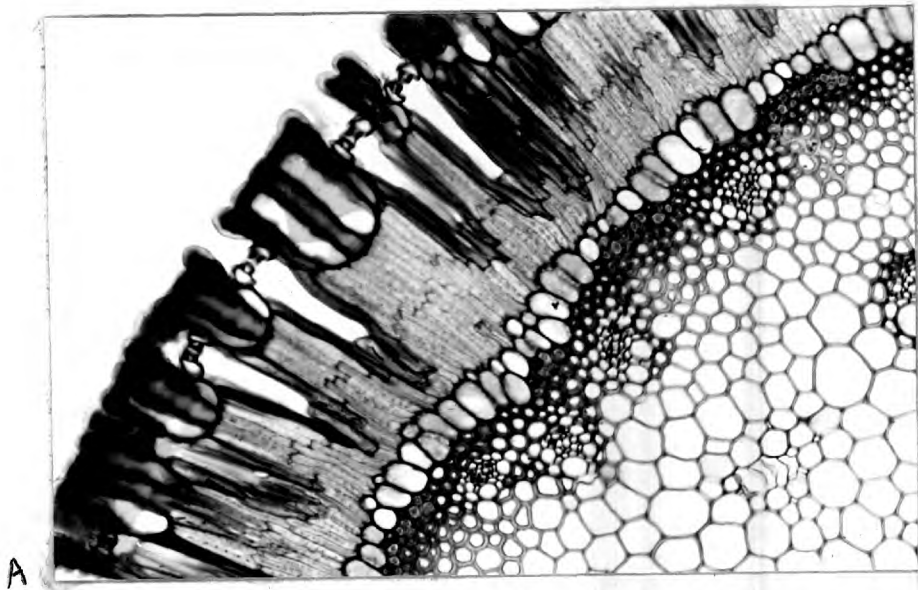


Fig. 9. Cannemolis dregei, culm T.S. ; A x140,  
B x465

higher than wide; those next to stomata overarching the subsidiary cells; outer walls very thick, anticlinal walls wavy, moderately thickened, inner walls moderately thickened. Stomata; sunken to about half way down anticlinal walls of surrounding epidermal cells; subsidiary cells of type (g), ridge on outer wall very pronounced at either end of stomata, less pronounced in median T.S.; guard cells with lips at outer and inner aperture (7,8); lumina of type (4), but wider than normal. Chlorenchyma; composed of palisade peg-cells in 2 layers, individual cells 7,8 or 9 times higher than wide, with numerous small to medium-sized pegs; protective cells extending in 1 layer from just inside substomatal cavity lined by epidermal cells to half way into inner chlorenchyma layer; inner ends of protective cells with blunt points; apertures between protective cells elongated, narrowly elliptic, occurring in inner 1/3 of tube. Parenchyma sheath; mainly 1-, occasionally 2-layered, cells  $2\frac{1}{2}$  to 3 times higher than wide, with convex outer and inner walls and straight anticlinal walls. Sclerenchyma sheath; 6-8-layered, outline rounded, with irregular, convex ridges alternating with pvbs. and opposite to shorter cells of parenchyma sheath. Vascular bundles: (i) peripheral; phloem partially enclosed by arc of medium-sized to wide, angular tracheids; some bundles larger than others; (ii) medullary; flanking mx. vessels wide, many-sided, with moderately thickened walls; phloem abutting onto xylem in places, but mainly separated from xylem by single layer of narrow cells with thin walls; px. poles absent from outer, smaller bundles. Bundle sheaths;

sclerenchymatous; fibres narrow, thick-walled, 2-layered at phloem pole; those on flanks and at xylem pole 1-layered, wider, with moderately thickened walls. Central ground tissue; parenchymatous, with strands of narrow, thin-walled cells dispersed in matrix; cells at culm centre thin-walled and breaking down. Silica; spheroidal-nodular bodies present in some cells of outer layer of sclerenchyma sheath. Tannin; present in some epidermal cells.

C. nitida (Mast.) Pill.

Culm diameter: 1.25 and 2mm.

Card characters: 3, 5b, 6b, 7, 9, 14, 20, 22, 23, 26, 27, 28, 30, 31, 37,  
 Esterhuysen 42, 44, 47, 48, 49, 50, 51, 52, 55, 56, 58b, 68, 110, 112,  
 8382 114, 115, 117, 121, 122, 123.  
 3, 5b, 6b, 7, 9, 14, 20, 22, 25, 26, 27, 31, 37, 42, 44, 47,  
 48, 49, 50, 51, 52, 55, 56, 58b, 68, 110, 112, 114, 115,  
 10085 117, 118, 121, 122, 123.

Culm surface

Epidermal cells; 4-6-sided, as long as or up to  $1\frac{1}{2}$  times longer than wide, walls moderately thickened to thick, not wavy. Stomata; overarched by adjacent epidermal cells, visible through transversely orientated, rectangular or bone-shaped aperture. Subsidiary cells cf type (xviii) but with rounded ends, slightly longer than guard cells; guard cells of type (ix); apertures of type (vi). Tannin; present in many epidermal cells. Cuticular marks; granular, with wide, longitudinal striations.

Culm T.S.

Cuticle; very thick. Epidermal cells;  $1\frac{1}{2}$ -2 times higher than wide in 8382, up to 3 times higher than wide in 10085; outer wall very thick, slightly convex, other walls

moderately thickened, anticlinal walls straight or wavy.

Stomata; sunken, positioned about half way down anticlinal walls of adjacent epidermal cells, and slightly overarched by their outer ends, particularly at either end of the stoma; subsidiary cells of type (i), but inner wall more rounded and bulbous than normal; guard cells with slight lips at inner aperture (8), the outer wall sloping sharply towards subsidiary cells at either end of the stoma, due to increase in length of walls to pore in those regions; lumina of type (4a). Chlorenchyma; composed of 2 similar layers of palisade peg-cells, individual cells 7-8 times higher than wide, except when opposite protective cells, where about 5 times higher than wide; pegs small to medium-sized, short, frequent. Protective cells moderately thick-walled, extending from just inside substomatal cavity lined <sup>by</sup> epidermal cells, to about half way into inner chlorenchyma layer; individual cells with sharply pointed inner ends; apertures between cells elongated, with pointed ends, present towards inner end of substomatal cavity. Parenchyma sheath; 1-layered, cells slightly wider than high or as high as, or up to  $1\frac{1}{2}$  times higher than wide, with rounded corners. Sclerenchyma sheath; 6-7-layered, fibres thick-walled, those of outer layers narrow, those of inner layers wider, difficult to distinguish from outermost cells of ground tissue; some intercellular spaces present. Vascular bundles: (i) peripheral; phloem pole situated between arms of U composed of several wide, angular tracheids; (ii) medullary; outline tangentially oval or rounded, flanking mx. vessels of inner

bundles medium-sized to wide, angular, with slightly thickened walls; most of phloem situated between flanking mx. vessels, but separated from them by a single layer of narrow cells with slightly thickened walls; px. present in inner, larger bundles only. Bundle sheaths; sclerenchymatous; fibres moderately thick-walled, narrow, and in 2 layers at phloem pole; wider, in 1 layer on flanks and in 1-2 layers at xylem pole. Central ground tissue; parenchymatous, outer cells thick-or moderately thick-walled, central cells thin-walled, breaking down to form central cavity. Silica; spheroidal-nodular bodies present in some cells of outer layers of sclerenchyma sheath. Tannin; present in many epidermal cells.

C. parviflora (Thb.) Pill.

Culm diameter: 3 mm.

Card characters: 5b, 6b, 7, 9, 11, 19, 20, 21, 22, 25, 26, 31, 37, 42, 44, 47, 48, 49, 50, 51, 52, 55, 56, 58b, 60, 69, 110, 112, 114, 115, 118, 121, 122, 123.

Culm surface

Epidermal cells; 4-6-sided, as long as to  $1\frac{1}{2}$  times longer than wide; walls thick or very thick, sometimes wavy. Stomata; close together; visible at much lower plane of focus, through longitudinally orientated, rectangular apertures with thick cuticular rims formed by overarching epidermal cells. Subsidiary cells slightly longer than guard cells, with rounded ends, crescent-shaped (xiv) or with wavy walls (xviii); guard cells narrow, of type (xb); apertures of type (ii). Tannin; none seen. Cuticular marks; finely granular.

Culm T.S.

Cuticle; very thick. Epidermal cells; 5-6 times higher than wide, outer walls very thick, flattened-dome-shaped, cuticle extending between adjacent cells to depth equivalent to thickness of outer walls. Outer ends of anticlinal walls thick, thickening tapering and walls moderately thickened at inner ends, wavy; inner walls moderately thickened. Stomata; deeply sunken, attached to anticlinal walls of surrounding epidermal cells about half way down their length. Subsidiary cells similar to type (f), but outer wall extended into ridge at either end of stoma, following increased height of guard cells in these regions (fig. 10B); guard cells with slight lips at outer (7) and inner (8) apertures; lumina of type (4). Chlorenchyma; peg-cells in 2 layers, those of outer layer about 15 times higher than wide, inner cells about 5-10 times higher than wide; pegs small, not infrequent. Protective cells occupying about half of volume of outer chlorenchyma layer because of density of stomata; individual cells moderately thick-walled, extending from about 1/3 of way up substomatal cavity lined by epidermal cells, to over half way into inner chlorenchyma layer; ends rounded; apertures between protective cells short and narrow, occurring in files in inner half of substomatal tube. Parenchyma sheath; 1-2-layered, cells opposite pvbs. up to twice as high as wide, those opposite low ridges from sclerenchyma sheath only slightly higher than wide; individual cells with rounded corners and slightly thickened, copiously pitted walls. Sclerenchyma sheath; 8-9-layered, produced into low, dome-

shaped ridges, between pvbs., these 1-3 cells high and about 10 cells wide next to sheath, tapering to 4-5 cells at outer face; individual fibres very thick-walled, narrow in outer layers, wider in inner layers. Vascular bundles: (i) peripheral; unusually large, with numerous, wide, angular tracheids <sup>⊕</sup> arranged in single-layered V or U; phloem pole rounded or radially oval, situated between xylem arms; (ii) medullary; outline rounded, with 1 or 2 medium-sized to wide, angular, moderately thick-walled mx. vessels on either flank; phloem poles overarching and extending slightly between flanking mx. vessels, abutting directly onto them in places, but more frequently separated from them by a single layer of narrow, thin-walled, parenchyma cells; px. present in larger. inner bundles only. Bundle sheaths; sclerenchymatous, best developed round inner bundles; narrow, thick-walled fibres present in 2-3 layers at xylem and phloem poles; wider, moderately thick-walled fibres present in 1 layer on bundle flanks. Central ground tissue; parenchymatous, cells of outer layers around vascular bundles wide, with slightly to moderately thickened walls, with strands of 2-5 narrow, thin-walled cells scattered amongst them; central cells thin-walled, breaking down to form central cavity. Silica; spheroidal-nodular bodies present in stigmata in outer layer of ridges of sclerenchyma sheath. Tannin; none seen.

⊕ It is possible that some of the wider xylem cells of the peripheral bundles may be vessels in this species; a distinct wall could not be seen between the scalariform thickenings of end walls (perforation-plates).

C. scirpoides Mast. Culm diameter: 1 by 2 mm.

Card characters: 2a, 5b, 7, 9, 14, 18, 21, 26, 27, 28, 31, 37, 42, 44, 47, 48, 49, 50, 51, 52, 54, 55, 60, 71, 72, 73, 78, 88, 112, 115, 121, 122, 123.

(Sample examined is a rachis, with a semicircular outline, but otherwise resembles a normal culm).

Culm surface

Epidermal cells; 4-6-sided, mostly  $1\frac{1}{2}$ -2 times longer than wide, but some, particularly next to stomata, only as long as wide; walls moderately thickened, wavy. Stomata; subsidiary cells of type (xvii); guard cells of type (x); apertures of type (ii). Tannin; present in many epidermal cells. Cuticular marks; granular, with longitudinal striations.

Culm T.S.

Outline; semicircular. Epidermal cells; mostly as high as wide, some slightly higher than wide; outer walls thick, slightly convex; other walls moderately thickened; anticlinal walls slightly wavy or straight. Stomata; superficial; subsidiary cells of types (f) or (i); guard cells with lips at outer aperture (7), and ridge on inner wall (9); lumina of type (3). Chlorenchyma; peg-cells in 2 similar layers,  $3\frac{1}{2}$ -4 times higher than wide; pegs small, frequent. Protective cells with slightly thickened walls, individual cells extending from epidermis to about half way into inner chlorenchyma layer, joining onto their neighbours at slightly expanded inner and outer ends; apertures between cells wide, elongated. Parenchyma sheath; 1-layered, cells slightly wider than high, with rounded corners. Sclerenchyma sheath;



4-7-layered; cells of outer layers between pvbs. narrow, very thick-walled, with narrow lumina; cells to outside of pvbs. and in inner layers of sheath moderately thick-walled, and with wider lumina; cells of innermost layers difficult to distinguish from outer cells of ground tissue. Vascular bundles: (i) peripheral; with 2-5 wide, angular, thin-walled tracheids arranged in arc partially enclosing tangentially oval phloem pole; (ii) medullary; some outer bundles having 1 central, wide, angular mx. vessel, others , and inner bundles, with 1 wide, angular mx. vessel on either flank; phloem abutting directly onto xylem; px. absent from smaller, outer bundles. Bundle sheaths; sclerenchymatous; fibres at poles narrow, thick-walled, in 1-3 layers, those on flanks wider, with moderately thickened walls, in 1 layer. Central ground tissue; parenchymatous; cells of outer layers with moderately thickened to thick walls, central cells thin-walled and breaking down to form cavity. Silica; small spheroidal-nodular and slightly irregular bodies present in stigmata in outer layer of sclerenchyma sheath. Tannin; present in many epidermal cells.

C. virgata Steud.

Culm diameter: 4, 5, 3, and 3 mm.

Card characters: 3, 5c, 7, 9, 14, 18, 19, 21, 26, 27, 28, 31, 34, 36, 37, 44,  
 CA 742 47, 48, 49, 50, 51, 52, 54, 55, 58, 68, 71, 73, 78, 81, 88,  
 (basal) 112, 115, 121, 122, 123.  
 3, 5c, 7, 9, 14, 18, 19, 21, 26, 27, 28, 31, 36, 37, 42, 44,  
 46, 47, 48, 49, 50, 51, 52, 54, 55, 58, 68, 71, 72, 73, 78,  
 1113 B 81, 88, 110, 112, 115, 121, 122, 123.  
 3, 5c, 7, 9, 14, 18, 19, 20, 21, 22, 26, 27, 28, 31, 34, 36,  
 37, 42, 44, 47, 48, 49, 50, 51, 52, 54, 55, 58, 68, 71, 73,  
 1114 B 78, 81, 88, 89, 90, 93, 94, 99, 104, 108, 117, 121, 122,  
 123.

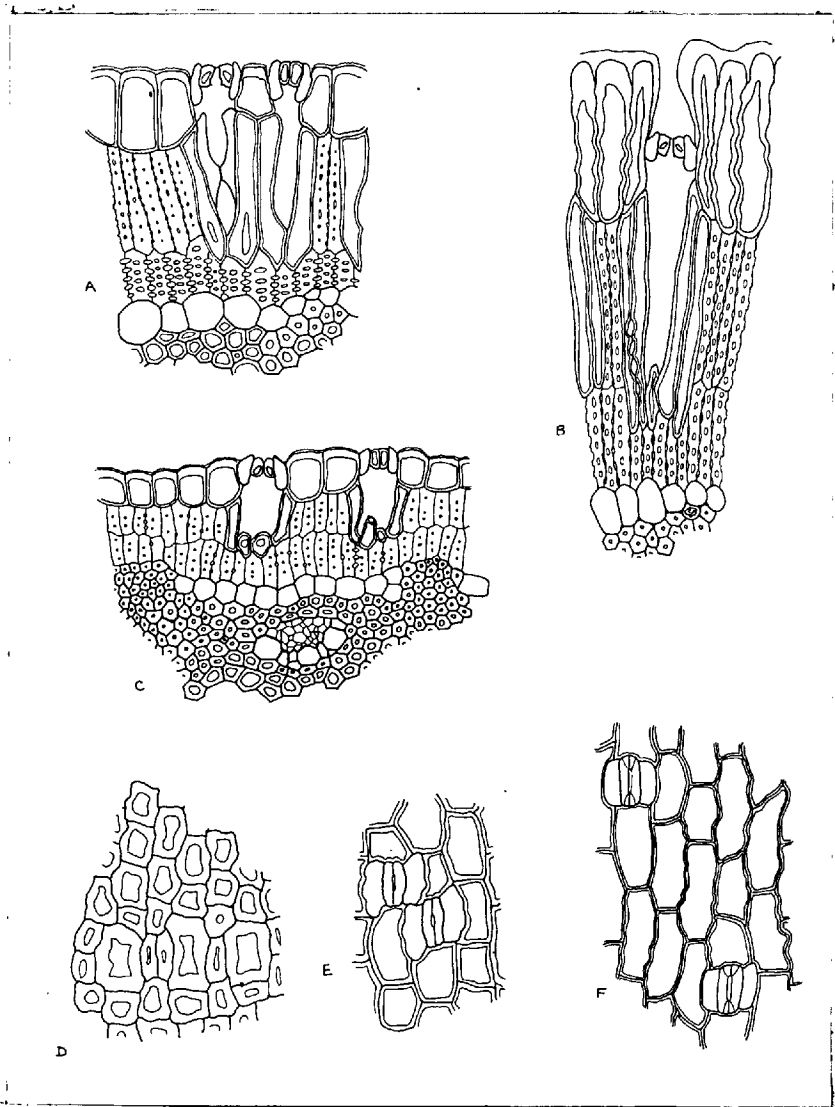


Fig. 10. Cannemeis. A,E virgata, B,D parviflora  
 C,F, accuminata A,B and C culm T.S. ; D,E and F culm  
 surface; all xl85

Culm surface

Epidermal cells; mostly 6-sided, some 4- or 5-sided; those next to stomata as long as wide, others 2-3 times longer than wide, walls moderately thickened to thick, straight to wavy. Stomata; subsidiary cells with wavy walls (xvii); guard cells narrower than normal, with constricted ends (x); apertures of type (vii). Tannin; present in many epidermal cells. Cuticular marks; granular, with longitudinal striations.

Culm T.S.

Cuticle; thick, with slight ridges. Epidermal cells; mostly twice as high as wide, outer walls very thick, slightly convex, outer walls of cells next to stomata curving inwards towards them; anticlinal and inner walls moderately thickened, anticlinal walls not wavy. Stomata; superficial; subsidiary cells similar to type (n) but with ridge extending slightly beyond outer wall of guard cell; guard cells with small lips at outer and inner apertures (7,8); lumina of type (4a). Chlorenchyma; palisade peg-cells in 2, and occasionally 3, layers; cells of outer layer about 5-6 times higher than wide, those of inner layer about 4 times higher than wide; pegs small (cells in CA742 all about twice as high as wide, without pegs, or lobed). Protective cells extending in 1 layer from epidermis to over half way into inner chlorenchyma layer; walls slightly to moderately thickened; cells either expanded and touching one another at outer and inner ends, with a wide, elongated aperture, or with elongated pegs dividing the large aperture into several shorter ones. Parenchyma sheath; 1- or 2-layered,

interrupted in places by ribs from sclerenchyma sheath; where 2-layered, cells half size of those in 1-layered regions; walls slightly to moderately thickened. Sclerenchyma sheath; 5-7-layered, with short ribs 1-3 cells high and 3-7 cells wide between pvbs. partially or entirely penetrating parenchyma sheath. Fibres of ribs and outer 3-4 layers of sheath narrow, with very thick walls, fibres opposite and to outside of pvbs. narrow, with moderately thickened walls, those of inner layers wider, with moderately thickened walls. Vascular bundles: (i) peripheral, mainly with 1 medium-sized, thin-walled, angular tracheid on either flank of arc of several narrow tracheids; phloem pole small, rounded, situated in concavity of xylem arc; (ii) medullary; flanking mx. vessels wide, angular, walls moderately thickened; phloem capping and partially between mx. vessels, abutting directly onto them in places; px. absent from smallest, outer bundles. Bundle sheaths sclerenchymatous; fibres narrow, thick-walled, in 2 layers at phloem pole and 1 layer at xylem pole; wider; with moderately thickened walls, in 1 layer on flanks. Central ground tissue; parenchymatous; outer cells with moderately thickened walls, inner cells thin-walled, breaking down to form central cavity. Silica; spheroidal-nodular bodies present in stigmata in outer layer of ribs from sclerenchyma sheath. Tannin; present in many epidermal cells.

Leaf, rhizome and root T.S., see generic description.

Chaetanthus R.Br.Generic and specific description.Culm surface

Fig. c. pp. 125

Hairs; present, multicellular, flattened, covering culm surface, each attached by single basal cell; form much as in some Australian species of Leptocarpus; see fig. 30 B.

Epidermal cells; rectangular, up to 6x as long as wide, anticlinal walls moderately thickened, wavy. Stomata; subsidiary cells flattened dome-shaped (xvi), guard cells slightly longer, of type (ix). Cuticle; smooth to slightly ridged.

Culm T.S.

Fig. on p. 125: A, B

Outline; terete. Hairs; see above; basal cell of hair slightly sunken into epidermis. Epidermal cells; more or less square, outer walls thick, slightly dome-shaped, anticlinal walls moderately thickened, straight, inner walls moderately thickened. Stomata; slightly sunken, subsidiary cells thin-walled type, <sup>(f)</sup> guard cells relatively thin-walled, with outer lip (7) and inner ridge (9), lumina ~~widely~~ triangular (A). Hypodermis; absent. Chlorenchyma; cells palisade, without pegs; present in 2 similar layers and divided into up to about 14 sectors by pillar cells. Palisade cells arranged in transverse plates usually 1 cell thick as seen in L.S.; air-spaces present between adjacent cells and also between plates of cells. Parenchyma sheath; very discontinuous, represented by: (i) small, thin-walled cells, many of which containing silica-bodies, and (ii) pillar cells in longitudinal files, normally 2,

but occasionally 1 or 3 cells wide, joining ridges from sclerenchyma cylinder to epidermis and dividing chlorenchyma into 14 or more sectors. Pillar cells 5-6 times as long as wide, walls thick, with simple pits; individual cells widest at outer end, tapering away from epidermis but widening again slightly at inner end. Sclerenchyma sheath; composed of 2-5 layers of <sup>very</sup> thick-walled fibres; individual fibres having rounded outline, intercellular spaces filled with extracellular substances; outline of sheath rounded, with ridges occurring opposite to pvbs. Vascular bundles: all embedded in sclerenchyma sheath; (i) peripheral; situated in ribs of sclerenchyma sheath, each having 1 wide, angular tracheid on either flank, or with several angular, medium-sized tracheids in a single layered arc, phloem well developed, walls of cells slightly thickened; (ii) medullary; with 1 wide, angular, thin-walled mx. vessel on either flank; vessels separated from one another by c.3 rows of tracheids and narrow vessels; perforation plates simple, oblique, wall pitting scalariform; numerous narrow vessels and tracheids present at xylem pole; phloem ensheathed by single layer of narrow, slightly thickened cells. Bundle sheaths; sclerenchymatous, fibres in 1 layer on flanks and 1-2 layers at xylem and phloem poles. Central ground tissue; parenchymatous, walls slightly to moderately thickened; cells breaking down to form central cavity. Silica; present as (i) spheroidal-nodular bodies in some cells of parenchyma sheath, and (ii) granular material, in some pillar cells. Tannin; none seen. Crystals; none seen.

Leaf, Rhizome and Root material not seen.

Chaetanthus leptocarpoides R.Br.

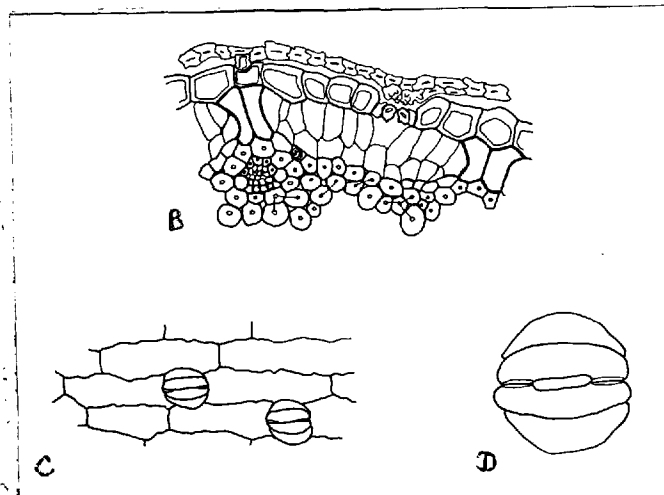
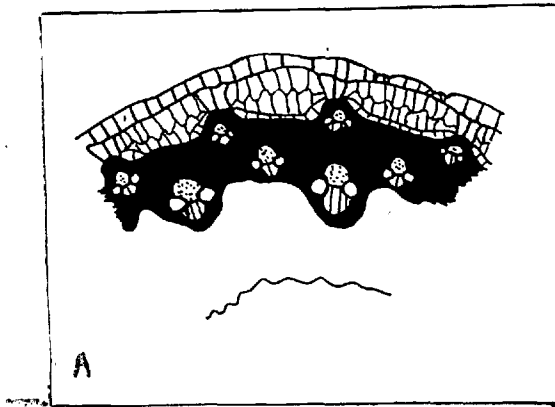
Material examined: Pritzel No.136, Australia.

(K)

Card characters:

culm diameter: 1.0 mm.

1, 3, 5, 7, 9, 14, 20, 22, 26, 27, 28, 31, 44, 45, 47, 48, 49,  
50, 51, 52, 55, 56, 60, 68, 112, 114, 115, 121, 122, 123.



Chondropetalum Rottb.Generic descriptionCulm surface:

Hairs; absent. Papillae; infrequent. Epidermal cells; arranged in longitudinal files; either all hexagonal, square or oblong, or with several different types, i.e. 4, 5, 6, or 7-sided, present in the same epidermis. Walls straight or wavy, moderately thickened or thick. Lumina following cell outlines or round to oval. Gaps between transverse (end) walls of cells frequent; rounded in outline; base of cavity so formed lined by outer wall of cell of inner epidermal layer (see culm T.S.). Stomata; paracytic; subsidiary cells with curved or more or less parallel sides, or with 3 faces; end walls rounded (xv), perpendicular (xi), obtuse (xii) or angular (xvi); guard cells normally thick-walled, longer than or the same length as subsidiary cells, parallel sided and with rounded ends, (ix), or with slightly constricted ends (x). Silica; bodies absent; silica-like material present in (few) cells of one species. Tannin; frequent, in cells of inner epidermis (see culm T.S.). Cuticular marks; mainly granular, occasionally striated.

Culm T.S.:

Outline; terete or, infrequently, oval. Cuticle; thick, continuous into depressions. Epidermal cells; in 1, 2, 3 or, infrequently, 4 layers; individual cells ranging from 20 $\mu$  to 130 $\mu$  high. Cells of inner layers frequently protruding between those of outer layer (alternating with them as seen in



L.S. in most species). Cells wider than high, higher than wide or more or less square; proportionate heights of layers differing in various species. Wall thickness; outer walls thick to very thick; other walls of outer layer of cells normally moderately thickened; all walls of inner cell layer(s) thin or slightly to moderately thickened, except when exposed to surface, when as thick as normal outer wall. Anticlinal walls usually straight, infrequently wavy. Outer walls sometimes concave. Stomata; superficial or sunken; exhibiting a range of types of guard and subsidiary cells; see individual species. Chlorenchyma; consisting of palisade, peg-cells in 2 and sometimes 3 layers; protective cells always present, apertures between protective cells rounded or elongated. Parenchyma sheath; of 1 or several layers of cells; cells normally rounded-hexagonal, (end-walls transverse as seen in L.S.); walls slightly or moderately thickened. Round or oval simple pits present. Sclerenchyma sheath; normally well developed; outline frequently slightly ridged to accommodate pvbs., and with slight ridges between them. Sheath containing all pvbs. and sometimes some outer mvbs. Fibres thick-walled, either wide and with a wide lumen or narrow and with a narrow lumen; outline hexagonal, corners sometimes rounded. Fibres normally distinct from cells of central ground tissue, Vascular bundles; (i) peripheral; phloem pole rounded or oval, abutting directly onto 1- (rarely 2-) layered horse shoe of medium-sized to narrow, angular tracheids, or horseshoe of xylem with 1 wider tracheid on either flank and narrower ones

in between; tracheids with scalariform wall pitting; (ii) medullary; phloem pole rounded to oval, often encircled by single layer of narrow cells with thin walls next to phloem but with other walls thickened; xylem, medium-sized or wide, angular or rounded metaxylem vessel on either bundle flank, normally separated from one another by 2-3 files of narrow tracheids or xylem parenchyma cells. Vessels: walls thick or slightly to moderately thickened; pitting opposite scalariform; perforation plates slightly to very oblique, scalariform, reticulate, scalariform-fenestrate or scalariform-reticulate. Protoxylem pole developed in all, or only larger (central) bundles; medullary bundles mainly of types 2b and 6. Bundle sheaths; sclerenchymatous, normally with 2 layers of narrow, thick-walled fibres at either pole, lumina of fibres narrow, and 1 layer of wider fibres, with moderately thick to thick walls and wider lumina, at bundle flanks. Sheath reduced to caps only in some species. Central ground tissue; parenchymatous, cells wide, usually hexagonal, walls slightly or moderately thickened. Intercellular spaces sometimes present. Central cavity rare. Silica; bodies absent, silica-like material present in some cells of one species. Tannin; frequent in inner epidermal layers, occasional in central ground tissue. Crystals; absent.

Leaf:

Examined in T.S. in 1 species only (C. deustum Rottb.).

Sheathing base, encircling culm  $1\frac{1}{2}$  turns; section parallel sided, tapering to margins.

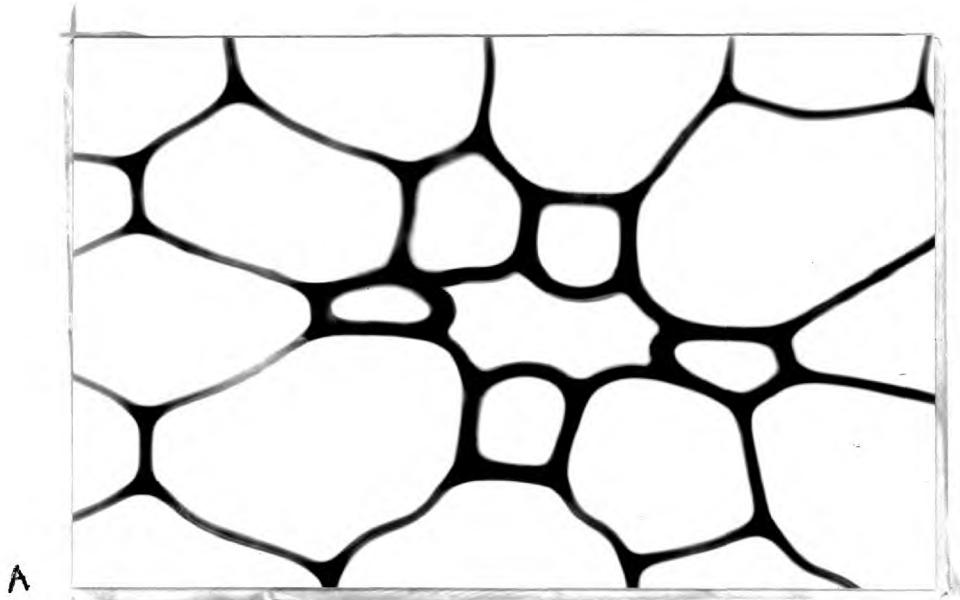
Epidermis: (i) adaxial; cells 5-sided, outer wall flat, anticlinal walls short and straight and inner side bounded by 2, straight walls with an included angle of c.  $110^{\circ}$ ; all walls slightly thickened; (ii) abaxial; cells more or less square, outer wall thick, inner and anticlinal walls moderately thickened, pits simple, numerous on anticlinal walls. Stomata; superficial, guard cells moderately thick-walled, subsidiary cells type (k). Hypodermis; absent. Chlorenchyma; consisting of lobed cells, about as wide as high, in 2-3 irregular layers immediately below abaxial epidermis. Protective cells present, similar to lobed cells but thick-walled. Vascular bundles; phloem abutting directly onto xylem; xylem in larger bundles with 1 wide, angular tracheid on either flank and a row of narrower tracheids between them; in smaller bundles present as a group of narrow tracheids. Bundle sheaths; O.S. parenchymatous, as cap to phloem pole only, but extended laterally in a single layer to adjacent bundles; I.S. sclerenchymatous, 1-layered. Sclerenchyma; girders 1-2 layers thick and up to 12 cells wide, joining onto sclerenchyma of bundle sheath at xylem pole and reaching adaxial epidermis. Ground tissue; isolated parenchyma cells. Air-spaces; none present. Tannin; some mx. tracheids occluded. Silica; none present. Crystals; none present.

Rhizome T.S.;

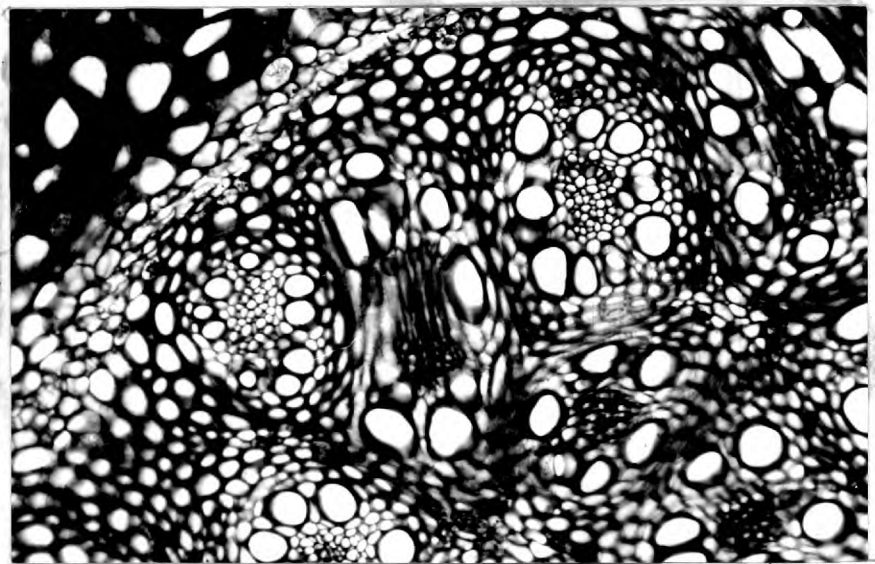
Seen in C. rectum Pill., C. microcarpum (Kth.) Pill. and C. tectorum Rafin.

Epidermal cells; thin-walled, twice as wide as high.

Hypodermis; 5-layered: outer layer similar to epidermis, cells



A



B

Fig. 11. Chendropetalum. A. capitatum, T.L.S. culm epidermis, showing outer ends of 4 protective cells (x1000). B. microcarpum, part of rhizome T.S. showing amphivasal vascular bundles (x250).

of other layers with similar dimensions, but walls thickened. Cortex; of up to 7 layers of thin-walled, rounded cells; intercellular spaces large; cells of 2 distinct sizes in C. tectorum; cells of innermost layer narrow. Endodermoid sheath; cells in 1 layer, inner and anticlinal walls heavily thickened, outer wall thin, lumina partly or entirely occluded. Vascular bundles; mainly collateral, some nearly amphivasal; orientation random, but all tending to run parallel with long axis of rhizome; each with 1,2 or several wide, rounded metaxylem vessels and several narrower, angular vessels and tracheids. Vessel wall pitting scalariform, opposite and alternate, bordered; perforation plates scalariform-fenestrate, very oblique. Tracheids with scalariform pitting in end walls. Phloem pole ensheathed by single layer of narrow, thick-walled cells. Bundle sheaths; sclerenchymatous, fibre ends pointed as seen in L.S. Ground tissue; cells parenchymatous, walls thick, indistinguishable from cells of bundle sheath when seen in T.S.; strands of thin-walled cells also present in C. rectum and C. tectorum. Tannin; none seen. Silica; none seen. Crystals; none seen. (Fig. 11B)

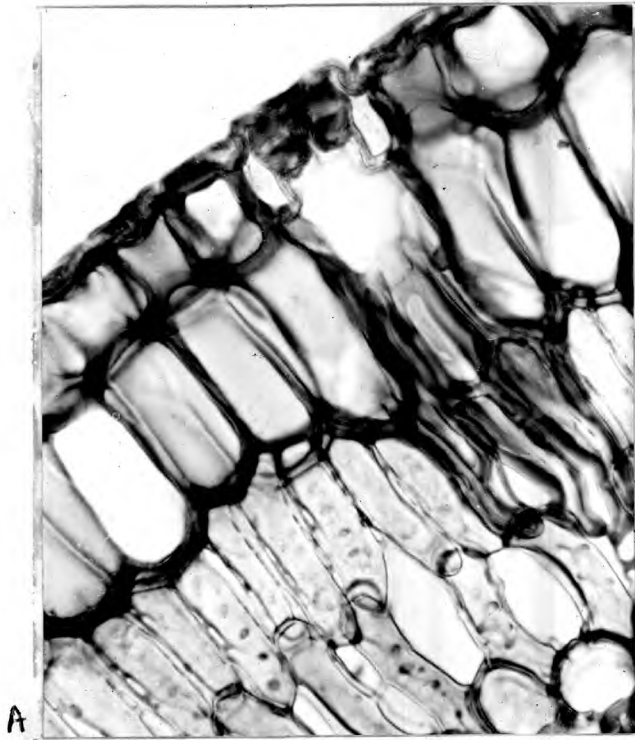
#### Root T.S.;

Seen in C. rectum Pill., C. nudum Pill. and C. tectorum Rafin. Root hairs; arising from cells similar to those of epidermis, shaft narrower than cell base. Epidermis; cells thin-walled, square to upright. Hypodermis; absent. Cortex; (i) outer, 3-layered, outermost cells thin-walled, inner layers thick-walled; (ii) middle cortex of large, thin-walled cells with large intercellular spaces; (iii) inner cortex 2-3 layered,

cells small, thin-walled. Endodermis; 1-layered, cells with thin outer wall and heavily thickened anticlinal and inner walls; passage cells, none seen. Pericycle; 2-3 layered, cells angular, thick-walled, slightly wider than high; lumina polygonal, with rounded corners. Vascular tissue; phloem in small, peripheral strands, alternating with px. groups; mx. vessels in 1 ring, to inside of phloem circle; vessel wall pitting scalariform, perforation plates simple, more or less transverse; walls thin or moderately thickened. Central ground tissue; parenchymatous, cell walls thick, pitting simple. Tannin; none seen. Silica; none seen. Crystals; none seen.

Material examined:

<i>C. aggregatum</i> (Mast.) Pill.	Schlechter 9821	2410 (K)
<i>C. andreaeanum</i> Pill.	Esterhuysen 11523	2413 (K)
<i>C. capitatum</i> <sup>(Steud.)</sup> Pill.	Drège 2510, An. 1840 type	30122A (K)
<i>C. chartaceum</i> Pill.	Esterhuysen 24298, An. 1955.	2414 (K)
<i>C. deustum</i> Rottb.	Parker, R.N. 4913	241 (K)
<i>C. ebracteatum</i> (Kth.) Pill.	Burchell 52 $\Delta$	247 (K)
<i>C. hookerianum</i> (Nees) Pill.	Burchell	9631 (M)
"	"	9632 (M)
"	Schlechter 10341	246 (K)
<i>C. macrocarpum</i> (Kth.) Pill.	Acocks, J.P. 19651	248 (K)
<i>C. marlothii</i> Pill.	Esterhuysen 24469, An. 1955	249 (K)
<i>C. microcarpum</i> (Kth.) Pill.	Schlechter 10503, Det. Mast.	245 (K)
<i>C. mucronatum</i> (Poir.) Pill.	Parker, R.N. 4912	2411 (K)
<i>C. nitidum</i> Pill.	Esterhuysen 14589	2415 (K)
<i>C. nudum</i> (Rottb.) Pill.	Prior, A., Capetown, An. 1947	242 (K)
<i>C. paniculatum</i> Pill.	Esterhuysen 3587	2412 (K)
<i>C. rectum</i> Pill.	Parker, R.N. 3482	244 (K)
<i>C. tectorum</i> (L.f.) Pill.	Burchell 3996 An. 1813	243 (K)
"	Cheadle, V.I. CA 907, Cape.	(S)



A



B

Fig. 12. Chendropetalum tectorum. A. T.S.,  
B. L.S. outer part of culm showing protective cells  
and peg cells. (x350).

Species descriptions:C. aggregatum (Mast.) Pill.

Culm diameter: 4mm.

Card characters: 5,6,7,9,14,20,22,26,31,37,42,44,48,50,51,53,  
55,56,58,68,110,112,114,115,117,121,122,124.Culm surface:

Papillae; absent. Epidermal cells; irregular, 4-,5-,6- and 7-sided, walls moderately and evenly thickened, outline of lumina as those of cells; gaps frequent between transverse walls, filled with granular substance. Stomata; subsidiary cells more or less square ended (xi), guard cells thick-walled in central region, thinner at ends (ix). Tannin; frequent in inner epidermal cells.

Culm T.S.

Epidermal cells; in 2 layers, outer c.40 $\mu$  high and c.30 $\mu$  wide; outer wall thick, anticlinal and inner walls moderately thickened; lumina square to slightly higher than wide; cells of inner layer 100 to 150 $\mu$  high, c.30 $\mu$  wide; anticlinal walls straight, inner walls convex. Stomata; slightly sunken, subsidiary cells type (f), guard cells type (b), lumina type (4). Chlorenchyma; consisting of peg-cells, with 4 rows of pegs; protective cells well developed, extending inwards more or less to full depth of chlorenchyma; apertures between protective cells wide and elongated. Parenchyma sheath; mainly 2-layered but 3-layered on either side of sclerenchyma rib enclosing most peripheral bundles. Sclerenchyma sheath; 10-layered; fibres moderately thick-walled (staining purple with safranin/haematoxylin mixture). Vascular bundles; (i) peripheral; all tracheids medium-sized; (ii) medullary; as for genus but phloem abutting directly onto



xylem (6b). Bundle sheaths; weakly developed, otherwise as for genus. Tannin; frequent in inner epidermal cells and ground tissue. Central ground tissue; parenchymatous.

C. andreaeanum Pill.

Culm diameter: 3.5mm.

Card characters: 5,6,7,9,12,20,22,26,27,28,31,37,42,44,48,50,51, 52,54,55,56,58,68,110,112,114,115,117,118,121, 122,124.

Culm surface:

Epidermal cells; more or less regularly hexagonal, moderately thick-walled, walls straight; no gaps between cells. Stomata; subsidiary cells slightly shorter than guard cells, side walls parallel, end walls rounded; guard cells thickened on inner wall, aperture wide. (See fig. 14 D.) Cuticular marks; granular, slight longitudinal striations also present.

Culm T.S.

Epidermal cells; 1-layered, 100-110 $\mu$  high, and c.40 $\mu$  wide; outer walls very thick, other walls moderately thickened, anticlinal walls straight, inner walls convex. Stomata; superficial; subsidiary cells type (k); but twice as deep as guard cells; guard cell walls thin next to subsidiary cells, otherwise thick; lumina nearly square. Chlorenchyma; 2-layered, each layer 110-120 $\mu$  deep; pegs mainly in 6 files per cell; protective cells thick-walled, extending to parenchyma sheath, apertures between protective cells elongated, situated about  $\frac{1}{2}$  way down length of cells. Parenchyma sheath; outline slightly ridged, mainly 3-, sometimes 4-layered, cells of outer layer narrower than others; walls moderately thickened. Schlerenchyma sheath; 6-8 cells thick, grading into cells of

ground tissue. Fibre walls moderately thickened, but only weakly lignified; lignification stronger in cells sheathing pvbs. Vascular bundles; (i) peripheral; mainly with 1 medium-sized tracheid on either flank and narrow ones between them; (ii) medullary; all free, as for genus, mx. vessels wide, angular. Bundle sheaths; sclerenchymatous, mainly 1 cell wide. Central ground tissue; as for genus.

(Steud.)

C. capitatum Pill.

Culm diameter: 2 mm.

Card characters: 2, 5c, 7, 9, 14, 20, 22, 23, 26, 31, 37, 42, 44, 48, 50, 51, 52, 54, 58, 68, 110, 112, 114, 115, 121, 122, 124.

Type

Culm Surface:

Epidermal cells; 5-, 6-, and 7-sided, longer than wide; walls thick; cells next to stomata smaller and with thicker walls. Stomata; subsidiary cells shorter than guard cells (see fig. 13C). Cuticular marks; granular; wavy lines present above anticlinal walls of epidermal cells.

Culm T.S.

Epidermal cells; in 1 layer; cells c. 100 $\mu$  high and c. 35 $\mu$  wide; outer walls very thick, other walls moderately thickened; anticlinal walls occasionally wavy, inner walls convex. Stomata; superficial, subsidiary cells of type (m), guard cells with slight lip at outer aperture (7), thick-walled, lamina oblique, lenticular (4). Chlorenchyma; 2-layered, each layer c. 55 $\mu$  high, outer cells c. 10 $\mu$  wide, inner cells 15-20 $\mu$  wide; pegs and air-spaces fewer and larger in inner layer; protective cells extending partly into inner layer, apertures between protective cells large, round to oval. Parenchyma sheath; 1-3 cells thick, mainly 1-layered over pvbs. Sclerenchyma sheath; 10-12 cells wide, widest opposite pvbs.;

individual fibres thick-walled, distinct from ground tissue. Vascular bundles; (i) peripheral; 1 wide tracheid on either flank and narrow ones between them; (ii) medullary; as for genus, phloem abutting directly onto xylem (2a), some bundles in contact with sclerenchyma sheath. Bundle sheaths and Central ground tissue; as for genus. Silica; present as fine granules in some cells of parenchyma sheath.

C. chartaceum Pill.

Culm diameter: 3.5mm.

Card characters: 2,5,6,7,9,15,20,22,26,31,37,42,44,48,50,51,52, 54,55,56,57,68,110,112,114,115,121,122,124.

Culm surface:

Epidermal cells; irregular, 4-7 walled, stomata often associated with smaller cells; walls moderately thick; lumina rounded to oval. Stomata; very frequent; similar to those of C. andreæanum. Cuticular marks; granular.

Culm T.S.

Epidermal cells; height c.130 $\mu$ , width c.30 $\mu$ ; outer walls slightly corrugate, very thick, remaining walls moderately thickened; inner walls convex; anticlinal walls very infrequently slightly wavy. Stomata; superficial, similar to those of C. capitatum. Chlorenchyma; mainly 2-layered; cells of inner layer occasionally divided tangentially into half; protective cells in 2-layers, combined height reaching almost to parenchyma sheath; apertures between protective cells round to oval. Parenchyma sheath; 2-3 layered; cell walls thick. Sclerenchyma sheath; 8-10 cells thick, ridged opposite to each pvb.; fibres moderately thick-walled, more heavily lignified round pvbs. Vascular bundles; (i) peripheral; both types

present as described for genus; (ii) medullary; as for genus, with sheath round phloem strand. Bundle sheaths; as for genus, but all fibres narrow, walls slightly thickened. Central ground tissue; parenchymatous cells of various sizes, walls slightly thickened; no central cavity. Tannin; frequent in cells of epidermis.

C. deustum Rottb.

Culm diameter: 1.0mm.

Card characters: 2,5,7,9,14,20,22,26,27,28,31,37,42,44,48,50,51,53,54,55,56,58,68,71,72,81,88,110,112,115,117,121,122,124.

Culm surface:

Epidermal cells; square, walls more or less straight, but outer edges wavy; gaps between end walls of cells. Stomata; subsidiary cell long anticlinal wall angled, conforming to adjacent epidermal cells; end walls perpendicular to obtuse; guard cells type (ix). Cuticular marks; granular.

Culm T.S.

Epidermal cells; in 2 layers; cells of outer layer more or less rectangular, c. 22 $\mu$  high and c. 33 $\mu$  wide; outer wall very thick, (c. 8 $\mu$ ); anticlinal walls moderately thickened, straight. Depressions between cells having square corners, c.10 $\mu$  deep. Cells of inner layer c. 35 $\mu$  high and c. 33 $\mu$  wide; walls moderately thickened. Stomata; superficial, subsidiary cells type (k), guard cells with lip at inner and outer aperture, cuticle accentuating outer lip (7,8). Chlorenchyma; cells in 2 layers of equal height (each c. 45 $\mu$ ), pegs infrequent, air-spaces wide; protective cells normally 1 layer deep and extending  $\frac{1}{2}$  way into inner palisade layer; apertures between

protective cells wide and high. Parenchyma sheath; 1-layered, cells almost square, exhibiting a range of sizes. Vascular bundles: (i) peripheral; all tracheids medium-sized; (ii) medullary; as for genus, phloem abutting directly onto xylem. Bundle sheaths; weak, present round some bundles; frequently reduced to 2-layered caps at xylem and phloem poles. Central ground tissue; parenchymatous, walls slightly thickened. Tannin; frequent, in cells of inner epidermis, occasional in cells of ground tissue.

### Leaf

See generic description.

C. ebracteatum (Kth.) Pill.

Culm diameter: 2.5mm.

Card characters: 2,5,7,9,14,20,22,26,27,28,31,37,42,44,48,50,  
51,53,54,55,56,58,68,110,112,114,115,117,121,  
122,124.

### Culm surface:

Epidermal cells; square to oblong; end walls concave, with circular gaps between them. Stomata; subsidiary cells having perpendicular to obtuse ends (xi, xii), sides parallel; guard cells type (ix). Cuticular marks; granular.

### Culm T.S.

Epidermal cells; in 2 layers: outer cells c. 40 $\mu$  high and c. 32 $\mu$  wide; outer and anticlinal walls straight, inner wall with 3 facets and trough-shaped, all walls moderately thickened; depressions between some cells as deep as straight anticlinal walls of adjacent cells, sides straight, outward facing wall flat; cells of inner layer up to c. 140 $\mu$  high and about 32 $\mu$  wide, walls moderately thickened; outer walls

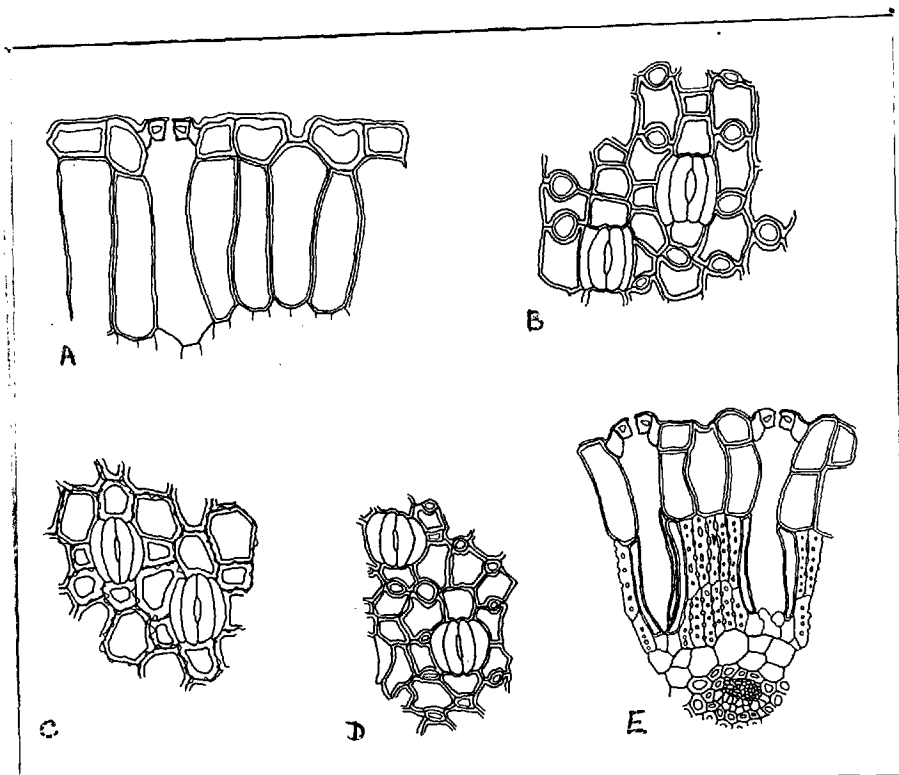


Fig. 13. Chondropetalum. A. ebracteatum, culm epidermis T.S.; B. ebracteatum, culm epidermis surface. C. capitatum culm epidermis surface. D, E nudum culm epidermis surface and outer part of culm T.S. (x185).

dovetailing with inner walls of outer layer; anticlinal walls straight, inner walls convex. Stomata; as in C. deustum, but subsidiary cell walls slightly thickened. Chlorenchyma; 2-layered, each layer c. 75 $\mu$  high; pegs of outer layer smaller and more numerous; protective cells in 1 or 2 layers, extending part way into inner palisade layer, or almost to parenchyma sheath; apertures between protective cells elongated, slit-like. Parenchyma sheath; 2; occasionally 3-layered, cell walls slightly thickened. Sclerenchyma sheath; well developed, c. 8 cells thick, walls very thick, lumina narrow. Vascular bundles: (i) peripheral; all tracheids medium-sized; (ii) medullary; as for genus, phloem ensheathed. Bundle sheaths; as for genus, but with 5 layers of fibres at phloem pole. Central ground tissue; large, parenchymatous cells, walls moderately thickened, intercellular spaces large.

C. hookerianum (Nees) Pill.

Culm diameter: 1.1 - 1.2 mm.

Card characters: 1, 5, 7, 9, 12, 20, 22, 26, 31, 35, 37, 42, 44, 48, 50, 51, 53, 54, 55, 56, 58, 68, 110, 112, 114, 115, 117, 121, 122, 124.  
 246  
 3, 7, 9, 14, 20, 22, 26, 27, 28, 31, 36, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 110, 112, 114, 115, 121, 122, 124.  
 9632  
 1, 2, 7, 9, 14, 22, 26, 27, 28, 31, 42, 44, 50, 51, 53, 54, 55, 9631 (Basal) 56, 60, 61, (62), 68, 110, 112, 114, 115, 121, 122, 124.

Culm surface:

Epidermal cells; oblong, anticlinal walls wavy at surface, straight at slightly lower focus, end walls concave, gaps present. Stomata; subsidiary cells slightly longer than guard cells, end walls rounded (xv). Cuticular marks; granular.

Culm T.S.

Epidermal cells; 2-layered; as in C. ebracteatum; cells of outer layer c. 25 $\mu$  wide and c. 30 $\mu$  high; cells of inner layer c. 50 $\mu$  wide and c. 100 $\mu$  high. Stomata; as in C. ebracteatum. Chlorenchyma; 2-layered, each layer c. 70 $\mu$  high; pegs small and well spaced; protective cells as in C. ebracteatum. Parenchyma sheath; 1-layered. Sclerenchyma sheath; 5-8 layered, fibre walls very thick; some medullary bundles enclosed. Vascular bundles: (i) peripheral; all tracheids medium-sized; (ii) medullary, as for genus, mx. vessels wide, rounded or slightly angular, phloem ensheathed. Bundle sheaths; as for genus. Central ground tissue; parenchymatous, walls moderately thickened, intercellular spaces large. Tannin; in some epidermal cells.

C. macrocarpum (Kth.) Pill.

Culm diameter: 3 mm.

Card characters: 4,6,7,9,12,20,22,26,31,37,42,44,48,50,51,53,  
55,56,58,66,110,112,114,115,121,122,124.

Culm surface:

Epidermal cells; mostly hexagonal, sometimes 4- or 5-sided, slightly wider than long or nearly square. Cells at either side of stoma produced into 2 lobes or papillae over-arching sunken stomatal apparatus. Anticlinal walls straight. Stomata; subsidiary cells slightly longer than guard cells, type (xv), with rounded ends; guard cells type (ix).

Cuticular marks; granular.

Culm T.S.

Cuticle; thick, outer part clear, inner part granular and staining red with safranin. Epidermal cells; in 2-3



layers; outer cells more or less square to upright, reaching c. 40 $\mu$  high and c. 30 $\mu$  wide; intermediate cells sporadic, normally short, c. 10 $\mu$  high and c. 30 $\mu$  wide; inner cells 80-90 $\mu$  high and c. 30 $\mu$  wide; outer walls of outer layer thick, other walls in all layers moderately thickened; anticlinal walls straight. Papillae extending over stomata (see fig. 15B). Stomata; sunken, subsidiary cells type (g), guard cells thick-walled, with lip at outer aperture accentuated by cuticle (7), and with a ridge on inwardly facing wall (9); lumen triangular (2). Chlorenchyma; 2-layered; pegs wide, well separated, air-spaces large. Protective cells thick-walled, inner ends extending almost to parenchyma sheath, somewhat pointed; apertures long, wide, ends pointed. Parenchyma sheath; 1-2 layered opposite pvbs., 3-<sup>4</sup> layered between them. Sclerenchyma sheath; 3-4 layered; fibres thick-walled. Vascular bundles: (i) peripheral; tracheids, both wide and narrow arranged in horse shoe; (ii) medullary; as for genus, phloem ensheathed, flanking mx. vessels rounded, with scalariform-fenestrate perforation plates, px. pole absent from some outer bundles. Bundle sheaths; as for genus, fibres at phloem pole very thick-walled. Central ground tissue; parenchymatous, walls moderately thickened.

C. marlothii Pill.

Culm diameter: 3.5 mm.

Card characters: 5,6,7,9,14,20,22,26,31,37,42,44,48,50,51,53,55,56,68,110,112,114,115,117,121,122,124.

Culm surface:

Epidermal cells; irregular, 4-6 sided, walls thickened, not wavy; gaps between transverse walls small, oval.

Stomata; subsidiary cells parallel-sided, ends rounded (xv); guard cells with slightly constricted ends (x), equal in length to subsidiary cells; aperture parallel sided to dumb-bell-shaped (ii,vi). Tannin; present in cells of inner layers. Cuticular marks; granular.

Culm T.S.

Epidermal cells; in 2 layers; cells of outer layer up to c.  $40\mu$  high and  $30-35\mu$  wide, cells of inner layer up to c.  $120\mu$  high and  $30-35\mu$  wide; walls of outer layer thick, those of inner layer moderately thickened. Stomata; slightly sunken, subsidiary cells type (f), guard cells with oblique, triangular lumina (4), upturned lip at outer aperture (6) and second lip at inner aperture (8). Chlorenchyma; 2-layered, outer cells slightly shorter than those of inner layer, pegs short, frequent, intercellular spaces small; protective cells extending to  $2/3$  depth of inner layer; apertures between protective cells short, rounded, <sup>mostly</sup> occurring near base of tube. Parenchyma sheath; 2-3-(4-) layered, widest on either side of pvbs. Sclerenchyma sheath; 7-8 cells wide, widest at regions between pvbs. Walls of fibres thick, lumina wide. Vascular bundles: (i) peripheral; 2-3 wide tracheids in a horse shoe; (ii) medullary; all free, phloem ensheathed, flanking mx. vessels wide, angular. Bundle sheaths; as for genus, but not continuous on flanks. Central ground tissue; parenchymatous, walls moderately thickened. Tannin; present in all cells of inner epidermal layer and in scattered cells of ground tissue.

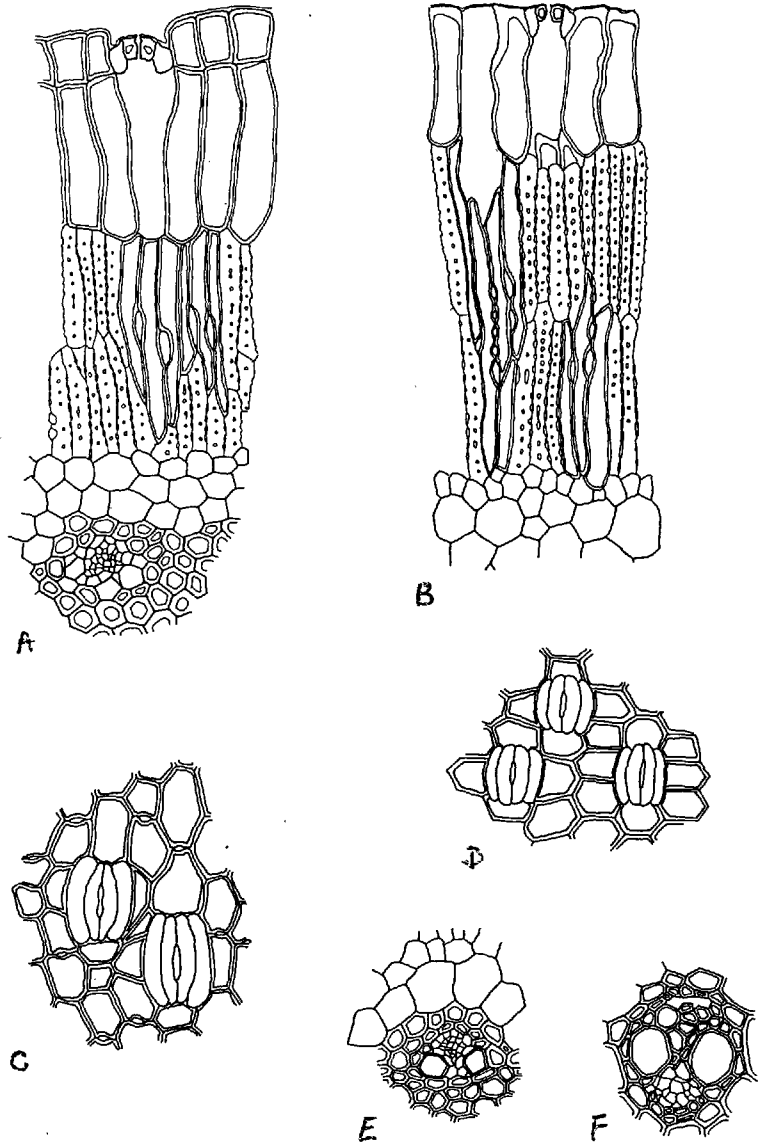


Fig. 14. Chandrepetalum. A, C marlothii, part of culm T.S. and culm epidermis surface. B, D, E and F andraeanum, B. part of culm T.S., D. culm epidermis surface, E. peripheral vascular bundle, F. medullary vascular bundle (x185).

C. microcarpum (Kth.) Pill.

Culm diameter: 0.8 mm.

Card characters: 2,5,7,9,12,14,20,22,26,27,28,31,37,42,44,48,  
50,51,53,68,91,112,113,114,121,122,124.

Culm surface:

Not seen.

Culm T.S.

Epidermal cells; in 2 layers; outer cells c. 20 $\mu$  high and 25-30 $\mu$  wide, inner cells of same width, but 50-60 $\mu$  high (seen to alternate with cells of outer layer, in L.S.).  
Stomata; deeply sunken, attached to cells of inner epidermal layer; subsidiary cells type (b), guard cells with oblique, triangular lumina (4). Facing walls of pairs of guard cells close to one another only at outer aperture and sloping apart to inside. (L.S. stoma: one end mounted higher on epidermal cell than other; all stomata inclined in same direction; guard cells having marked constriction at centre).  
Chlorenchyma; 2-layered; cells broad, c. 3-4 times higher than wide; pegs fine, numerous; protective cells mostly dumb-bell-shaped, extending almost to parenchyma sheath.  
Parenchyma sheath; mainly 1-, occasionally 2-layered.  
Sclerenchyma sheath; 4-5 cells wide, fibres thick-walled, lumina narrow in all but inner layer; slightly ribbed opposite pvbs.  
Vascular bundles: (i) peripheral; all tracheids narrow; (ii) medullary; some attached to sclerenchyma sheath; as for genus, phloem ensheathed, flanking mx. vessels angular, thick-walled, px. pole absent from some outer bundles.  
Bundle sheaths; as for genus.  
Central ground tissue; parenchymatous, cells distinct from fibres of sclerenchyma sheath, walls slightly to moderately thickened.  
Tannin; present in inner epidermal cells.

Rhizome T.S.

Epidermis, Hypodermis and Outer Cortex; not seen.  
Inner Cortex; cells thin-walled, parenchymatous, about as wide as high, loosely packed. Endodermoid sheath; 1-layered, outer walls thin, inner and anticlinal walls thickened, lumina cup-shaped. Vascular bundles; phloem ensheathed, outline rounded; mx. vessels round, thick-walled, arranged in a horse shoe; no px. present; distributed at random, but retaining orientation as in stem. Bundle sheaths; indistinct; group of several cells with thick walls and narrow lumina present at phloem pole. Ground tissue; outer 6 layers thick-walled, grading rapidly into wider, thinner-walled cells at centre.  
Tannin; none seen.

C. mucronatum (Poir.) Pill.

Culm diameter: 7 mm.

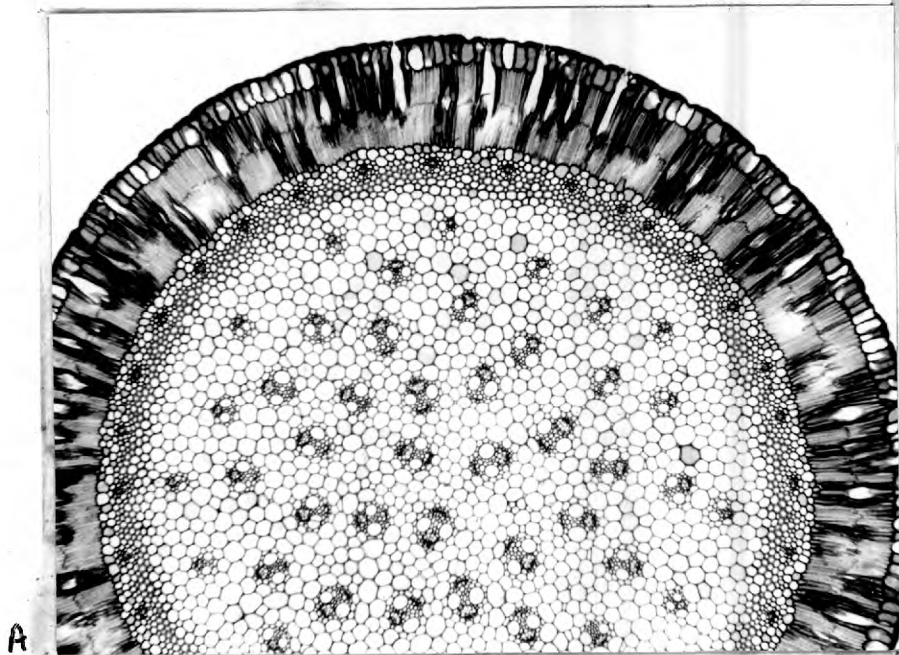
Card characters: 5,6,7,9,15,20,22,26,31,37,42,44,48,50,51,53,  
 54,55,56,58,68,110,112,114,115,117,121,122,124.

Culm surface:

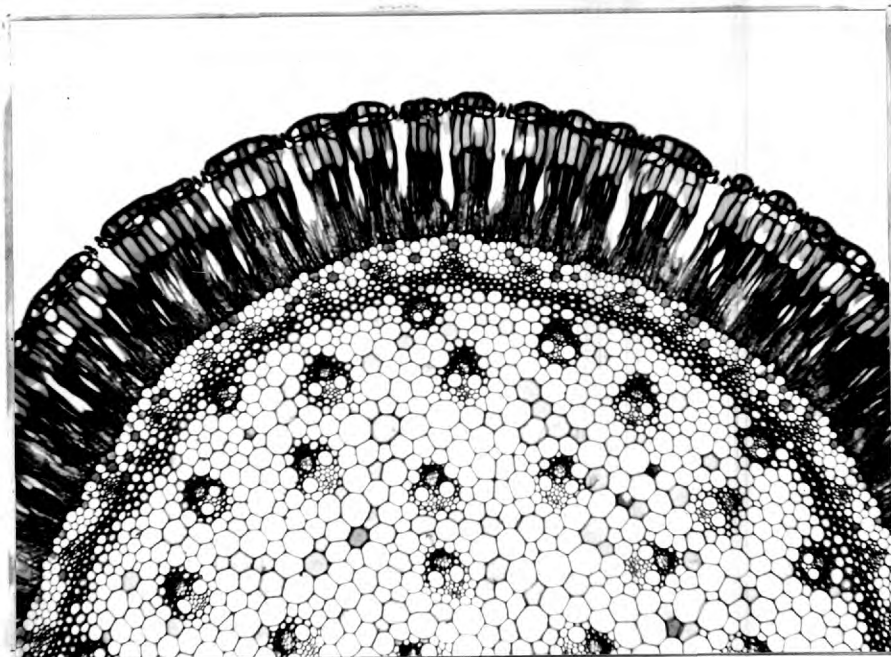
Epidermal cells; mainly hexagonal, some with 4 or 5 walls; slightly longer than wide; walls thick, straight; gaps present between transverse walls of some cells. Stomata; subsidiary cells parallel-sided, end walls perpendicular or slightly angular (xi,xiii), guard cells thick-walled, slightly longer than subsidiary cells, ends slightly constricted and rounded (x); aperture type (ii).. Cuticular marks; granular.

Culm T.S.

Epidermal cells; in 2 layers; outer cells 30-50 $\mu$  high, 25-30 $\mu$  wide; inner cells up to 120 $\mu$  high and 20-30 $\mu$  wide, inner wall frequently wedge-shaped; cells of irregular



A



B

Fig. 15. Chondropetalum A. nitidum, B. macrocarpum,  
part of culm T.S. (x50)

heights, some intruding into chlorenchyma. Outermost wall very thick, often with concave face, other walls of outer layer thick; walls of inner layer moderately thickened; all anticlinal walls straight. Stomata; superficial; subsidiary cells type (g), but extending inwards much further, being twice as high as guard cells; guard cells thick-walled, outer lip accentuated by cuticle (7), ridge on inner wall (9), lumina wide, triangular (3). Chlorenchyma; 2 layers combined 230-250 $\mu$  high; pegs frequent, air-spaces large; protective cells elongated, extending almost to parenchyma sheath, apertures between protective cells long, wide and with pointed ends, often arranged in series. Parenchyma sheath; cells thick-walled, in 2 layers. Sclerenchyma sheath; weak, cells in up to 5 layers, walls thick, lumina wide. Vascular bundles: (i) peripheral; tracheids all wide; (ii) medullary; as for genus, flanking mx. vessels angular, walls slightly thickened, some bundles attached to sclerenchyma sheath. Bundle sheaths; as for genus. Central ground tissue; parenchymatous, cells wide, walls thin or slightly thickened. Tannin; present in cells of inner epidermal layer and some of central ground tissue. (Specimen invaded by fungus).

C. nitidum Pill.

Culm diameter: 2.1 mm.

Card characters: 2,5,7,9,12,20,22,26,31,37,42,44,48,50,51,52,54,55,56,58,68,110,112,114,115,121,122,124.

Culm surface:

Epidermal cells; mainly hexagonal, some 4 or 5-sided, as long as wide or c. 1.5 times as long as wide; cells next to stomata with thick, slightly wavy walls, walls of

remaining cells straight, moderately thickened. Stomata; subsidiary cells (xi) or (xii), guard cells (x), aperture (ii). Cuticular marks; granular.

Culm T.S.

Epidermal cells; 1-layered; height c. 80 $\mu$ , width 30-40 $\mu$ ; outer walls thick, inner and anticlinal walls slightly thickened; anticlinal walls slightly wavy. Stomata; superficial; subsidiary cells type (m); guard cells thick-walled, lumina triangular, slightly oblique (4), slight lip at outer aperture (7). Chlorenchyma; 2-layered, each c. 100 $\mu$  high; pegs wide, short, regularly spaced, occasionally confluent; protective cells extending to parenchyma sheath, similar in shape to peg-cells, but with thick walls and fewer pegs; apertures numerous, in series along sides of tube. Parenchyma sheath; 1-2-layered. Sclerenchyma sheath; 4-5-layered, outline circular, with slight ridges opposite to and between pvbs.; fibre walls thick, lumina wide. Vascular bundles: (i) peripheral; mainly with 1 wide tracheid on either flank; (ii) medullary; flanking mx. vessels wide, rounded-polygonal, px. pole present only in inner, larger bundles, phloem ensheathed; all free from sclerenchyma sheath. Bundle sheaths; as for genus, most strongly developed round central bundles. Central ground tissue; parenchymatous, walls slightly thickened, intercellular spaces present. Tannin; none seen.

(Rottb.)

C. nudum Pill.

Culm diameter: 1.0 mm.

Card characters: 2, 5, 7, 9, 14, 20, 22, 26, 31, 37, 42, 44, 48, 50, 51, 53, 54, 58b, 68, 104, 105, 106, 110, 114, 115, 121, 122, 124.



Culm surface:

Epidermal cells; mostly hexagonal, as long as or slightly longer than wide; end walls concave, gaps present; other walls slightly wavy. Stomata; subsidiary cells parallel-sided, ends angular (xiii), guard cells parallel-sided, ends rounded (ix), aperture (ii) or (vi), according to level of focus. Cuticular marks; granular.

Culm T.S.

Epidermal cells; 1-2-layered; cells of outer layer more or less square in median section, c. 30 $\mu$  high and 30-35 $\mu$  wide, cells of inner layer usually c. 60 $\mu$  high but c. 75 $\mu$  high when extending to surface. Depressions above such cells c. 15 $\mu$  deep. Stomata; superficial, subsidiary cells of type (f), guard cells thick-walled, lips present at inner and outer apertures (7,8), lumina triangular, narrow (2). Chlorenchyma; 2-layered, pegs wide, unevenly spaced, smaller in outer layer; protective cells thick-walled, extending from inside tube formed by epidermal cells round substomatal cavity almost to parenchyma sheath. Apertures between protective cells with curved sides, pointed ends, found near inner end of cells and extending outwards c.  $\frac{1}{4}$ - $\frac{3}{8}$  length of tube. Parenchyma sheath; (1), 2-3 cells wide. Sclerenchyma sheath; 7-8 cells wide, ribbed opposite to and between pvbs. Fibres of c. 5 outer layers thick-walled, with narrow lumina and rounded corners and with intercellular spaces filled with extracellular substances.

Vascular bundles: (i) peripheral; tracheids all narrow, in 1-2 layered horseshoe; (ii) medullary; mostly free from sclerenchyma sheath, some with only 1, central, wide, rounded,

mx, vessel, others with 1 on each flank, px. present only in inner bundles, phloem ensheathed by narrow, particularly thick-walled cells. Bundle sheaths; as for genus. Central ground tissue; parenchymatous, walls thick or moderately thickened, grading rapidly into cells of sclerenchyma sheath. Tannin; none seen.

Root T.S.

Root hairs; not seen. Epidermal cells; thin-walled, as high as wide. Cortex; single outer layer of thin-walled cells, enclosing region of thick-walled cells, rectangular in outline,  $1-1\frac{1}{2}x$  as wide as high, in 3 layers; middle and inner cortex as for generic description. Endodermis; 1-layered; inner and anticlinal walls thickened to exclusion of lumen in many cells. Pericycle; 3-4-layered, (see generic description) Vascular system, central ground tissue; see generic description. Tannin; none observed.

C. paniculatum Pill.

Culm diameter: mm.

Card characters: 5,6,7,9,14,20,22,23,26,31,37,42,44,48,50,51,  
52,54,55,56,58,68,110,112,114,115,117,121,122,  
124.

Culm surface:

Epidermal cells; mainly hexagonal, mostly as long as wide, walls thick, particularly in cells bordering on stomata. Stomata; subsidiary cells with perpendicular to slightly angular ends (xi,xvi), long wall with 3 facets (xviii), guard cells thick-walled, ends slightly constricted, rounded (x).; aperture (ii). Cuticular marks; granular.

Culm T.S.

Epidermal cells; 1-layered, upright, 80-90 $\mu$  high, 30-40 $\mu$  wide, all walls thick, anticlinal walls straight, except those lining sub-stomatal cavity, inner walls convex. Stomata; superficial, subsidiary cells of type (i), walls slightly thickened, guard cells thick-walled, lip at inner and outer aperture (7,8), lumina oblique, triangular (4). Chlorenchyma; 2-layered, cells of outer layer slightly higher than inner and pegs more numerous and narrower; protective cells thick-walled, very elongated, parallel sided through outer palisade, tapering and curving together in inner palisade, often reaching parenchyma sheath; apertures between protective cells rounded, or elongated and with pointed ends, normally situated at junction of palisade layers. Parenchyma sheath; 1-<sup>(2)</sup>layered, cells large (30-40 $\mu$  high and c. 20 $\mu$  wide); walls thick (cellulose). Sclerenchyma sheath; cells in up to 9 layers, outer narrowest, walls thick, lumina wide, intercellular spaces present, filled with extracellular substances. Vascular bundles; (i) peripheral; 1, wide angular tracheid on either flank, walls slightly thickened; (ii) medullary; flanking metaxylem vessels wide, angular, phloem ensheathed, px. absent from some peripheral medullary bundles. Bundle sheaths; as for genus. Central ground tissue; parenchymatous, cells wide, walls thick, intercellular spaces present. Tannin; none seen.

C. rectum Pill.

Culm diameter: 1.0 and 1.2 mm.

Card characters: 2,5,7,9,12,19,22,24,26,27,28,30,31,37,42,44,45,48,50,51,53,55,56,58,68,90,91,94,97,99,104,105,106,110,114,117,121,122,124.

Culm surface:

Epidermal cells; rectangular or elongated-hexagonal, c. twice as long as wide, gaps present, walls thick, wavy at outer surface. Stomata; subsidiary cells variable, parallel-sided, end walls angular, perpendicular or obtuse (xi, xii, xiii), guard cells with slightly constricted ends (x), apertures type (ii). Cuticular marks; granular.

Culm T.S.

Epidermal cells; 2-3- (4)-layered; when 2-layered, outer cells c. 1.5 times wider than high, inner cells c. 2.5 times higher than outer layer; when 3- or 4-layered, outer layer as above, middle layer(s) as outer and inner 1.5 times higher than outer layer; walls of cells of outer and middle layers thick, those of inner cell layer moderately thickened. Stomata; sunken, attached to cells of outer and middle layers of epidermis, subsidiary cells type (c), guard cells much constricted in median section, expanded at either end, ridge present on outer and inner walls (9), lumina triangular, oblique (4). Chlorenchyma; 2-3 layered, pegs larger on upper and lower than on anticlinal walls; protective cells of same length as cells of outer palisade only, apertures between protective cells elongated, reaching almost to apices and bases of protective cells. Parenchyma sheath; consisting of 1 layer of wide cells. Sclerenchyma sheath; of 6-7 layers, fibres thick-walled, lumina narrow. Vascular bundles; (i) peripheral; tracheids all narrow; (ii) medullary; flanking mx. vessels medium-sized, rounded, thick-walled, px. present in all bundles, phloem ensheathed, some bundles free from

sclerenchyma sheath. Bundle sheaths; as for genus; those of pvbs. less strongly thickened than surrounding fibres of sclerenchyma sheath. Central ground tissue; parenchymatous, walls moderately thickened.

Leaf; not seen.

Rhizome and root; see generic description.

(L.f.)

C. tectorum Pill.

Culm diameter: 1.2 and 1.7 mm.

Card characters: 2,5,7,9,15,20,22,23,26,31,37,42,45,48,50,51,  
Burchell 3996 53,54,55,56,60,68,110,112,114,115,117,121,122,  
124.  
Cheadle CA907 2,5,7,9,14,19,20,22,26,29,31,37,42,44,48,51,53,  
54,68,104,105,106,110,113,115,121,122,124.

Culm surface:

(3396 only) Epidermal cells; rectangular, slightly longer than wide, anticlinal walls wavy; rounded gaps present. Stomata; subsidiary cells wide, parallel-sided, ends obtuse (xii), as long as guard cells, guard cells with curved long anticlinal walls and rounded ends (ix), aperture of type (ii).

Cuticular marks; granular.

Culm T.S.

Epidermal cells; 1-2-layered, walls thick, cells of outer layer slightly wider than high, inner layer either reaching to the outer surface, the cells being twice as high as wide, or reaching to the outer layer and being 1.25 times as high as wide (the two different heights are to be found in the same cell, according to the point at which the section is taken, since cells of the inner layer alternate with those of the outer).

Stomata; superficial, subsidiary cells of type (f), guard cells without lips, lumina square to triangular (3). Chlorenchyma;

2-3 layered, consisting of peg-cells (3396 basal; cells lobed); protective cells extending inwards from half way up substomatal tube formed by epidermal cells to depth of outer layer of palisade cells; pegs present on walls of protective cells facing palisade cells; apertures between protective<sup>cells</sup>/wide and elongated. Parenchyma sheath; of 1-2-layers. Sclerenchyma sheath; up to 8 layers thick, broadest opposite to and between pvbs.; fibres thick-walled. Vascular bundles: (i) peripheral; with single row of narrow tracheids; (ii) medullary; flanking mx. vessels thin-walled, many angled, px. present only in inner bundles, phloem ensheathed, some bundles free from sclerenchyma sheath. Bundle sheaths; as for genus, but sometimes reduced to caps at bundle poles. Central ground tissue; parenchymatous, consisting of wide, moderately thick-walled cells. Tannin; present in some cells of inner epidermal layers. Rhizome and root T.S.; see generic description.

Coleocarya S. T. BlakeGeneric and specific description.Culm surface:

Hairs; absent. Epidermal cells; 4-sided, as long, or up to twice as long as wide, those next to stomata of the shorter type; walls moderately thick to thick, wavy. Stomata; subsidiary cells crescent-shaped (xiv) or with angular ends (xiii), long anticlinal walls slightly wavy; guard cells of type (ix) but tending towards type (viii); apertures narrow, type (ii). Cuticular marks; granular, with distinct, wide, longitudinal striations. Tannin; none seen. Silica; none seen. Crystals; none seen.

Culm T.S.

Epidermal cells; 4-sided, those between stomata as high as or slightly higher than wide, those next to stomata extending further into chlorenchyma, with walls bordering onto adjacent epidermal cells equal in height to those cells, and walls bordering onto substomatal cavity produced inwards, being  $1\frac{1}{2}$ -2 times longer than the others. Outer walls v. thick, anticlinal walls v. thick at outer ends, thickening tapering rapidly, the inner half of these walls and the inner walls being slightly thickened. Anticlinal walls, particularly those lining substomatal cavity, wavy. Stomata; superficial, subsidiary cells of type (m), guard cells with slight inner and outer lips (5,8); lumina of type (2b). Chlorenchyma; composed of 1 layer of palisade, peg-cells; cells opposite stomata 2-3 times as high as wide, those between stomata about 4-6 times as high as wide; pegs

well developed, in files of 8-12. Parenchyma sheath; 1-layered, cells tangentially oval, <sup>up to</sup> about twice as wide as high, walls slightly thickened; some stegmata present. Sclerenchyma sheath; composed of 5-6 layers of fibres, those of outer 1-3 layers thick or very thick-walled, narrow, those of inner layers wider, fibres of innermost layer widest, walls moderately thickened to thick. Sheath not ridged. Vascular bundles; (i) peripheral; xylem composed of single-layered arc of tracheids, flanking tracheids medium-sized, others narrow, all thin-walled and angular; phloem situated in concavity of arc, composed of 6-10 sieve tubes and companion cells; (ii) medullary; outline rounded; flanking mx. vessels medium-sized, angular, with slightly thickened walls, separated from one another by 3-5 rows of narrow, parenchymatous cells; mx. vessel walls with scalariform pitting, perforation plates oblique, scalariform; px. poles present in all medullary bundles; phloem poles radially oval in outline, separated from xylem by single layer of narrow parenchyma cells with slightly thickened walls; most medullary bundles free from culm sclerenchyma sheath, those in ground tissue grouped in twos or threes, their sheaths being in contact at the flanks. Bundle sheaths; sclerenchymatous, 1-2-layered, fibres at poles narrower than those on flanks, those next to phloem pole very thick-walled, those next to xylem pole v. narrow, with slightly thickened walls, others moderately thick-walled. Central ground tissue; parenchymatous, outer



cells moderately thick-walled, innermost cells wider, with slightly thickened walls, some breaking down. Silica; spheroidal-nodular bodies present in stegmata in parenchyma sheath. Tannin; none seen. Crystals; none seen. Leaf, rhizome and root, not seen.

Coleocarya gracilis S. T. Blake

Material examined: Blake, S. T. 14300 An. 1940,  
Stradbroke, Is. Austr. Dupl. Type (K)

Card characters: Culm diameter: 1.2 mm.  
5a, 6b, 7, 9, 14, 20, 22, 25, 31, 42, 43, 47, 49, 52,  
54, 55, 56, 60, 68, 112, 114, 115, 118.

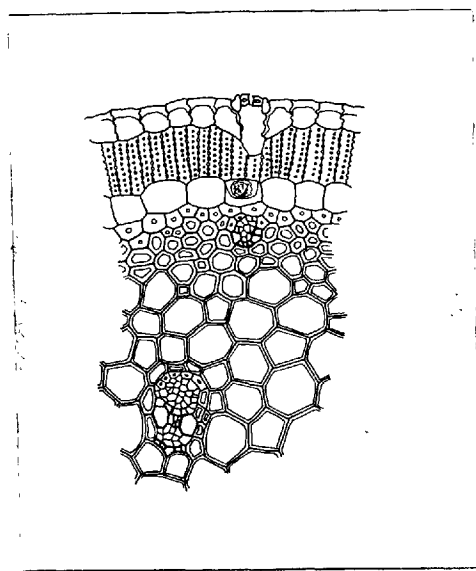


Fig. 16. Coleocarya gracilis outer part of culm T.S.  
(x185)

Dielsia GilgGeneric and specific description.Culm surface

Hairs and papillae; absent. Epidermal cells: of 2 types; (i) large thick-walled cells in uniseriate (rarely biseriate) longitudinal files; outline of individual cells 4-6 sided,  $1\frac{1}{2}$ -2 times as wide as long; (ii) smaller cells with slightly thickened walls, mostly axially elongated and with 6-7 sides; of varying sizes. Walls slightly wavy in some cells. Stomata; subsidiary cells variable (fig. 17ci): guard cells equal in length to subsidiary cells, the pair having a lemon-shaped outline of type (x), (fig. 17ci). Silica; bodies absent. Tannin; present in large cells. Cuticular marks; granular.

Culm T.S.

Figs. 17Ai, Bi

Outline; polygonal. Epidermal cells; of 2 types; (i) large, (see culm surface) at angles of culm, opposite and joined to wedge-shaped sclerenchyma girders from the mechanical cylinder; these cells 2-3 times as high as and up to twice as wide as the other cells; outer walls thick, slightly corrugated, other walls thin to slightly thickened. Anticlinical walls slightly wavy, with 2 facets, the lumen widening from the outer wall to a point equal in height with the shorter cells of the epidermis and narrowing again to the inner wall; (ii) smaller cells (see culm surface) more or less square in outline; outer walls thick, slightly corrugated, other walls thin to slightly thickened. Stomata; subsidiary cells compressed at centre, but extending above and below

guard cells (g); guard cells with ridge; on inner wall (9) lumina of type (1). Hypodermis; absent. Chlorenchyma; consisting of palisade peg-cells in 2-3 layers; walls thin. Parenchyma sheath; cells rounded, in 1 layer; extending on flanks of sclerenchyma girders to base of larger epidermal cells. Sclerenchyma sheath; composed of 4-6 layers of thick-walled fibres; produced at regular intervals into girders each c.4 cells wide, and terminating in a large epidermal cell. Vascular bundles; (i) peripheral; xylem composed of single or double row of narrow tracheids, the tracheids of the <sup>outer</sup> layer being slightly wider than the rest; phloem abutting directly onto the xylem, composed of 6-12 cells; bundle enclosed in sclerenchyma sheath and situated either opposite to or between sclerenchyma girders; (ii) medullary; almost oval in outline, with 1 wide, angular mx. vessel on either flank; vessels with opposite wall pitting and scalariform, oblique perforation plates. Phloem separated from xylem by single layer of narrow cells having thin walls next to phloem cells and thick walls towards xylem. All medullary bundles enclosed in or in contact with sclerenchyma sheath or cylinder. Bundle sheaths; sclerenchymatous, cells in 1 layer; cells narrowest and with thickest walls at phloem pole. Central ground tissue; parenchymatous, outer c.5 layers of cells with slightly thickened walls, central cells very thin-walled, frequently breaking down to form central cavity. Tannin; present in larger epidermal cells. Crystals; none present. Silica; spheroidal-nodular bodies numerous, occurring solitarily in some cells of parenchyma sheath.

Leaf, Rhizome and Root not seen.

Dielsia cygnorum Gilg

Material examined: Diels, An. 1902, W. Australia 5116 (K)  
 Pritzel, E. No. 304, W. Australia 5115 (K)

Card characters: Culm diameter: 0.5 & 0.8 mm.

Diels, 1902 1,2,7,9,14,20,22,23,26,27,28,31,42,44,45,47,  
 49,50,51,52,54,55,56,60,69,112,114,115,117,  
 123,124.

Pritzel 304 1,2,7,9,14,19,20,21,<sup>22</sup>23,25,26,27,28,31,42,44,  
 45,47,49,50,51,52,54,55,56,57,69,112,114,115,  
 123,124.

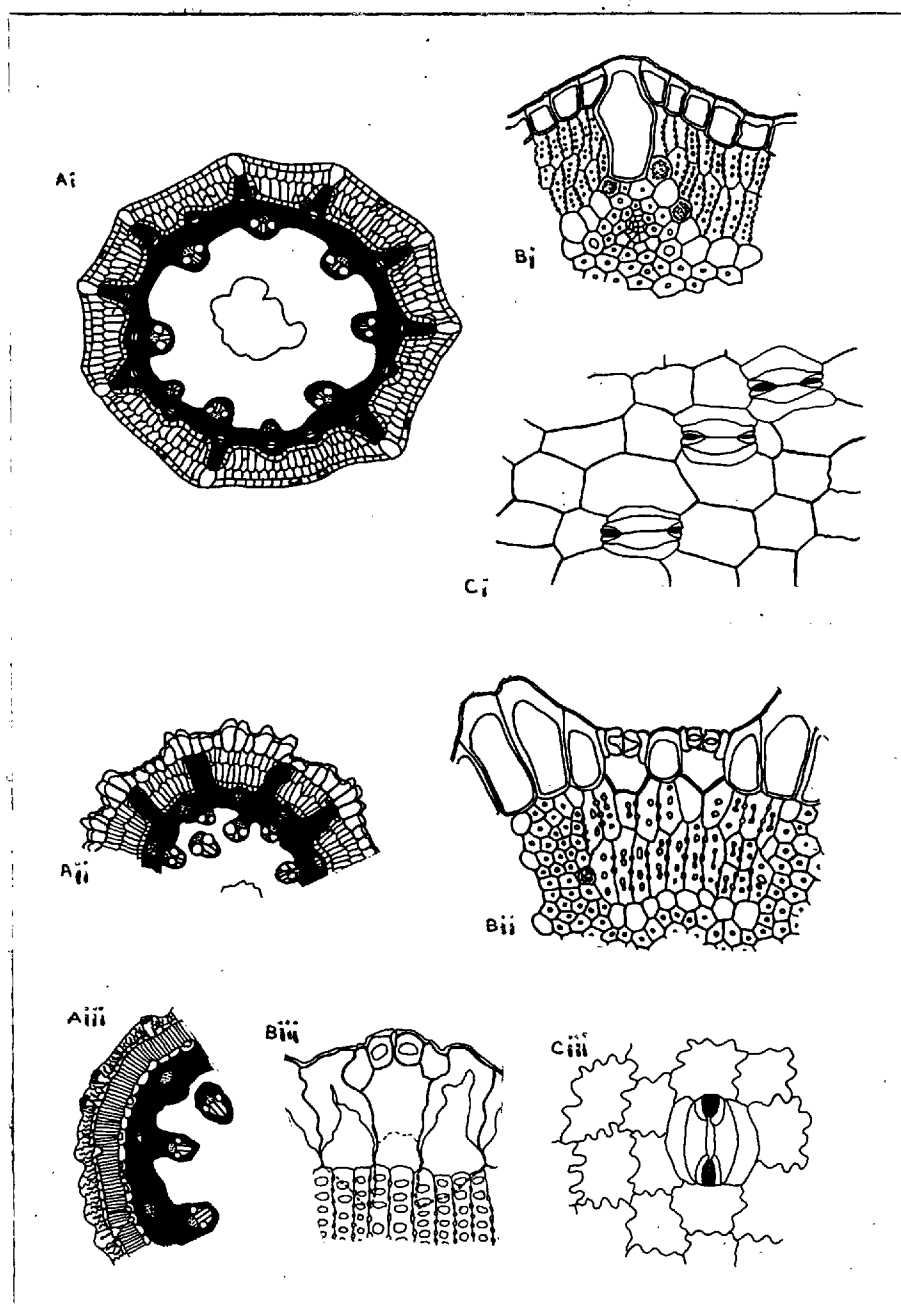


Fig. 17. Ai-Ci. Dielsia cygnorum; culm T.S. (x40).  
 culm T.S. detail (x150), culm surface (x235).  
 Aii, Bii. Phylloceros insignis; culm T.S. (x40),  
 culm T.S. detail (x150).  
 Aiii-Ciii Onychosepalum laxiflorum; part of culm T.S.  
 (x40), detail of stomata and epidermis T.S. (x235),  
 culm surface (x235).

Elegia L.Generic descriptionCulm surface:

Hairs; absent. Papillae; present in E. parviflora and E. neesii, but never well developed. Epidermal cells; frequently elongated-hexagonal (58b) or rectangular (58), or rectangular with wavy anticlinal walls (60); transverse walls frequently concave, bordering gaps between cells of outer epidermal layer. Stomata; paracytic, subsidiary cells thin-walled, crescentiform or parallel-sided and with round or angular ends; guard cells thick-walled, about as long as subsidiary cells. Silica; absent. Tannin; frequently visible, but normally confined to cells of inner epidermal layer (when present). Cuticular marks; granular; longitudinal ridges sometimes present.

Culm T.S.:

Outline; terete. Cuticle; thick. Papillae; present in E. parviflora and E. neesii. Epidermal cells; normally in 2 layers but 1- or 3-4-layered in some species; cells of both layers of equal height or those of inner layer higher than those of outer layer. Outer epidermal cells of unequal heights in 1 species (E. calcarea Nees), and discontinuous in E. neesii; occasional gaps present between cells of outer layer in some species, the bases of these being lined by outer walls of cells from inner layer. Outer cell walls frequently thick and curving inwards at cell margins, inner and anticlinal walls slightly to moderately thickened; walls

of inner cell-layer frequently thinner than those of outer layer. Stomata; superficial or sunken; when sunken, often attached to cells of inner epidermal layer. Subsidiary cells exhibiting a wide range of shape but mainly types (f), (g), (h) and (i); guard cells often with outer lip (5,7), inner lip (8) or ridge (9). Hypodermis; interpreted as inner epidermis. Chlorenchyma; peg-cells in 2 (rarely 3) layers of similar height; cells of inner layer frequently having larger pegs; protective cells present, extending from epidermis into culm through 1 or more layers of chlorenchyma according to species. Parenchyma sheath; 1- 2- (3-) several-layered; walls thin or slightly thickened, cells rounded, wide. Sclerenchyma sheath; fibres thick-walled or moderately thick-walled, in 3-7 layers in most species. Vascular bundles; (i) peripheral; frequently with arc of narrow tracheids partially enclosing phloem pole; (ii) medullary; outline frequently radially oval, mostly having 1 wide metaxylem vessel on either flank, the phloem normally being separated from the xylem by a single-layered sheath of narrow cells with thickened walls next to xylem and thin walls next to phloem; vessel wall pitting scalariform, perforation plates slightly oblique or oblique, scalariform; px. present in all or only inner bundles; some or all bundles embedded in culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous, fibres normally in 1 layer at xylem pole and bundle flanks and in 2-3 layers at phloem pole. Central ground tissue; parenchymatous, central cells sometimes

breaking down to form central cavity. Silica; no silica bodies present. Crystals; none present. Tannin; present in some epidermal cells.

Leaf

Leaf surface:

Seen in E. asperiflora, E. stipularis and E. verticillaris. Hairs; absent. Papillae; present in E. verticillaris. Epidermal cells; (abaxial only) more or less square, or slightly elongated, or up to 3 times as long as wide; anticlinal walls wavy. Stomata; (abaxial only) subsidiary cells crescent-shaped (xiv) or parallel-sided and with angular ends (xiii); guard cells with more or less parallel sides and rounded ends (ix), or of type (x), with constricted ends. Silica; bodies absent. Tannin; present in some cells. Cuticular marks; granular.

Leaf T.S. (sheathing base)

Seen in E. asperiflora, E. fistulosa, E. grandis, E. stipularis and E. verticillaris.

Shape; flattened, tapering to margins, encircling culm with  $1\frac{1}{2}$  turns. Epidermal cells; (i) abaxial; 1-layered, except in E. grandis, cells more or less square; outer walls thick, or very thick, sometimes produced into dome-shaped papillae, anticlinal walls slightly to moderately thickened, straight, inner walls thin to slightly thickened; (ii) adaxial; cells 4 or 5-sided, walls thin to slightly thickened. Stomata; sunken in E. grandis, superficial in other species; subsidiary cells extending above and below guard cells (c); guard cells with slightly oblique lumina



(4b). Chlorenchyma; 1-2-layered, cells palisade and with pegs, or more or less isodiametric and lobed, walls thin. Vascular bundles: of 2 sizes, large and small alternating, phloem well developed, xylem represented by relatively few (4-8) tracheids or with 1 wide tracheid on either flank (E. grandis). Bundle sheaths; sclerenchymatous, fibres moderately thick-to thick-walled, in 1 layer on flanks and up to 3 layers at bundle poles; parenchymatous sheath, if present, indistinguishable from ground parenchyma. Sclerenchyma; restricted to bundle sheaths, except in E. grandis, where continuous between bundles, in 5 layers, fibres very thick-walled, separated from chlorenchyma by 2 layers of parenchymatous cells and from abaxial epidermis by 2-3 layers of parenchymatous cells. Ground tissue; parenchymatous in all species except E. grandis (see sclerenchyma), present between bundles and in 1-3 layers separating chlorenchyma from adaxial epidermis; walls frequently thin, but occasionally slightly thickened. Air-cavities; absent. Silica; absent. Crystals; absent. Tannin; present in cells of abaxial epidermis.

Leaf blade

T.S. only

Seen in E. neesii

Outline; oval, major axis 0.75 mm., minor axis 0.3 mm. Epidermal cells; rectangular, slightly wider than high; in 1 layer. Stomata; slightly sunken, as for stem of same species. Chlorenchyma; cells palisade, 2-3 times higher than wide, present in 2 layers; pegs present, few.

Parenchyma sheath; mainly 1-, occasionally 2-layered, cells rounded, medium sized. Vascular bundles; 3 present, arranged in an arc; phloem poles abaxially orientated; xylem composed of 3 groups of narrow tracheids occupying most of central area of arc. Sclerenchyma; present as caps 1-2 layers thick, between phloem and parenchyma sheath. Ground tissue; none present. Silica; none present. Crystals; none present. Tannin; none seen.

Rhizome T.S.

Seen in E. asperiflora, E. fistulosa, E. parviflora, and E. stipularis.

Epidermal cells; 5-sided, outer walls slightly convex, thick, anticlinal walls short, thick, inner walls with 2 faces, moderately thickened. Hypodermis; up to 6 layers of sclereids; cells of inner 2 layers having thick inner walls and thinner outer and anticlinal walls. Cortex; (outer = hypodermis?) inner, composed of 4-5 layers of thin-walled, more or less isodiametric, lobed, parenchymatous cells.

Endodermoid layer; normally 1-layered; outer walls thin, other walls thickened. Vascular bundles: (i) peripheral/<sup>collateral</sup> with U-shaped arrangement of vessels; (ii) medullary; amphivasal; vessels medium-sized, thick-walled, angular, wall pitting scalariform, pits wide, bordered; perforation plates oblique, simple. Lumina frequently tannin-filled. Bundle sheaths; sclerenchymatous, fibres thick-walled, arranged in 2-3 layers, walls heavily pitted. Central ground tissue; parenchymatous, forming islands or lacunae between vascular bundles. Silica; none present. Crystals; none present.

Tannin; present in many cells of epidermis and cortex, and in some vessels.

Root T.S.

Seen in E. asperiflora, E. fistulosa, E. parviflora and E. stipularis.

Root hairs; developed from cells similar to remainder of epidermis. Epidermal cells; thin-walled, square or rectangular and upright. Hypodermis; 1 layer of thin-walled cells, about  $\frac{1}{2}$  height of epidermal cells. Cortex; with or without outer region of fibres in 4-5 layers; cells of middle cortex thin-walled, parenchymatous, either arranged in radial plates of 1 cell in thickness, or continuous; inner cortex composed of 1-2 layers of smaller, parenchymatous cells. Endodermis; 1-layered, cells thin-walled, or with thickenings on inner and anticlinal walls. Pericycle; cells either in 1-2 layers and parenchymatous, or in 5-6 layers and sclerenchymatous. Vascular system; protoxylem and phloem strands alternating in periphery of stele; metaxylem vessels either in a single ring, or in ring and also scattered throughout centre of root; in the last instance, phloem strands may accompany vessels in the centre. Central ground tissue; sclerenchymatous and composed of narrow, thick-walled fibres, or parenchymatous (E. asperiflora). Silica; absent. Crystals; absent. Tannin; absent.

Material examined

The genus is a South African endemic.

<i>E. asperiflora</i> Kth.	Schlechter 9571	Vogelgat	15710	(K)
"	Burchell 8140		1579	(K)
"	Schlechter 6017	An.1894	15711	(K)
"	Acocks, J.H.P. 21672			
	19.8m. W. of Humansdorp		1576	(K)
"	Fourcade, H.G. 2434	An.1927		
	Humansdorp		1578	(K)
"	Parker, R.N. 4683	An.1951		
	Jonkershock		1577	(K)
"	Herb. Benth. 106!	in Drège's Herb.	15712	(K)
"	Cheadle, V.I. CA709			(S)
<i>E. coleura</i> Nees ex Mast.				
	Rehmann, A. 2571	Worc. Div.	1575	(K)
<i>E. cuspidata</i> Mast.	MacGillivray, Voyage of H.M.S.			
	Herald, 1832, Bot. no.437,			
	Limon Bay, C.O.G.H. (type)		15110	(K)
<i>E. equisitacea</i> Mast.	Fourcade, H.G. 1373	An.1921	101211	(K)
<i>E. fistulosa</i> Kth.	Cheadle, V.I. CA833	Cape		(S)
<i>E. galpinii</i> N.E.Br.	Riversdale Div.		15735	(K)
<i>E. glauca</i> Mast.	Esterhuysen 22570		1574	(K)
<i>E. grandis</i> Kth.	Burchell No number			(K)
<i>E. intermedia</i> Pill.	Barker, W. 22454	Kirstenbosch	1573.	(K)
<i>E. juncea</i> L.	Bolus 4456 ♂	An.1878		
	Cape Town		1571	(K)
<i>E. muirii</i> Pill.	Esterhuysen 23162	An.1954	15717	(K)
<i>E. neesii</i> Mast.	Burchell 569	Table Mt.	30121A	(K)
"	Esterhuysen 11461	An.1945		
	Stellenbosch		15716	(K)
<i>E. parviflora</i> Kth.	Cheadle, V.I. CA708	Cape		(S)
"	Godfrey GH1259	An.1952		
	Vanrhinsdorp		26119A	(K)
"	Esterhuysen 25742	An.1956		
	Ceres Div.			(K)

<i>E. parviflora</i> Kth.	Parker, R.N. 4842 ♀ Bettys Bay, Caledon Div.	261111A (K)
"	Parker, R.N. 4843 ♂ Bettys Bay, Caledon Div.	261110A (K)
"	Taylor 3029 Cape	261115A (K)
"	Vogts, M. 50 Caledon Div.	261114A (K)
"	Smith, C.A. 5025 Bredasdorp	261112A (K)
"	Kuntze, O. / <sup>350</sup> Caledon Div.	26116A (K)
"	" 194	26115A (K)
"	Drège 2517!	26113A (K)
"	Burchell 8647	26114A (K)
"	Drège 120 Dutoits Kloof	26118A (K)
"	Esterhuysen 3683 Worc. Div.	26117A (K)
"	Acocks, J.P.H. 17460 Calvinia Dist.	26112A (K)
<i>E. racemosa</i> Pers.	Hutchinson, J. 34	15728 (K)
<i>E. spathacea</i> Mast.	Parker, R.N. 4693 ♂ An. 1951 Rooi Els	1572 (K)
<i>E. squamosa</i> Mast.	♀	15715 (K)
<i>E. stipularis</i> Mast.	Pickstone 22 ♂ Paarl and Caledon Div.	101212 (K)
"	Cheadle, V.I. CA825 Cape	(S)
<i>E. thyrsoidea</i> Pill.	Fourcade, H.G. / <sup>2345</sup> An. 1922 Headwaters of Wagerboom R.	15727 (K)
<i>E. vaginulata</i> Mast.	Bolus 5480	15713 (K)
<i>E. verreauxii</i> Mast.	Zeyher	15714 (K)
<i>E. verticillaris</i> Kth.	Worsdell, W.C. An. 1909	101210 (K)

Specific descriptions

*E. asperiflora* Kth. Culm diameter: 1-2 mm.

Card characters:

Schlechter 9571 2b, 5b, 7, 9, 14, 20, 22, 26, 27, 28, 31, 37, 42, 44, 48, 50,  
51, 53, 54, 55, 56, 58b, 68, 110, 112, 114, 115, 117, 121,  
122.

Burchell 8140 2b, 5b, 7, 9, 15, 20, 22, 26, 27, 28, 31, 37, 42, 44, 48, 50,  
51, 53, 54, 55, 56, 58b, 68, 110, 112, 114, 115, 121, 122.

Schlechter 6017	2b, 5b, 7, 9, 14, 19, 20, 22, 26, 27, 28, 31, 37, 42, 44, 48, 50, 51, 53, 54, 55, 56, 58b, 68, 110, 112, 114, 115, 117, 121, 122.
Acocks 21672	2b, 5b, 7, 9, 14, 20, 22, 26, 27, 28, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 58b, 68, 110, 112, 114, 115, 117, 120, 121, 122.
Fourcade 2434	2b, 5b, 7, 9, 14, 20, 22, 26, 27, 28, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 58, 68, 110, 112, 114, 115, 117, 120, 121, 122.
Parker 4683	2b, 5b, 6a, 7, 9, 14, 20, 22, 26, 27, 28, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 58b, 68, 110, 112, 114, 115, 117, 121, 122.
Drège 106!	2b, 5b, 7, 9, 14, 20, 22, 23, 26, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 58b, 68, 110, 112, 114, 115, 121, 122.
Cheadle CA709 (basal)	1, 2, 7, 9, 14, 19, 22, 26, 27, 28, 31, 34, 46, 47, 50, 53, 54, 55, 56, 61, 66, 68, 71, 72, 78, 89, 90, 93, 99, 103, 105, 106, 110, 121, 122.

Culm surface:

Epidermal cells; square to  $1\frac{1}{2}$ -2 times as long as wide, walls slightly or moderately thickened, wavy; rounded gaps present between end walls of some cells. Stomata; subsidiary cells shorter than guard cells, walls thin, of types (xi) or (xiii), or long walls slightly wavy; guard cells of type (ix), apertures (2). Tannin; present in some epidermal cells. Cuticular marks; granular.

Culm T.S.

Fig. 18E

Epidermal cells; present in 2 layers of equal height (only 1 cell thick in places); individual cells slightly higher than wide. Cells of outer layer having thick outer walls and slightly to moderately thickened inner and anticlinal walls, all walls straight; walls of cells of

inner layer slightly to moderately thickened. Stomata; superficial, subsidiary cells of type (i); guard cells with outer and inner lips (7,8); lumina triangular (2). Chlorenchyma; 2-layered, outer cells slightly shorter than inner; protective cells extending from epidermis to part way into inner layer, individual cells slightly swollen at inner and outer ends and forming tube with long apertures in its sides. Parenchyma sheath; mainly 2-layered, 1- or 3-layered in places. Sclerenchyma sheath; 4-6-layered, fibres thick-walled. Vascular bundles; (i) peripheral; well developed, phloem pole enclosed in arc of wide tracheids; (ii) medullary; mx. vessels on flanks wide, angular, phloem ensheathed. Occasional fusions or close approximations of 2 peripheral bundles, or peripheral with medullary bundle observed. Some medullary bundles free from culm sclerenchyma sheath. Bundle sheaths, ground tissue; as for genus.

Leaf surface (abaxial).

Epidermal cells; elongated, rectangular, walls thick, very wavy. Stomata; subsidiary cell long walls wavy, guard cells as in culm.

Leaf T.S. poorly preserved.

Rhizome T.S. Cortical region not preserved; other characters as for generic description.

Root T.S.

Very little thickening in any tissue. Epidermal cells; upright,  $1\frac{1}{2}$  times as high as wide. Hypodermis; 1 layer of thin-walled cells. Cortex; outer 2 layers of cells having slightly lignified walls, other cells loosely packed,

rounded, parenchymatous, in 8-10 layers, cells of outer layers largest. Endodermis; cells thin-walled, more or less square. Pericycle; 1-layered, cells thin-walled. Vascular system; single polyarch. Central ground tissue; parenchymatous.

E. coleura Nees ex Mast. Culm diameter: 1.5 mm.

Card characters: 2b, 5b, 7, 9, 14, 20, 22, 26, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 58, 70, 110, 112, 114, 115, 121, 122

Culm surface:

Epidermal cells; mostly rectangular, occasionally wider at middle than ends, c. twice as long as wide; anticlinal walls moderately thickened, wavy; rounded gaps present between cell end walls, these often containing silica-like material. Stomata; subsidiary cells of types (xi) and (xv), long anticlinal walls often slightly wavy; guard cells longer than subsidiary cells and with pincer-shaped ridge at each end of aperture, apertures type (vii). Tannin; none seen. Cuticular marks; granular.

Culm T.S.

Fig. 18c

Epidermal cells; in 2 layers (occasionally 3), cells within layers of uneven heights, overall height of combined layers more or less constant. Cells square or higher than wide, anticlinal walls straight. Outer walls of outer cells thick, other walls moderately thickened. Occasional gaps occurring in outer cell layer, bases of which lined by outer walls of cells of inner layer. Stomata; superficial, subsidiary cells type (i); guard cells with lip at outer and inner apertures (7,8); lumina wide, triangular (3).



Chlorenchyma; composed of 2 palisade layers, pegs small, air-spaces large; protective cells extending from epidermis to half way into inner palisade layer, apertures between protective cells wide and elongated. Parenchyma sheath; mainly 2- occasionally 3-layered. Sclerenchyma sheath; mainly 3-layered, fibres moderately thickened, lumina wide. Vascular bundles; (i) peripheral; as for genus; (ii) medullary; flanking mx. vessels angular, thin-walled; phloem ensheathed; some bundle fusion seen; some medullary bundles free from culm sclerenchyma. Bundle sheaths; as for genus. Central ground tissue; parenchymatous, with no central cavity. Tannin; none seen. Silica;? granular, present in pits between cells of outer epidermis.

E. cuspidata Mast.

Culm diameter: 4.0 mm.

Card characters: 5c,6c,7,9,15,20,22,26,31,36,37,42,44,48,50,  
(type) 51,53,54,55,57c,60,68,110,112,114,115,117,  
121,122.

Culm surface:

Epidermal cells; outlines irregular, mainly more or less square or rectangular, anticlinal walls wavy. Rounded gaps present between cells. Stomata; as in E. coleura, but more frequent. Tannin; none seen. Cuticular marks; granular.

Culm T.S.

Epidermal cells; mainly in 2 layers, outer cells more or less square, anticlinal walls wavy, inner cells rectangular, 3-4 times as high as outer cells, sometimes reaching to outer surface. Outer walls thick, inner and anticlinal walls

moderately thickened. Depressions present between some cells of outer layer, each lined with outer wall of inner cell. Stomata; superficial, subsidiary cells of type (i); guard cells with lip at outer aperture (7); lumina triangular, wide (3). Chlorenchyma; peg-cells as for genus, protective cells extending from part way up tube formed by epidermal cells surrounding stoma, to half way into inner chlorenchyma layer, apertures between protective cells elongated, opening to cells of outer chlorenchyma layer. Parenchyma sheath; 1-, mainly 2-, sometimes 3-layered. Sclerenchyma sheath; 5-layered, fibres thick-walled. Vascular bundles; (i) peripheral; 1 medium-sized tracheid on either flank, or horseshoe of medium-sized tracheids; (ii) medullary; flanking mx. vessels very wide, angular, almost touching one another in some bundles, separated by 2 or 3 rows of narrow cells in others; phloem ensheathed; many bundles free from sclerenchyma sheath. Bundle sheaths; as for genus. Central ground tissue; parenchymatous, with no central cavity. Tannin; none seen.

E. equisetacea Mast.

Culm diameter: 2.5 mm.

Card characters: 3,5,6,7,9,12,14,20,22,23,26,27,28,31,37,42,  
44,47,48,50,53,54,55,56,60,68,82,110,112,  
115,121,122.

Culm surface:

Epidermal cells; mostly rectangular, about twice as long as wide, anticlinal walls wavy. Stomata; as in E. coleura. Cuticular marks; granular.

Culm T.S.

Epidermal cells; in 2 layers, those of outer layer slightly wider than high and half height of those of inner layer. Outer walls thick, curving inwards at margins of cells, all other walls straight, moderately thickened.

Stomata; superficial, subsidiary cells of type (h); guard cells with lip at inner and outer apertures (7,8); lumina wide, triangular (3). Chlorenchyma; consisting of peg-cells in 2 layers, those of outer layer the shorter, pegs and air-spaces small; protective cells as in E. cuspidata, but walls only slightly thickened and apertures between cells extending from near the outer end to near the inner end. Parenchyma sheath; mostly 2-layered, occasionally 1 or 3 cells thick. Sclerenchyma sheath; well developed, mainly 4-layered, fibres thick-walled. Vascular bundles; (i) peripheral; arc of wide tracheids in single layer; (ii) medullary; flanking mx. vessels wide, angular, separated from one another by 2-3 files of narrow cells; phloem ensheathed; px. poles absent from smaller, outer bundles; outline tangentially oval. Bundle sheaths; as for genus.

Central ground tissue; parenchymatous, breaking down at culm centre to form cavity. Tannin; present in some cells of inner epidermal layer.

E. fistulosa Kth.

Culm diameter: 2.5 mm.

Card characters: 1,2,7,9,10,12,15,26,28,31,34,37,42,44,45,47,  
48,50,53,55,56,58,59,68,71,78,81,88,89,93,  
94,99,104,108,110,117,121,122.

Culm surface:

Epidermal cells; rectangular or hexagonal and  $1\frac{1}{2}$ -2

times longer than wide. Stomata; subsidiary cells of type (xv), guard cells type (ix). Tannin; none seen.

Cuticular marks; granular.

Culm T.S.

Fig. 18F

Epidermal cells; in 2-3 layers, outer cells more or less square, inner cells 2-3 times as high as those of outer layer, some reaching culm surface; outer walls thick, other walls slightly to moderately thickened. Stomata; sunken, subsidiary cells of type (p), attached to inner epidermal cells; guard cells with lip at outer aperture (7), and ridge on inner wall (9); lumina of type (3). Chlorenchyma; peg-cells in 2-3 layers, pegs and air-spaces small; protective cells extending from epidermal cells into inner layer of peg-cells, adjacent cells touching one another at few points. Parenchyma sheath; 1-2-layered. Sclerenchyma sheath; 3-4-layered, fibres of outer layers thick-walled, those of inner layer slightly wider and with moderately thick end walls. Vascular bundles; (i) peripheral; with arc of medium-sized tracheids; (ii) medullary; with wide, angular flanking mx. vessels; phloem ensheathed. Bundle sheaths; as for genus. Central ground tissue; parenchymatous.

Leaf T.S. See generic description.

Rhizome T.S. As for generic description, but Endodermoid layer poorly differentiated and Central ground tissue restricted to strands of parenchyma between bundles.

Root T.S.

As for genus, but Hypodermis with 1 layer of thin-walled

cells only; Cortex with 2 outer layers of fibres, middle region occupied by radial plates of thin-walled cells followed by 2 inner layers of narrow, thin-walled cells. Endodermis; cells with strongly thickened inner and anticlinal walls and thin outer walls. Pericycle; parenchymatous. Vascular system; mx. vessels scattered. Central ground tissue; sclerenchymatous.

E. galpinii N.E.Br.

Culm diameter: 2.5 mm.

Card characters: 2b, 5b, 7, 9, 14, 20, 22, 23, 26, 31, 37, 42, 44, 48, 50, 51, 53, 54, 55, 56, 58b, 68, 110, 112, 114, 115, 117, 121, 122.

Culm surface:

Epidermal cells; outlines irregular, mainly hexagonal, as long as, or up to  $1\frac{1}{2}$ -2 times longer than wide, some cells square, others rectangular, elongated longitudinally or transversely; walls moderately thickened, straight.

Stomata; solitary or paired, or in groups of up to 4; if in pairs or groups, then having oblique, common wall between adjacent subsidiary cells (fig. 18B). Tannin; present in some cells. Cuticular marks; granular.

Culm T.S.

Epidermal cells; present in 2 layers; those of outer layer more or less square, those of inner layer elongated, being c. 3-4 times higher than those of outer layer. All walls of outer cells thick, those of the inner moderately thickened; outer walls of cells of outer layer curving inwards to the anticlinal walls (fig. 18A). Stomata;

slightly sunken, subsidiary cells of type (h), walls thin; guard cells with lip at outer aperture accentuated by cuticle (7b) and ridge on inwardly facing wall (9); lumina of type (1). Chlorenchyma; palisade peg-cells present in 2 layers, cells of inner layer c  $\frac{1}{4}$  as long again as those of the outer, and with wider intercellular spaces; pegs fine and numerous in both layers. Protective cells thick-walled, extending from epidermis almost to parenchyma sheath; apertures between adjacent cells wide and elongated. Parenchyma sheath; mainly 2-layered, but 1- or 3-layered in places; walls slightly thickened. Sclerenchyma sheath; thick-walled fibres present in up to 7 layers. Vascular bundles; (i) peripheral; as for genus; (ii) medullary; as for genus; outermost without protoxylem pole. Bundle sheaths; sclerenchymatous, as for genus. Central ground tissue; parenchymatous, with intercellular spaces; breaking down at centre of culm. Tannin; present in some epidermal cells.

E. glauca Mast.

Culm diameter: 4.0 mm.

Card characters: 2, 5b, 7, 9, 14, 20, 22, 26, 31, 37, 42, 44, 48, 50, 51, 53, 55, 56, 58b, 68, 110, 112, 114, 115, 121, 122.

Culm surface:

Epidermal cells; mainly 6-sided, some 5- or 7-sided, mainly  $1\frac{1}{2}$ -2 times as long as wide, but some as long as wide; walls thick, wavy at surface but straight at slightly lower focus. Stomata; solitary, subsidiary cells of type (xi); guard cells of type (ix). Cuticular marks; granular.

Culm T.S.

Epidermal cells; present in 2 layers, cells rectangular, up to twice as high as wide, those of inner layer slightly higher than those of the outer; outer walls thick, other walls moderately thickened; anticlinal walls wavy.

Stomata; sunken; attached low down in tube formed by outer epidermal cells; subsidiary cells of type (g); guard cells with outer and inner lips (7,8); lumina of type (4).

(Guard cells relatively narrow in median T.S., nearly twice as wide at each end). Chlorenchyma; palisade peg-cells in 2 similar layers, protective cells thick-walled, extending from epidermal cells to about: 1/3 of way into inner layer of palisade cells; apertures between protective cells present towards their inner ends. Parenchyma sheath; mainly 2-layered; walls densely covered with simple pits. Sclerenchyma sheath; fibres in up to 7 layers; walls moderately thickened but lignin-poor; intercellular spaces present, filled with extracellular substances. Vascular bundles: (i) peripheral; rounded, with arc of wide-medium-sized, angular tracheids; phloem pole well developed; (ii) medullary; outline rounded, as for genus; mx. vessels on flanks many-sided, with slightly thickened walls, separated one from the other by 1-2 files of flattened, thin-walled cells. Bundle sheaths; sclerenchymatous, as for genus. Central ground tissue; parenchymatous (alternating rectangular and square cells as seen in L.S.), cell walls thin, breaking down in culm centre.

E. grandis Ktze.

Culm diameter: 2 mm.

Card characters: 2b, 5b, 7, 9, 11, 14, 19, 22, 26, 27, 28, 31, 37, 42, 44, 47, 48, 50, 51, 53, 55, 56, 58a, 68, 71, 78, 81, 88, 110, 112, 114, 115, 121, 122.

Culm surface;

Epidermal cells; 4-sided, mostly slightly wider than long, some up to  $1\frac{1}{2}$  times wider than long, walls moderately thickened. Stomata; smaller than in other Elegia species, visible at lower plane of focus than surface of epidermis and slightly overarched by adjacent epidermal cells; subsidiary cells of type (xiii); guard cells of type (x); apertures of type (ii). Tannin; present in many epidermal cells. Cuticular marks; granular, longitudinal striations.

Culm T.S.

Cuticle; thick, ridged, Epidermal cells; present in 2, or occasionally, 3 layers; cells of outer layer mostly about  $1\frac{1}{2}$  times higher than wide, outer walls very thick, dome-shaped, anticlinal walls with tapering thickening, being thick at outer ends and moderately thickened at inner ends, not wavy, inner walls moderately thickened; cells of inner layer similar in size to those of outer, rectangular, some divided periclinally into half, walls slightly thickened. Stomata; sunken, attached to cells of inner epidermal layer; subsidiary cells of type (e), guard cells with pronounced, upturned, cuticular lip at outer aperture (6) and lip at inner aperture (8); lumina of type (4b). Chlorenchyma; composed of 2 similar layers of palisade peg-cells, each cell 6-7 times higher than wide, with medium sized, well spaced



pegs. Protective cells extending from inner walls of epidermal cells through outer chlorenchyma layer; adjacent cells touching one another at outer end only, each with concave long walls and slightly expanded ends. Parenchyma sheath; 2-3-layered, cells rounded-hexagonal, mostly wider than high, those of outer layer being the smallest. Sclerenchyma sheath; 5-6-layered, with slight ribs opposite pvbs.; fibres in main part of sheath v. thick-walled, with narrow lumina, those in the 1 or 2 layers surrounding pvbs. wider, with moderately thickened walls. Vascular bundles: (i) peripheral; as for genus, tracheids narrow and medium-sized, angular; (ii) medullary; as for genus, flanking mx. vessels wide, angular, with slightly thickened walls, separated from one another by 2-3 rows of narrow, parenchymatous cells; phloem ensheathed; px. present in all bundles; some bundles free from culm sclerenchyma sheath. Bundle sheaths; as for genus, fibres at phloem pole v. thick-walled, others with slightly to moderately thickened walls. Central ground tissue; parenchymatous, outer cells with moderately or slightly thickened walls, inner cells thin-walled and breaking down. Tannin; present in some epidermal cells.

Leaf T.S. See generic description; Epidermis; (i) abaxial, 2 layered and as in culm; (ii) adaxial, cells 4 sided, about 4 times wider than high.

E. intermedia Pill.

Culm diameter: 1.2 mm.

Card characters: 2,5,7,9,14,20,22,23,26,27,28,31,37,42,44,47, (lateral branch) 48,50,51,53,54,55,56,58b,68,110,117,121,122.

Culm surface:

Epidermal cells; rectangular to hexagonal, mainly  $1\frac{1}{2}$ -2 times longer than wide, walls moderately thickened, wavy at surface but straight at lower focus; rounded gaps present between end walls of some pairs of cells. Stomata; subsidiary cells of types (xi) or (xiii), long anticlinal walls sometimes wavy; guard cells of type (ix). Tannin; none seen. Cuticular marks; granular.

Culm T.S.

Epidermal cells; present in 2 layers; cells of outer layer slightly wider than high, those of inner layer as wide as and  $1\frac{1}{2}$ -3 times higher than the outer cells, sometimes protruding between them and reaching the surface. Outer walls thick, all other walls moderately thickened, anticlinal walls slightly wavy. Stomata; superficial, subsidiary cells of types (f) and (h); guard cells with lips at inner and outer apertures (7,8); lumina of type (3). Chlorenchy-  
ma; peg-cells in 2 similar layers, pegs small, sparse; protective cells extending from epidermis to half way into inner chlorenchy-  
ma layer, walls moderately thickened; apertures between protective cells present in inner half of tube. Parenchyma sheath; mainly 2-layered, with abundant simple pits. Sclerenchyma sheath; 2-3-layered; fibres moderately thickened. Vascular bundles; (i) peripheral; small, with arc of wide, thin-walled, angular tracheids to inner side of rounded phloem pole; (ii) medullary; as for genus; outermost without px. Bundle sheaths; sclerenchy-  
matous, fibres in 1 layer, those at bundle poles with

thickest walls. Central ground tissue; parenchymatous, cells large, thin-walled, frequently breaking down at culm centre.

E. juncea L.

Culm diameter: 2.0 mm.

Card characters: 2b, 5b, 7, 9, 14, 20, 22, 25, 26, 27, 28, 31, 37, 42, 44, 48, 50, 51, 53, 54, 55, 56, 58b, 68, 110, 112, 114, 115, 121, 122.

Culm surface:

Epidermal cells; mainly 6-sided, 1.5-3 times as long as wide; anticlinal walls moderately thickened, not wavy. Stomata; subsidiary cells of type (xx); guard cells of type (ix); apertures of type (ii). Cuticular marks; granular.

Culm T.S.

Epidermal cells; present in 2 layers, those of outer layer slightly higher than wide, those of inner layer  $1\frac{1}{2}$ -2 times higher than the outer, but of the same width; outer walls thick, curving inwards at the cell margins (fig. 8D), other walls moderately thickened, those of the inner cells being slightly thinner than those of the outer; anticlinal walls mainly straight. Stomata; superficial, subsidiary cells of type (f); guard cells with lip at outer aperture and ridge on inner wall (7,9); lumina triangular, wide (3). Chlorenchyma; consisting of palisade peg-cells in 2 similar layers, pegs sparse, fine, air spaces elongated; protective cells extending from epidermal cells to about half way into the inner chlorenchyma layer, having elongated apertures. Parenchyma sheath; 2-3-layered. Sclerenchyma sheath; 4-layered, walls of fibres moderately thickened. Vascular

bundles; (i) peripheral; as for genus; (ii) medullary; as for genus, but cells separating phloem from xylem wider than normal and with slightly thickened walls; px. present in all bundles. Bundle sheaths; sclerenchymatous, as for genus but with 2 layers of thick-walled fibres at xylem pole. Central ground tissue; parenchymatous, central cells frequently breaking down.

E. muirii Pill.

Culm diameter: 1.8 mm.

Card characters: 2,5,7,9,14,20,22,26,27,31,37,42,44,48,50,51,53,55,56,58,68,110,112,114,115,117,121,122.

Culm surface:

Epidermal cells; 4- or 5-, but mainly 6-sided, mainly  $1\frac{1}{2}$ -2 times as long as wide, walls thick, very slightly wavy; rounded gaps present between the end walls of some pairs of cells. Stomata; subsidiary cells of types (xi) and (xii); guard cells of type (ix). Cuticular marks; granular.

Tannin; none seen.

Culm T.S.

Epidermal cells; present in 2 similar layers, individual cells mainly twice as high as wide; all walls thick, not wavy, those of inner layer slightly thinner than those of the outer. Stomata; sunken, attached to the epidermal cells at the junction between the inner and outer layers; subsidiary cells of type (e); guard cells of type (ii), with beak-like outer lip at either end as seen at lower focus; lumina of type (2). Chlorenchyma; peg-cells mainly in 2, occasionally in 3 layers; pegs sparse; cells closer together

as seen in T.S., separated by wider spaces as seen in L.S.; protective cells extending from epidermis to part way into inner palisade layer. Parenchyma sheath; cells mainly in 2 layers, individual cells more or less hexagonal. Sclerenchyma sheath; cells in 4 layers, walls thick, lumina wide. Vascular bundles: (i) peripheral; several narrow tracheids arranged in an arc partly surrounding rounded phloem pole; (ii) medullary; with 1 medium-sized, angular, moderately thick-walled mx. vessel on either flank; phloem ensheathed; px. pole present in all bundles; all bundles free from sclerenchyma sheath. Bundle sheaths; sclerenchymatous, fibres narrow, thick-walled and in 4 layers at phloem pole; wider, with moderately thickened walls, in 1 layer on flanks and 2 layers at xylem pole. Central ground tissue; parenchymatous, outer cells with moderately to slightly thickened walls, inner cells thin-walled and breaking down at culm centre.

E. neesii Mast.

Culm diameter: 2.0 mm.

Card characters: 2b, 5b, 7, 9, 14, 20, 22, 26, 27, 31, 37, 42, 44, 45, 48,  
 Esterhuysen 49, 50, 51, 52, 53, 55, 56, 58b, 66, 68, 71, 81, 87, 88,  
 114, 61 110, 112, 115, 121, 122.  
 Burchell 569 2, 5b, 7, 9, 14, (20-28 not seen), 31, 37, 42, 44,  
 (type) 47, 48, 50, 51, 53, 55, 56, 58b, 66, 68, 110, 112, 114,  
 115, 117, 121, 122.

Culm surface:

Epidermal cells; present in 2 layers; outer layer discontinuous, the cells occurring in irregular areas, the cells of the inner layer being exposed in between them; cells

of outer layer papillate, papillae appearing rounded at high focus, hexagonal outline of cells visible at lower focus; cells of inner layer hexagonal, mainly 2-3 times longer than wide, walls thick, slightly wavy. Stomata; located in inner layer of epidermis; subsidiary cells of types (xiii-xiv); guard cells of type (ix); apertures of type (iii). Cuticular marks; prominent longitudinal striations.

Culm T.S.

Fig. 20A

Epidermal cells; present in 2 layers. Outer layer discontinuous, cells solitary or in groups of 2-3, individual cells papillate, with broad basal region, anticlinal walls tapering to rounded outer wall (cells c.30-40 $\mu$  wide at base, tapering to c.15-25 $\mu$  near apex of papilla and c.70 $\mu$  high). Papillae of adjacent cells frequently diverging. Outer walls and exposed anticlinal walls very thick, other walls moderately thick to thick. Inner layer continuous, cells <sup>4-6-sided, 1½ times higher than wide</sup> or more or less square, outer walls moderately thickened, anticlinal and inner walls slightly thickened. Stomata; attached to epidermal cells of inner layer; subsidiary cells of type (q); guard cells with outer and inner lips (7,8); lumina wide, triangular, oblique, type (4). Chlorenchyma; mainly 2-, occasionally 3-layered, pegs sparse, air-spaces between cells narrow (wider in L.S.); protective cells as high as cells of outer chlorenchyma layer, walls slightly thickened, apertures between protective cells extending from near epidermal cells almost to inner end of substomatal cavity. Parenchyma sheath; mainly 2-, occasionally 1-layered. Sclerenchyma sheath; 4-5-layered; walls of fibres of outer

2 layers thick, those of inner layers moderately thickened; lumina wide. Vascular bundles: (i) peripheral; with 1 medium-sized tracheid on either flank with an arc of narrow tracheids between them; phloem pole partly surrounded by arc; (ii) medullary; as in E. muirii. Bundle sheaths; sclerenchymatous, fibres narrow, thick-walled, in 2 layers at phloem pole, wider, 1-layered on flanks and 2-layered at xylem pole. Central ground tissue; parenchymatous, outer layers with slightly to moderately thickened walls, inner cells thin-walled, breaking down at culm centre.

Leaf. See generic description.

E. parviflora Kth.

Culm diameter: 0.8-2 mm.

Card characters: Group A.

Acocks 17460	2b, 5b, 7, 9, 14, 20, 22, 23, 26, 27, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 58b, 68, 112, 114, 115, 117, 121, 122.
Esterhuysen 25742	2b, 5b, 7, 9, 14, 20, 22, 23, 26, 27, 28, 30, 31, 36, 37, 42, 44, 47, 48, 50, 51, 53, 55, 58b, 66, 68, 110, 112, 114, 115, 117, 121, 122.
Godfrey GH1259	2b, 5b, 7, 9, 14, 20, 22, 23, 24, 26, 30, 31, 37, 42, 44, 47, 48, 50, 51, 53, 55, 56, 58b, 68, 110, 112, 114, 115, 121, 122.
Burchell 8647	2b, 5b, 7, 9, 14, 20, 22, 26, 27, 30, 31, 36, 37, 42, 44, 47, 48, 49, 50, 51, 53, 55, 56, 58b, 68, 110, 112, 114, 115, 121, 122.
Esterhuysen 3683	2b, 5b, 7, 9, 14, 19, 20, 21, 22, 26, 27, 30, 31, 37, 42, 44, 47, 48, 50, 51, 53, 58b, 68, 110, 112, 114, 115, 117, 121, 122.
Drège 120	<u>Group B.</u> 2b, 5b, 7, 9, 14, 20, 22, 23, 26, 27, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 110, 112, 114, 115, 117, 121, 122.

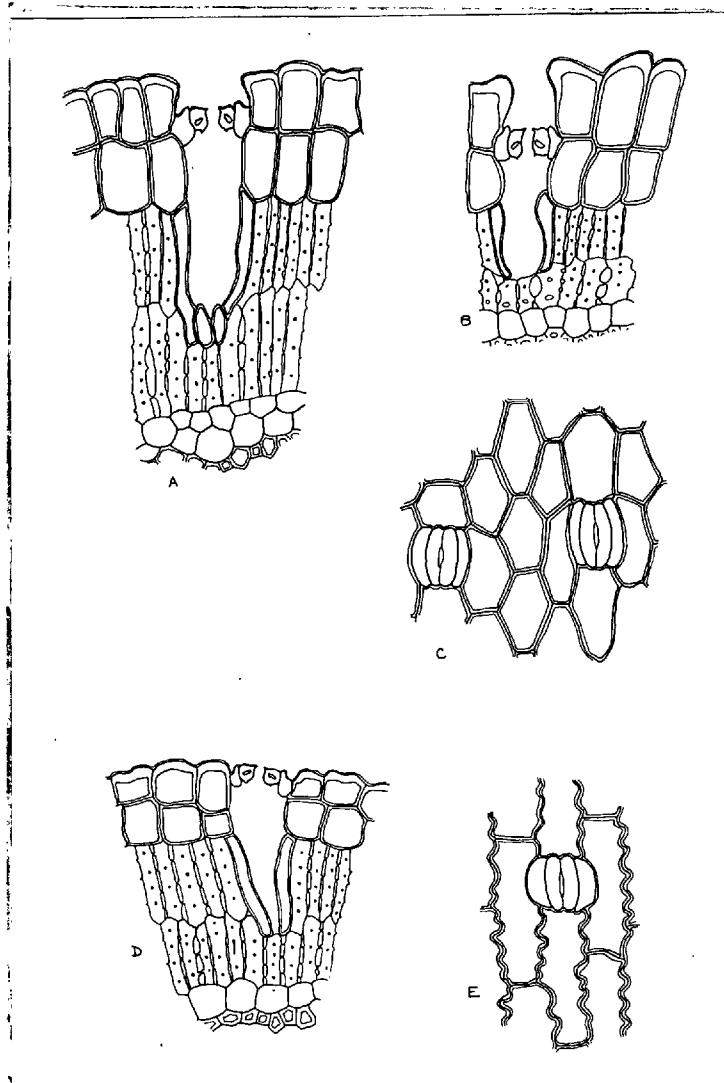


Fig. 19. *Eleocharis parviflora*. A, C, 26112; B, 26113; D, 26113A; E, 26114A. A, B and D outer part of culm T.S.; C and E, culm surface. (x200).



Parker 4842 and 4843	2b, 5b, 7, 9, 14, 20, 22, 23, 26, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 110, 112, 114, 115, 117, 121, 122.
Cheadle CA708	2b, 5b, 7, 9, 14, 19, 20, 22, 26, 27, 28, 31, 34, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 89, 90, 93, 103, 105, 106, 110, 121, 122.
Taylor 3029	2b, 5b, 7, 9, 14, 20, 22, 23, 26, 31, 36, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 110, 112, 114, 115, 117, 121, 122.
Vogts 50	2b, 5b, 7, 9, 14, 20, 22, 23, 26, 27, 28, 31, 42, 43, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 110, 112, 114, 115, 117, 121, 122.
Smith 5025	2b, 5b, 7, 9, 14, 20, 22, 23, 26, 27, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 112, 114, 115, 117, 121, 122.
Kuntze 350	2b, 5b, 7, 9, 14, 20, 22, 26, 27, 30, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 110, 112, 114, 115, 121, 122.
Kuntze 194	2b, 5b, 7, 9, 14, 20, 22, 26, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 112, 114, 115, 117, 121, 122.
Drège 2517!	2b, 5b, 7, 9, 14, 20, 22, 26, 30, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 110, 112, 114, 115, 121, 122.

Culm surface:

Figs. 19A-E

Papillae; outer epidermal cells slightly papillate (in group A only). Epidermal cells; in group A; normally hexagonal, slightly longer than wide to 2-3 times longer than wide; walls moderately thickened, not wavy; in group B; mostly rectangular, 2-5 times longer than wide, some cells more or less square; walls moderately thickened,

wavy. Stomata; in both groups, subsidiary cells parallel-sided, end walls mainly obtuse or perpendicular, sometimes angular (xi, xii, xiii, xviii, xix); guard cells of types (ix and x); apertures of type (vi). Tannin; frequent in epidermal cells. Cuticular marks; granular.

Culm T.S.

Papillae; overarching stomata, and present on other epidermal cells (in group A only). Epidermal cells; present in 2 layers; those of outer layer more or less square or slightly <sup>to 1½-2 times</sup> higher than wide (becoming wider than high in basal material); outer walls thick, convex (group A), frequently concave (group B); anticlinal walls and inner walls moderately thickened; cells of inner layer either of similar dimensions, or slightly taller or shorter than those of outer layer; walls moderately thickened. Stomata; in group A; sunken, attached to

epidermal cells at junction between the 2 layers; subsidiary cells predominantly of type (g); guard cells with outer lip (6) and poorly or well developed ridge on inner wall (9); lumina of type (4); in group B; superficial; subsidiary cells of types (f) or (g); guard cells with lip at outer aperture (6) and slight ridge on inner wall (9); lumina of type (2). Chlorenchyma; groups A and B; palisade peg-cells in 2 similar layers (1 layer in basal material); some protective cells extending from epidermis almost to parenchyma sheath, others only as high as cells of outer palisade layer; apertures between protective cells elongated, normally narrow, occasionally wide. Parenchyma sheath; normally 1-layered with occasional 2-layered areas; mainly 2-layered in one specimen. Sclerenchyma sheath; normally 2-4-layered (up to 8-layered in basal material); fibres moderately thick-walled, lumina wide. Vascular bundles: (i) peripheral; as for genus; (ii) medullary; as for genus, flanking mx. vessels rounded-angular, wide; phloem ensheathed. Bundle sheaths; sclerenchymatous, fibres in 3-4 layers at phloem pole, thick-walled, in 1-2 layers on flanks and 2-3 layers at xylem pole, with moderately thick walls. Central ground tissue; parenchymatous, walls of outer layers of cells moderately thick-walled, those of inner layers slightly thickened. Tannin; present in cells of inner epidermal layer.

Leaf; not seen.

Rhizome and root. See generic description.

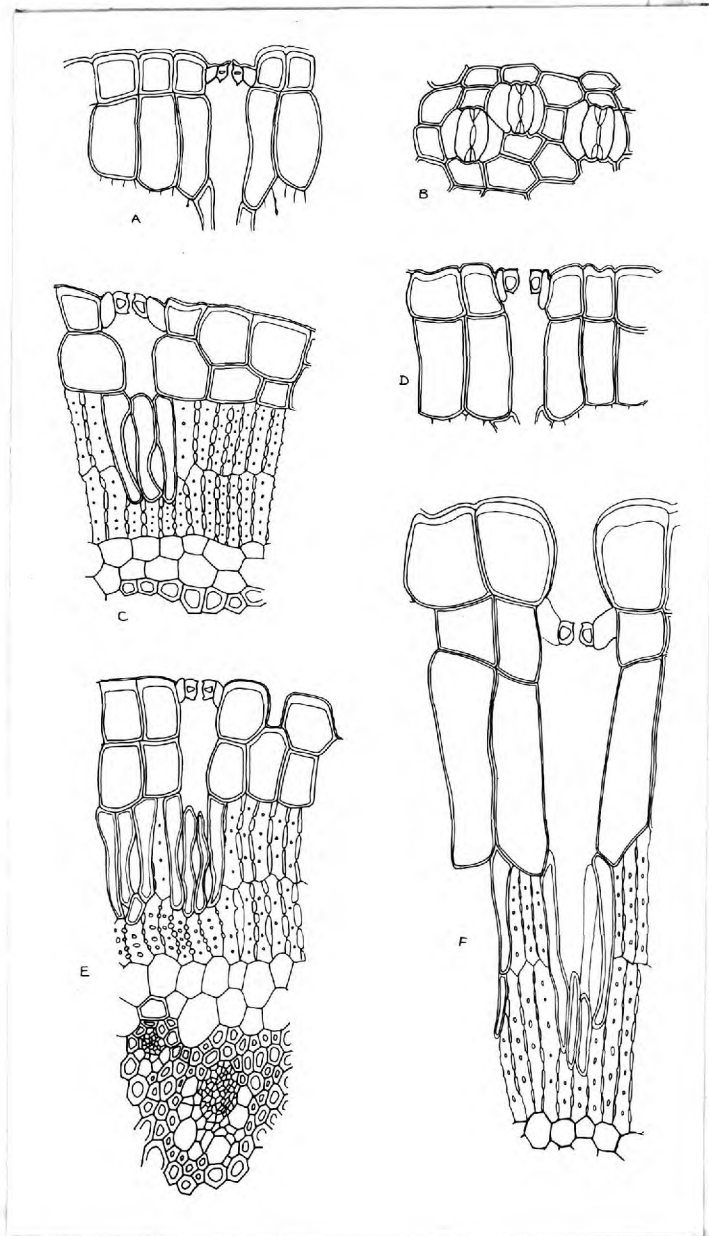


Fig. 18. *Eragrostis*. A, B, *galpinii* epidermis detail T.S. and surface; C, *coeleura*; D, *juncea*; E, *asperiflora* 15710; F, *fistulosa*, outer part of culm T.S., (x200).

E. racemosa Pers.

Culm diameter: 2.5 by 2 mm.

Card characters: 2,5,7,9,12,20,22,26,31,37,42,44,48,50,51,53,  
54,55,56,60,69,110,112,115,117,121,122.

Culm surface:

Epidermal cells; 4-sided,  $1\frac{1}{2}$ -2 times as long as wide, except at either end of stomata, where c.  $\frac{1}{2}$  as long as wide; walls moderately thickened, wavy. Stomata; subsidiary cells of types (xi and xii); guard cells of type (ix), occasionally narrowing at ends (x); apertures appearing as types (ii,iii, or iv) depending on plane of focus. Tannin; present in some cells. Cuticular marks; granular.

Culm T.S.

Epidermal cells; present in 2 layers, those of outer layer slightly to  $1\frac{1}{2}$  times wider than high, those of inner layer mostly twice as high as wide (about 3 times higher than those of outer layer); outer walls thick, some concave, most curving inwards at cell margins; all other walls moderately thickened, not wavy. Stomata; superficial, subsidiary cells of type (f); guard cells with lips at outer and inner apertures (7,8); lumina triangular, oblique (4). Chlorenchyma; 2-layered, pegs elongated, numerous; air-spaces wide. protective cells extending half way into inner chlorenchyma layer, joined to one another at their inner and outer ends only; apertures between protective cells wide, elongated. Parenchyma sheath; mainly 2-, occasionally 3-layered. Sclerenchyma sheath; 3-4-layered, fibres thick-walled, lumina wide. Vascular bundles: (i) peripheral; tracheids wide, otherwise as for genus; (ii) medullary; as for genus,

flanking mx. vessels rounded-angular, wide, walls moderately thickened; phloem ensheathed; px. present in all bundles, separated from sclerenchyma sheath by 1-2 conspicuous layers of compressed, narrow, parenchymatous cells. Bundle sheaths; as for genus; fibres at phloem pole v. thick-walled, others with slightly thickened walls. Central ground tissue; parenchymatous, cells v. wide, walls slightly thickened.

E. spathacea Mast.

Culm diameter 1.5 mm.

Card characters: 2b, 5b, 7, 9, 14, 20, 22, 23, 26, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 60, 68, 110, 112, 114, 115, 121, 122.

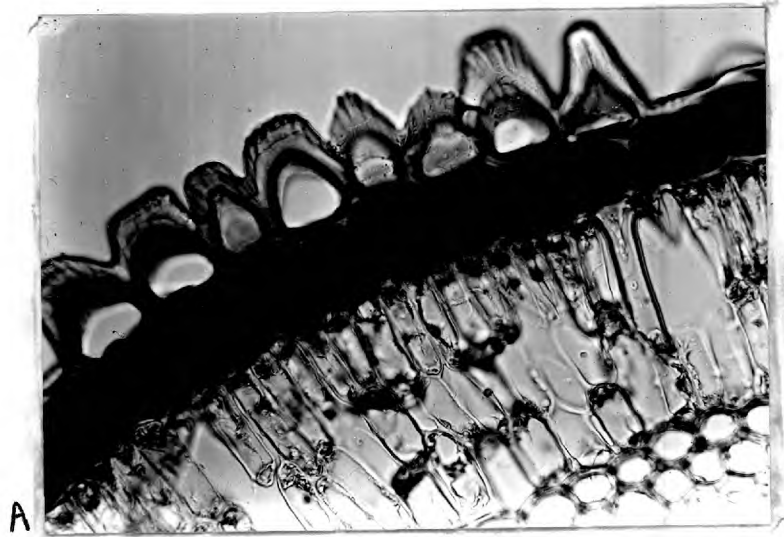
Culm surface:

Epidermal cells; more or less square, or rectangular and up to twice as long as wide, walls wavy, moderately thickened. Stomata; subsidiary cells of type (xiii), end walls occasionally perpendicular (xi); guard cells of type (ix); apertures of type (iv), with curved sides. Tannin; present in some cells. Cuticular marks; granular.

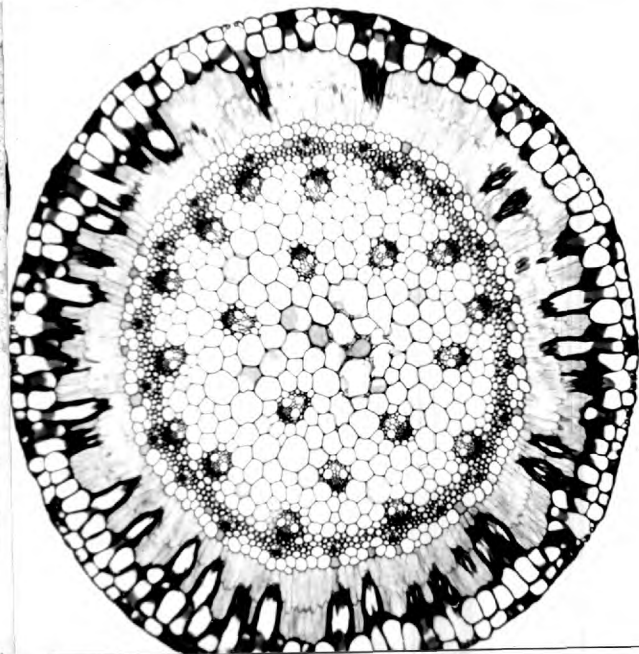
Culm T.S.

Fig. 20B

Epidermal cells; present in 2 layers, those of outer layer nearly square or  $1\frac{1}{2}$  times wider than high, those of inner layer mostly twice as high as wide and between twice and 3 times as high as those of outer layer; walls moderately thickened, outer walls curving inwards slightly at cell margins. Stomata; superficial, subsidiary cells of type (i); guard cells with inner and outer lips (7,8); lumina triangular, oblique (4). Chlorenchyma; palisade peg-cells present in 2 layers, those of inner layer slightly longer



A



B

Fig. 20. Elegia. A. neesii, epidermis T.S. (x580);  
B, spathacea culm T.S. (x50).

than those of outer layer, pegs small, numerous; air spaces narrow; protective cells extending from inner walls of epidermal cells to over half way into inner chlorenchyma layer; apertures elongated. Parenchyma sheath; 1-2-layered. Sclerenchyma sheath; c. 3-layered, fibres thick-walled, lumina wide. Vascular bundles: (i) peripheral; composed of 2-several wide, angular tracheids arranged in an arc; (ii) medullary; as for genus, flanking mx. vessels wide, angular; phloem ensheathed; px. poles absent from outer (smaller) bundles. Bundle sheaths; as for genus, fibres thick-walled, with narrow lumina. Central ground tissue; parenchymatous, cells wide, walls thin.

E. squamosa Mast.

Culm diameter: 1 mm.

Card characters: 2b, 5b, 7, 9, 14, 20, 22, 26, 27, 28, 30, 31, 42, 44, 48, 50, 51, 53, 54, 55, 56, 60, 68, 110, 112, 114, 115, 117, 121, 122.

Culm surface:

Epidermal cells; 4-sided, of 2 main types; (i) short, more or less square at either end of stomata; (ii) mostly twice as long as wide between stomata; walls moderately thickened, wavy. Stomata; subsidiary cells mainly of type (xi), occasionally of types (xiii and xii); guard cells of type (ix); apertures of type (vi). Cuticular marks; granular.

Culm T.S.

Epidermal cells; in 2 layers totalling c. 80 $\mu$  in thickness, cells of individual layers of irregular height, but mostly 20-40 $\mu$  wide (anticlinal walls inclined with respect to



culm surface as seen in L.S.); outer walls thick, curving inwards at cell margins, other walls moderately thickened, not wavy. Stomata; superficial, subsidiary cells of type (f); guard cells thick-walled, with lip at inner and outer apertures (7,8); lumina lenticular, oblique (4b). Chlorenchyma; palisade peg-cells present in 2 similar layers, pegs small, infrequent; protective cells extending into culm from inner walls of epidermal cells almost to parenchyma sheath, apertures between protective cells slit-like, elongated. Parenchyma sheath; mainly 1-, occasionally 2-layered. Sclerenchyma sheath; mainly 2-layered, fibre walls slightly to moderately thickened, lumina wide. Vascular bundles: (i) peripheral; as for genus, tracheids wide, angular, thick-walled; (ii) medullary; as for genus, flanking mx. vessels medium-sized, rounded-angular, with thick walls; phloem ensheathed; px. pores present in all bundles, separated from sclerenchymatous bundle sheath by 1 layer of narrow parenchymatous cells. Bundle sheaths; as for genus. Central ground tissue; parenchymatous, cells wide. Tannin; none observed.

E. stipularis Mast.

Culm diameter: 1.1, 1.5 mm.

Card characters: 1, 2, 7, 9, 12, 19, 21, 26, 27, 28, 31, 34, 42, 46, 47, 50,  
 Cheadle 52, 54, 55, 60, 68, 71, 78, 81, 89, 90, 93, 94, 98, 99,  
 CA825 (basal) 104, 108, 110, 117, 121, 122.  
 Pickstone 22. 1, 5a, 7, 9, 14, 20, 22, 26, 27, 28, 31, 37, 42, 44, 47, 48,  
 50, 53, 54, 55, 56, 58, 68, 71, 72, 78, 82, 110, 112, 115,  
 117, 121, 122.

Culm description based on Pickstone 22:

Culm surface:

Epidermal cells; rectangular, 2-3 times longer than wide, walls moderately thickened, not wavy. Stomata; subsidiary cells of type (xi), guard cells of type (ix), apertures of type (vi). Tannin; none seen. Cuticular marks; granular.

Culm T.S.

Epidermal cells; present in 2 layers, cells more or less square; outer walls thick, frequently convex, curving inwards at cell margins, other walls straight, slightly to moderately thickened. Stomata; superficial, subsidiary cells of type (h); guard cells with lip at outer aperture (6,7); lumina triangular, narrow, oblique (4). Chlorenchy-ma; composed of palisade peg-cells in 2 similar layers, pegs large, cells well separated by wide air-spaces; protective cells extending from epidermal cells to half way into inner palisade layer, touching one another at mouth and base of tube only, apertures between adjacent protective cells elongated, slit-like. Parenchyma sheath; 1-2-layered.

Sclerenchyma sheath; fibres <sup>in</sup> up to 6 layers, thick-walled, lumina medium-sized. Vascular bundles: (i) peripheral; as for genus, tracheids narrow; (ii) medullary; as for genus, flanking mx. vessels medium-sized, rounded-angular, walls moderately thickened; phloem partially ensheathed; px. poles absent from outer bundles. Bundle sheaths: as for genus.

Central ground tissue; parenchymatous, cells wide, walls thin to slightly thickened.

Leaf, Rhizome, Root, See generic description.

E. thyrsoides Pill.

Culm diameter 1.0 mm.

Card characters: 2b, 5b, 7, 9, 14, 20, 22, 24, 26, 27, 28, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 58, 60, 68, 110, 112, 114, 115, 121, 122.

Culm surface:

Epidermal cells; more or less rectangular,  $1\frac{1}{2}$ -3 times longer than wide, cells at ends of stomata shorter; walls moderately thickened, slightly wavy. Stomata; subsidiary cells narrow, of types (xii or xiii); guard cells of type (ix); apertures wide, of type (ii). Tannin; occluding lumina of most epidermal cells. Cuticular marks; granular.

Culm T.S.

Epidermal cells; present in 2 layers, cells more or less square; outer walls thick, curving inwards at margins, some concave; other walls slightly to moderately thickened. Stomata; superficial, subsidiary cells of type (f); guard cells with outer and inner lips (7,8); lumina lenticular, oblique (4b). Chlorenchyma; 2-layered, cell walls v. thin, pegs sparse, air-spaces largest between transverse layers; protective cells with slightly to moderately thickened walls, extending from epidermis almost to parenchyma sheath, joined to one another at inner and outer ends, apertures between adjacent cells long and wide. Parenchyma sheath; mainly 1-layered. Sclerenchyma sheath; 4-5-layered, walls of fibres slightly to moderately thickened, lumina wide. Vascular bundles: (i) peripheral; as for genus; (ii)

medullary; small; flanking mx. vessels narrow to medium-sized, angular, walls slightly thickened; phloem ensheathed. Bundle sheaths; weak; fibres in 1 layer, narrow and thick-walled at poles; wider, with slightly thickened walls on flanks. Central ground tissue; parenchymatous, cell walls slightly thickened. Tannin; plentiful in cells of outer epidermal layer, present in a few cells of central ground tissue.

E. vaginulata Mast.

Culm diameter: 1 mm.

Card characters: 2b,4b,7,9,14,20,22,26,31,42,44,47,48,50,51,53,55,56,58,60,68,110,112,114,115,121,122.

Culm surface:

Epidermal cells; 4-sided, mostly  $1\frac{1}{2}$ -2 times as long as wide, those at ends of stomata more or less square; walls moderately thickened, slightly wavy. Stomata; subsidiary cells of type (xii); guard cells of type (x); apertures wide, of type (ii). Cuticular marks; granular.

Culm T.S.

Epidermal cells; present in 2 layers, those of outer layer slightly to  $1\frac{1}{2}$  times higher than wide, outer walls thick, often slightly concave, curving inwards at cell margins, other walls moderately thickened; cells of inner layer similar in size to those of outer layer, but some higher, walls moderately thickened. Stomata; slightly sunken, but attached to cells of outer epidermal layer; subsidiary cells of type (f); guard cells with lips at inner and outer apertures (7,8); lumina of type (4).

Chlorenchyma; composed of 2 similar layers of palisade peg-cells; air-spaces between cells of 2 main sizes (i) small, rounded, frequent; (ii) larger, elongated, infrequent; protective cells extending from  $\frac{3}{4}$  way up sides of substomatal tube formed by inner layer of epidermal cells to half way into inner palisade layer, inner ends of cells hastate; apertures between protective cells elongated, with curved side and pointed ends. Parenchyma sheath; mainly 1-layered, 2-layered at sides of some pvbs., cells wide. Sclerenchyma sheath; weak, fibres in 2-3 layers, walls moderately thickened, lumina wide. Vascular bundles: (i) peripheral; unusual for genus, xylem pole consisting of several layers of narrow tracheids, with 1 or 2 medium-sized tracheids on the flanks; (ii) medullary; as for genus, flanking mx. vessels narrow, rounded-angular, walls thick; phloem poles ensheathed; px. present in all bundles. Bundle sheaths; as for genus, but fibres at poles v. thick-walled. Central ground tissue; parenchymatous, cells medium-sized to wide, walls moderately thickened; intercellular spaces filled with extracellular substances. Tannin; none seen.

E. verreauxii Mast.

Culm diameter: 0.75 mm.

Card characters: 2b, 5b, 7, 9, 14, 20, 22, 26, 31, 37, 42, 44, 47, 48, 50, 51, 53, 54, 55, 56, 58a, 60a, 68, 110, 112, 114, 115, 121, 122.

Culm surface:

Epidermal cells; 4-sided, more or less square or  $1\frac{1}{2}$ -2 times longer than wide; those at ends of stomata shorter, more or less rounded; walls moderately thickened, very wavy.

Stomata; subsidiary cells mainly of type (xviii) but slightly variable; guard cells of type (ix); apertures of type (ii). Cuticular marks; granular.

Culm T.S.

Epidermal cells; in 2, and occasionally 3 or 4 layers; those of outer layer mostly as high as or slightly higher than wide, inner cells as high as or up to  $1\frac{1}{2}$  times higher than those of outer layer. Outer walls thick, frequently concave, curving inwards at cell margins, other walls of outer cells moderately thickened; walls of inner cells slightly thickened, not wavy. Stomata; superficial, subsidiary cells of type (h); guard cells with outer lip (7) and ridge on inner wall (9); lumina triangular, narrow, slightly oblique (4). Chlorenchyma; consisting of palisade peg-cells in 2 similar layers, walls v. thin, pegs fine, short, numerous; protective cells extending from inner walls of epidermal cells almost to parenchyma sheath, inner ends expanded and going to a point, apertures between protective cells very wide, extending for almost whole height of the cells. Parenchyma sheath; mainly 1-layered. Sclerenchyma sheath; composed of 2-3 layers of fibres with wide lumina and slightly to moderately thickened walls. Vascular bundles: (i) peripheral; as for genus; (ii) medullary; small; flanking mx. vessels narrow, angular, thin-walled; phloem ensheathed. Bundle sheaths; as for genus. Central ground tissue; parenchymatous, walls of cells of outer layers slightly thickened, walls of inner cells thin.

E. verticillaris Kth.

Culm diameter: 5.0 mm.

Card characters: 5c,6a,6b,7,9,14,20,22,25,26,31,37,42,44,47,  
50,53,54,55,56,58,68,71,72,78,87,88,110,  
117,121,122.

Culm surface:

Epidermal cells; 4-and 6-sided, more or less square, or  $1\frac{1}{2}$ - $2\frac{1}{2}$  times as long as wide, walls moderately thickened, not wavy; cells of various lengths intermixed in longitudinal files, but short cells often present at ends of stomata. Stomata; subsidiary cells of types (xiii or xv); guard cells of type. (ix); apertures of type (vi). Cuticular marks; granular, with longitudinal striations.

Culm T.S.

Epidermal cells; present in 1-2 layers, cells of outer layer more or less square or slightly papillate, those of inner layer of similar dimensions or nearly twice as high. Outer walls thick, curving inwards at cell margins, other walls moderately thickened. Stomata; superficial, subsidiary cells of type (i); guard cells with outer and inner lips (6,8); lumina triangular, wide (3). Chlorenchyma; composed of 2 layers of similar cells with sparse, small pegs; air-spaces widest between transverse plates of cells (as seen in L.S.); protective cells extending from inner epidermal cell walls to half way into inner chlorenchyma layer, apertures between protective cells elongated. Parenchyma sheath; cells in 3 layers opposite pvbs., 4-layered in between them. Sclerenchyma sheath; well developed, about 5-7 layers thick, fibres narrow, thick-

walled. Vascular bundles: (i) peripheral; each with arc of tracheids, the flanking tracheids wide, the central ones narrow; (ii) medullary; very numerous, rounded in outline; flanking mx. vessels very wide, oval to round, close together in outer bundles, separated by 2-3 files of narrow parenchyma cells in inner bundles; phloem abutting directly onto xylem; px. poles absent from outermost bundles. Bundle sheaths; fibres 2-3-layered at phloem pole, 1-layered round rest of bundle, narrow; walls thick or moderately thickened. Central ground tissue; parenchymatous, cells medium-sized, walls moderately thickened; central cavity present. Tannin; none seen.

Leaf T.S. See generic description.



Harperia FitzgeraldGeneric and specific description.Culm surface:

Hairs; absent. Epidermal cells; as long as wide to  $1\frac{1}{2}$  times longer than wide, walls thick, wavy. Stomata; cells; subsidiary cells of types (xiii to xvii), as long as guard/guard cells of type (ix); apertures of type (ii), narrow.

Silica; granular material and irregularly-shaped bodies present in some epidermal cells. Tannin; none seen.

Cuticular marks; granular, with fine, longitudinal striations.

Culm T.S.

Outline; rounded, with irregular, low mounds.

Cuticle; thick. Epidermal cells; arranged in 1 layer; mainly  $2\frac{1}{2}$ -3 or 4 times higher than wide, but those next to stomata very elongated, with a tapering projection extending towards and often reaching parenchyma sheath, projections from adjacent cells surrounding a stoma united along their anticlinal walls and forming a substomatal tube, with rounded or oval apertures between the side walls, near the inner end of the tube, opening to adjacent chlorenchyma cells. Outer walls of epidermal cells very thick; anticlinal walls wavy, thick except for inner  $1/6$ , where slightly thickened; inner walls thin; inwardly directed projections from cells surrounding stomata with slightly thickened walls lining substomatal cavity and walls next to chlorenchyma cells thin, with numerous small pegs. All epidermal cells inclined at an angle of about  $50^{\circ}$  to culm surface as seen

in L.S. Stomata; superficial, subsidiary cells of type (m); guard cells with pronounced cuticular lips at outer aperture (5b); lumina of type (1). Chlorenchyma; composed of 1 layer of palisade peg-cells; individual cells about 10-12 times as long as wide, with numerous, small pegs. Parenchyma sheath; cells  $1\frac{1}{2}$ -2 times wider than high, with slightly thickened walls. Sclerenchyma sheath; 6-8-layered, fibres medium-sized to wide, hexagonal, with slightly rounded corners, walls thick; intercellular spaces filled with extracellular substances. Vascular bundles; (i) peripheral; tracheids narrow, arranged in single-layered arc partially enclosing small, tangentially oval phloem pole; (ii) medullary; with 1 narrow, rounded-angular mx. vessel having moderately thickened walls, on either flank; vessel wall pitting scalariform, perforation plates oblique, fenestrate-scalariform, vessels separated by 3-4 rows of very narrow cells; phloem poles ensheathed by 1 layer of very narrow cells with slightly to moderately thickened walls; px. present in all bundles; all bundles free from culm sclerenchyma sheath, some rotated from normal radial orientation. Bundle sheaths; sclerenchymatous, fibres narrow, thick-walled, with rounded corners; arranged in 2 layers at phloem pole, 1 layer on flanks and at xylem pole. Central ground tissue; parenchymatous, most cells with slightly to moderately thickened walls; small scattered areas of cells with thin walls also present; central cavity absent. Crystals; none seen. Silica; present as: (i) spheroidal-nodular bodies in stegmata of sclerenchyma sheath;

(ii) granular material or irregular bodies in some epidermal cells and some cells of central ground tissue.

Tannin; none seen.

Leaf, Rhizome and Root material not seen.

Harperia lateriflora Fitzgerald

Material examined: Fitzgerald, W. N.S.W. 48392, An.1903,  
Cunderdin, W. Australia 2751 (K)

Card characters:

Culm diameter: 1.0 mm.

2b, 5b, 7, 9, 14, 20, 24, 26, 27, 28, 31, 42, 43, 49, 50,  
51, 52, 54, 55, 56, 60b, 69, 110, 112, 114, 115, 118,  
121, 123, 124.

Hopkinsia FitzgeraldGeneric and specific description.Culm surface; not seen.Culm T.S.

Fig. 32A

Epidermal cells; oblong, c.  $2\frac{1}{2}$ -3 times as high as wide; outer walls convex, heavily thickened, occluding up to  $\frac{1}{2}$  lumen. Anticlinal and inner walls straight, thin. Those next to stomata with papillae overarching supra-stomatal cavity. Stomata; sunken to level of inner wall of epidermal cells and overarched by epidermal cells; subsidiary cells of type (c), guard cells without lips or ridges (12); lumina of type (1). Chlorenchyma; consisting of palisade cells, loosely packed, in 3 or occasionally 4 layers; pegs infrequent, short. Cells from  $\frac{1}{2}$ -4 times as high as wide. Parenchyma sheath; 1 (occasionally 2) layer(s) of cells, walls slightly thickened. Sclerenchyma sheath; strongly developed, c. 10-layered; outline ribbed; ribs corresponding to positions of peripheral vascular bundles. Two distinct zones present: (i) outer, fibres narrow, walls very thick; (ii) inner, fibres wider, walls thick, lumina wider. Vascular bundles: (i) peripheral; with small poles of phloem and xylem; (ii) medullary; with 1 narrow or medium-sized, rounded-angular metaxylem vessel on either flank; flanking vessels widely spaced; wall pitting scalariform, perforation plates simple, slightly oblique; phloem surrounded by sclerenchyma sheath; bundles graded in size: with small to medium-sized outer bundles, embedded in sclerenchyma sheath and larger, free, central, scattered bundles. Bundle sheaths; sclerenchymatous,

fibres 1-layered on flanks, 2-layered at xylem and 3-layered at phloem poles. Central ground tissue; parenchymatous; walls moderately thickened except for lacunae of thin-walled cells; no central cavity. Silica; none seen. Tannin; present in some epidermal and ground tissue cells. Crystals; none seen.

Leaf Surface; not seen.

Leaf T.S. (sheathing base).

Epidermis; (i) abaxial; outer walls thick, anticlinal and inner walls thin; cells mostly twice as high as wide; (ii) adaxial; walls thin; cells as high as wide to  $1\frac{1}{2}$  times higher than wide. Stomata; as in culm; present on abaxial surface only. Hypodermis; absent. Chlorenchyma; composed of 2-3 layers of more or less isodiametric cells situated below abaxial epidermis. Vascular bundles; with few cells in the phloem and xylem poles; larger bundles with 1 medium-sized angular tracheid on either flank, smaller bundles with narrow tracheids only. Bundle sheaths; sclerenchymatous, 1-2 layered. Sclerenchyma; continuous with bundle sheaths, in 4-5 layers, occupying up to  $\frac{1}{2}$  thickness of leaf, situated between adaxial epidermis and chlorenchyma. Ground tissue; 1 layer of parenchyma present between sclerenchyma and adaxial epidermis. Air-cavities; none present. Silica; none seen. Tannin; present in some epidermal cells. Crystals; none seen.

Rhizome T.S.

Epidermal cells; not seen. Cortex; outer 6-8 layers of cells parenchymatous with slightly thickened walls,

middle 8-9 layers consisting of hexagonal parenchymatous and sclerenchymatous cells intermixed, inner 3-4 layers composed of thin-walled rounded cells. Endodermoid sheath; not developed. Vascular bundles; scattered. Mx. vessels medium-sized, angular, with slightly to moderately thickened walls, arranged in horse-shoe around phloem, or completely encircling phloem. Bundle sheaths; sclerenchymatous, mostly 4 layered, fibres joining those of ground tissue and indistinguishable from them in places. Ground tissue; composed of sclerenchyma just described and lacunae of parenchymatous, thin-walled cells. Tannin, silica and crystals; none seen.

Root T.S.

Outer and cortical layers not seen. Endodermis; 1-layered, cells mostly  $1\frac{1}{2}$  times as high as wide, outer and anticlinal walls straight, inner walls with 2 faces; all walls heavily thickened. Pericycle; 7-8 layered, cells mostly  $1\frac{1}{2}$ -2 times as high as wide, those of outer layers with moderately thick to thick walls, those of inner layers with slightly to moderately thickened walls. Vascular system; phloem strands numerous, in single ring immediately to inside of pericycle; mx. vessels wide, mostly solitary, some pairs, radially oval, arranged in 1 ring. Central ground tissue; cells surrounding mx. vessels and extending inwards in 7-8 layers, narrow, hexagonal with slightly to moderately thickened walls; central cells narrow, rounded, thin-walled. Tannin, silica and crystals; none seen.

Material examined

Hopkinsia calovaginata (Gilg) ~~Gilg-Benedict~~ Cheadle, V.I. CA457,

An. 1961 Perth, W. Australia (S)

Card characters:

Culm diameter: 2 mm.

1,2,3,7,9,12,14,19,21,26,27,28,31,45,46,50,  
51,52,55,66,68,71,74,81,88,89,98,104,105,  
106,110,113,117,121,123,124.

Hypodiscus NeesGeneric descriptionCulm surface

Hairs, papillae; absent. Epidermal cells; 4-, 5-, or 6-sided, as long as or up to 4 times longer than wide, walls moderately thickened or very thick, straight or wavy. Stomata; subsidiary cells of types (xii), (xvii) and (xviii); guard cells of types (ix) and (x); apertures of type (ii). Silica; absent. Crystals; absent. Tannin; present in epidermal cells of some species. Cuticular marks; granular.

Culm T.S.

Outline; round or oval. Cuticle; moderately thick to thick. Epidermal cells; in 1 layer; more or less square or up to 2 (3) times higher than wide, outer walls thick or very thick, straight or concave; anticlinal walls slightly or moderately thickened, straight or wavy; inner walls slightly or slightly to moderately thickened. Stomata; superficial or sunken; subsidiary cells of types (e), (f), (j) and (i); guard cells sometimes with lips at outer and/or inner apertures, sometimes with ridge on inner wall; walls to pore convex (12) or concave (10); lumina oblique, triangular (4a). Chlorenchyma; composed of palisade peg-cells in two main types of arrangement: (i) cells in 2 (3) uninterrupted layers; (ii) cells in (2)3 layers, interrupted by girders from sclerenchyma sheath and their associated pillar cells. Peg-cells normally with few pegs, cells arranged in chequerboard-like manner as seen in T.L.S., each joining onto its neighbour at its four corners only,



individual cells alternating with air-spaces. Protective cells present in all species, normally surrounding substomatal cavity to depth of outer chlorenchyma layer only; cells represented by either: (i) little modified chlorenchyma cells, with slightly to moderately thickened walls lining the substomatal tube, and with rounded or oval apertures near to or at outer end of tube, particularly as seen in L.S., or (ii) palisade cells with expanded ends and parallel-sided middle portion, i.e. bone-shaped, or with ends extending laterally in an I shape or T shape; such cells in contact with neighbours at outer and inner ends only, apertures between them wide and very elongated. Parenchyma sheath; 1-layered in all species, either completely encircling culm, with all cells similar, or interrupted by sclerenchyma girders and with pillar cells as well as normal sheath cells; the number of pillar cells opposite to a girder is normally equal to number of cells making up width of girder. Sclerenchyma sheath; of two types; (i) outline rounded, 3-5-layered; (ii) outline rounded, with short or long rectangular girders radiating towards epidermis, these either partially or completely dividing chlorenchyma into sectors. Fibres narrow to medium-sized, thick-or very thick-walled; those surrounding pvbs. in species with girders medium-sized, moderately thick-walled. Vascular bundles: (i) peripheral; tracheids either (i) narrow, medium-sized or wide, arranged in 1-2-layered arc, or (ii) with 1 wider tracheid on either flank of arc; arc partially enclosing rounded or tangentially oval phloem pole; pvbs. alternating with girders in species

having them; (ii) medullary; (a) outer bundles, smaller than inner, with 1 narrow to medium-sized angular mx. vessel on either flank, these frequently touching, or separated by 1 row of narrow cells; wall pitting of mx. vessels scalariform, perforation plates oblique and scalariform or transverse - nearly transverse, simple; phloem close to xylem, frequently abutting directly onto it; px. absent from most bundles; (b) inner bundles, each with 1 medium-sized or wide, angular, mx. vessel, on either flank, these separated by 1-4 rows of narrow cells; phloem pole overarchingly flanking mx. vessels, frequently abutting directly onto them, but separated from them in places by narrow, parenchymatous cells; narrow sclereids or sclerified parenchyma cells present in phloem of some species; px. poles present in all inner bundles; bundles all enclosed in, some enclosed in, or all free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous; fibres at poles narrow with moderately thick or thick walls, in 1-2 (4) layers, those on flanks wider, with slightly to moderately thickened walls, often difficult to distinguish from ground tissue. Central ground tissue; parenchymatous; outer cells, surrounding vascular bundles, with slightly to moderately thickened walls; central cells, in bundle-free area, thin-walled, frequently breaking down to form cavity. Silica; spheroidal-nodular bodies present in some cells of outer layer of sclerenchyma sheath in some species. Crystals; absent. Tannin; present in some epidermal cells of some species.

Leaf surface

Abaxial, seen in H. albo-aristatus, H. aristatus and H. binatus.

Hairs; absent. Epidermal cells; 4-sided, as long as or up to 3 times longer than wide (up to 9 times longer than wide in 1 species), or hexagonal and up to twice as long as wide; walls moderately thickened, wavy in quadrangular cells, straight in hexagonal cells. Stomata; subsidiary cells of type (xviii) in all species; guard cells of types (ix) or (x). Tannin; none seen. Cuticular marks; granular.

Leaf T.S.

Sheathing base, seen in H. albo-aristatus, H. aristatus and H. neesii.

Hairs; absent. Epidermis; (i) adaxial; cells rectangular, mostly twice as wide as high, outer walls slightly thickened, other walls thin, or all walls thick (H. neesii); (ii) abaxial; cells 4-sided, as high as wide, with thick, convex outer walls (H. neesii) or about 1½-2 times higher than wide, with thick, concave outer walls (H. albo-aristatus), or about as high as wide, outer walls concave, moderately thickened (H. aristatus). Cells of both surfaces becoming progressively smaller, and meeting at leaf margins. Stomata; present in abaxial surface only, superficial in H. aristatus, sunken in H. albo-aristatus, not seen in H. neesii; subsidiary cells of types (b) or (c); guard cells with lips at outer and inner apertures (7,8); lumina of type (3). Chlorenchyma; composed of lobed or pegged cells, as high as wide to 2-3 times higher than wide, present in areas between vascular bundle sheaths, ground tissue and abaxial epidermis; protective cells present,

similar to bone-shaped type of culm. Vascular bundles; all small; smallest, with few narrow tracheids and phloem cells, alternating with larger, having 1 medium-sized tracheid on either flank of arc of narrow or narrow to medium-sized tracheids, and a larger phloem pole. Bundle sheaths; O.S. restricted to single-layered cap of parenchyma cells to abaxial side of bundle; I.S. sclerenchymatous; fibres in 1-2 layers at phloem pole, 3-4 layers at xylem pole, 3-4 layers on flanks, or joining laterally with that on flanks of adjacent bundles. Sclerenchyma; represented by bundle sheaths and their lateral bridges; bridging sclerenchyma either abutting directly onto adaxial epidermis, or separated from it by 1-2 layers of parenchymatous ground tissue. Ground tissue; parenchymatous, cells with thin or slightly thickened walls, present between and to adaxial side of vascular bundles, bordering onto chlorenchyma and adaxial epidermis; replaced between bundles in some cases by sclerenchyma as described above. Air-cavities; absent. Silica; individual, spheroidal-nodular bodies present in some cells of outer abaxial layer of sclerenchyma bundle sheath. Crystals; absent. Tannin; present in some abaxial epidermal cells.

Rhizome T.S.

Seen in H. albo-aristatus and H. aristatus.

Epidermal cells; narrow, square or slightly higher than wide, thick-walled. Outer cortex; cells mostly 2-3 times wider than and twice as high as those of epidermis, walls of all cells very thick, or those of occasional cells slightly

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cells present in 10-12 layers. Inner cortex; composed of 4-6 layers of thin-walled cells; cells slightly smaller than those of outer cortex. Endodermoid sheath; 1-layered, cells with thin outer walls and moderately thickened inner and anticlinal walls. Vascular bundles; mostly concentric, mx. vessels wide, angular, enclosing rounded phloem pole; bundles scattered. Bundle sheaths; difficult to distinguish from ground tissue, cells in 1-2 layers, flattened, with moderately thickened walls. Central ground tissue; matrix composed of cells with moderately thickened walls, interspersed with strands of thin-walled cells. Silica, crystals, tannin none seen.

#### Root T.S.

Seen in H. albo-aristatus, H. aristatus and H. willdenowia.  
Root hairs; arising from cells similar to remainder in epidermis, hair about  $\frac{1}{3}$ - $\frac{1}{2}$  width of base. Epidermal cells; 2-3 times wider than high, thin-walled. Outer cortex; composed of 2 layers of thin-walled cells and 1 layer of thick-walled cells, all similar in size to those of epidermis. Inner cortex; composed of radiating plates of cells separated from one another by air-spaces. Plates composed of 3-4-many cells in radial direction. Endodermis; cells in 1 layer, as high as wide or twice as high as wide, outer walls thin or moderately thickened, other walls very thick; lumina frequently entirely occluded in H. albo-aristatus.

Pericycle; cells parenchymatous, 5-6-sided, 2-3 times higher than wide, or about as high as wide, walls slightly to moderately thickened; cells in about 4 layers in H. albo-aristatus; 6-9 in H. aristatus and 5-6 in H. willdenowia. Vascular system; phloem strands numerous, arranged in 1 ring to inner side of pericycle; each strand composed of 1 or 2 wide sieve tubes and several narrow companion and parenchyma cells; px. poles present between phloem strands; mx. vessels wide, radially oval, arranged in 1 or 2 rings immediately to inside of that formed by phloem strands. Central ground tissue; composed of narrow, 5-6-sided cells with moderately thickened walls. Silica, crystals, tannin; none seen.

Material examined

H. albo-aristatus Mast.	Cheadle, V.I. CA770 Cape	(S)
H. altermans Pill.	Parker, R.N. 3520	1127 (K)
H. argenteus Mast.	Parker, R.N. 4770	1122 (K)
H. aristatus Nees	Cheadle, V.I. CA819 Cape	(S)
"	" CA824 Cape	(S)
H. binatus Mast.	Burchell	(M)
H. neesii Mast.	Esterhuysen 3750 ♀, An.1940, 4700 ft, S. slopes Bronteberg Mts.	1124 (K)
H. purpurea Pill.		1126 (K)
H. striatus Mast.	Esterhuysen An.1941	1123 (K)
H. synchronolepis Mast.	'816 Restio, = 9608 Drège!	1121 (K)
H. willdenowia Mast.	Parker, R.N. 4089 ♀, Sandy soil.	1125 (K)

Species descriptionsH. albo-aristatus Mast.

Culm diameter: 1 mm.

Card characters: 2a, 5b, 7, 9, 14, 20, 22, 26, 27, 31, 37, 42, 44, 47, 48, 50, 51, 52, 54, 55, 60, 68, 71, 73, 78, 88, 89, 90, 91, 99, 104, 105, 106, 117, 118, 121, 123, 124.

Culm surface

Fig. 21D

Epidermal cells; 4-sided, mainly 2-3 times longer than wide, but some, particularly those next to stomata, as long as or shorter than wide; walls slightly to moderately thickened, wavy. Stomata; subsidiary cells of type (xvii); guard cells of type (x); apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; granular, with a longitudinal striation near to each longitudinal wall.

Culm T.S.

Outline; round. Cuticle; moderately thickened.

Epidermal cells; mostly about as high as or slightly higher than wide; outer walls thick, slightly concave; other walls thin, anticlinal walls sometimes wavy. Stomata; superficial; subsidiary cells of type (e); guard cells with slight ridge on inner walls (9) and convex walls to pore (12); lumen shaped like trapezium with longest wall next to pore.

Chlorenchyma; composed of palisade cells in 2 layers, individual cells 4-5 times higher than wide, with few pegs; protective cells extending from epidermis to junction between chlorenchyma layers, with expanded ends and elongated apertures (generic type ii) (fig. 21C). Parenchyma sheath; cells rounded, with slightly to moderately thickened walls, present in 1 layer opposite to pvbs., interrupted between pvbs. by broad sclerenchyma ridges from sclerenchyma sheath;

ridges 1 fibre high and up to 7-9 fibres wide. Sclerenchyma sheath; 2-4 fibres wide, outline rounded, with low ridges just described; inner cells difficult to distinguish from central ground tissue. Vascular bundles: (i) peripheral, tracheids medium-sized, arranged in 1-layered arc partially enclosing tangentially oval phloem pole; (ii) medullary; as for genus; flanking mx. vessels of inner bundles medium-sized, angular, separated by 4-5 rows of narrow parenchyma cells and tracheids; perforation plates oblique, scalariform; phloem without sclereids, abutting directly onto xylem.

Bundle sheaths, central ground tissue; as for genus.

Silica; none seen. Tannin; present in some epidermal cells.

Leaf, rhizome and root; see generic description.

H. altermans Pill.

Culm diameter: 1 by 0.75 mm.

Card characters: 2a, 5b, 7, 9, 14, 18, 19, 22, 26, 27, 28, 30, 31, 37, 42, 45, 47, 48, 49, 50, 51, 52, 54, 55, 58a, 60, 70, 112, 114, 115, 121, 123, 124.

Culm surface

Epidermal cells; mostly 4-sided, frequently  $1\frac{1}{2}$ - $2\frac{1}{2}$  times longer than wide, but some shorter than or as long as wide; walls moderately thickened, axial walls wavy. Stomata; subsidiary cells of type (xvii); guard cells narrow, of type (ix); apertures of type (ii). Tannin; none seen. Cuticular marks; granular, with short lines running transversely across walls.

Culm T.S.

Fig. 23 B

Outline; oval. Cuticle; slightly thickened.

Epidermal cells; 4-sided, mostly twice as high as wide;



outer walls very thick, normally concave at outer surface, anticlinal and inner walls moderately thickened, lumina reduced to about half height of cells. Stomata: superficial; subsidiary cells of type (f); guard cells with slight lip at outer and inner apertures (7,8); lumina of type (4a). Chlorenchyma; composed of 3 similar layers of palisade peg-cells; individual cells 2-4 times higher than wide, with few, small pegs (pegs arranged in 4 files on most cells as seen in T.L.S.). Protective cells of generic type (ii), mostly I-shaped with moderately thickened walls. Parenchyma sheath; 1-layered; cells rounded, 5-6-sided, mostly as high as wide; layer interrupted in places by 1-4 fibres from sclerenchyma sheath. Sclerenchyma sheath; 5-7-layered, outline oval, with low ridges between pvbs.; fibres of outer 3-4 layers narrow to medium-sized, very thick-walled and with narrow lumina, those of inner layers wider, thick-walled, with wider lumina, those of innermost layers often difficult to distinguish from ground tissue. Vascular bundles: (i) peripheral; tracheids narrow to medium-sized and medium-sized, arranged in 1-layered arc partially enclosing phloem pole; (ii) medullary; as for genus; flanking mx. vessels of inner bundles angular, medium-sized or wide (or 2, narrow, on either flank); phloem pole abutting directly onto and overarching xylem; most bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous; fibres narrow, thick-walled, in 2-3 layers at phloem pole, 1 layer on flanks and 1-2 layers at xylem pole. Central ground tissue; parenchymatous; cells of outer layers thick or moderately

thick-walled; those of inner layers thin-walled, breaking down. Silica; spheroidal-nodular bodies present in stegmata of outer sclerenchyma layer, particularly in cells of ridges. Tannin; none seen.

H. argenteus Mast.

Culm diameter: 1.5 mm.

Card characters: 2a, 5b, 7, 9, 14, 19, 22, 26, 27, 31, 32, 33, 37, 42, 44, 47, 48, 49, 50, 51, 52, 54, 55, 56, 58b, 60, 68, 110, 112, 114, 115, 117, 118, 121, 123, 124.

Culm surface

Epidermal cells; irregular sizes; 4-, 5- and 6-sided, ranging from wider than long through as long as wide to  $1\frac{1}{2}$  times longer than wide; walls moderately thickened to thick, slightly wavy. Stomata; subsidiary cells of types (xiii) to (xvi), slightly shorter than guard cells; guard cells nearest to type (ix), but end walls slightly pointed; apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; granular.

Culm T.S.

Figs. 22A, 23C

Outline; round. Cuticle; thick. Epidermal cells; 2-2 $\frac{1}{2}$  times higher than wide; outer walls very thick, outer surface straight or slightly concave; anticlinal walls moderately thickened to thick, wavy; inner walls moderately thickened. Stomata; superficial; subsidiary cells of type (i) but elongated, about twice height of guard cells; guard cells narrow, with slight lip at inner aperture (8); lumina of type (4a). Chlorenchyma; cells in 2 or 3 layers, divided into 21 sectors by girders from sclerenchyma sheath and their associated pillar cells; chlorenchyma cells

palisade, from 3-8 times but mostly 5-6 times higher than wide; pegs few, cells arranged as in a chequerboard as seen in T.L.S.; protective cells of generic type (i). Parenchyma sheath; composed of moderately thick-walled pillar cells extending between sclerenchyma girders and epidermis, and 1 discontinuous layer of wide to medium-sized, <sup>slightly thickened to</sup> thin-walled, rounded-hexagonal cells, between and on inner flanks of girders. Sclerenchyma sheath; 4-6-layered, with 21 rectangular girders radiating from it at more or less regular intervals; each girder 2-5 cells wide and 8-10 cells high; fibres of girders and between pvbs. narrow, very thick-walled and with narrow lumina; those surrounding pvbs. wider, with moderately thick walls and wide lumina. Vascular bundles: (i) peripheral; tracheids wide and medium-sized, angular, arranged in single layered arc partially enclosing tangentially oval phloem pole; (ii) medullary; flanking mx. vessels of inner bundles wide, rounded-angular, with slightly thickened walls, separated from one another by 2-4 rows of narrow, thin-walled cells; phloem pole abutting directly onto xylem in places but separated from it by 1 layer of narrow cells for the most part. Bundle sheaths, central ground tissue; as for genus. Silica; spheroidal-nodular bodies present in stigmata in outer fibre layer of flanks of sclerenchyma girders. Tannin; present in some epidermal cells. (See figs. <sup>23c</sup> 22A).

H. aristatus Nees

Culm diameter: 1.5, 2 mm.

Card characters: 2a, 5b, 7, 9, 14, 20, 22, 26, 27, 28, 31, 37, 42, 48, 52, 54, 68, 71, 73, 77, 81, 110, 112, 113, 115, 121, 123, CA819 124.

(Culm material not normal; from within leaf sheath).

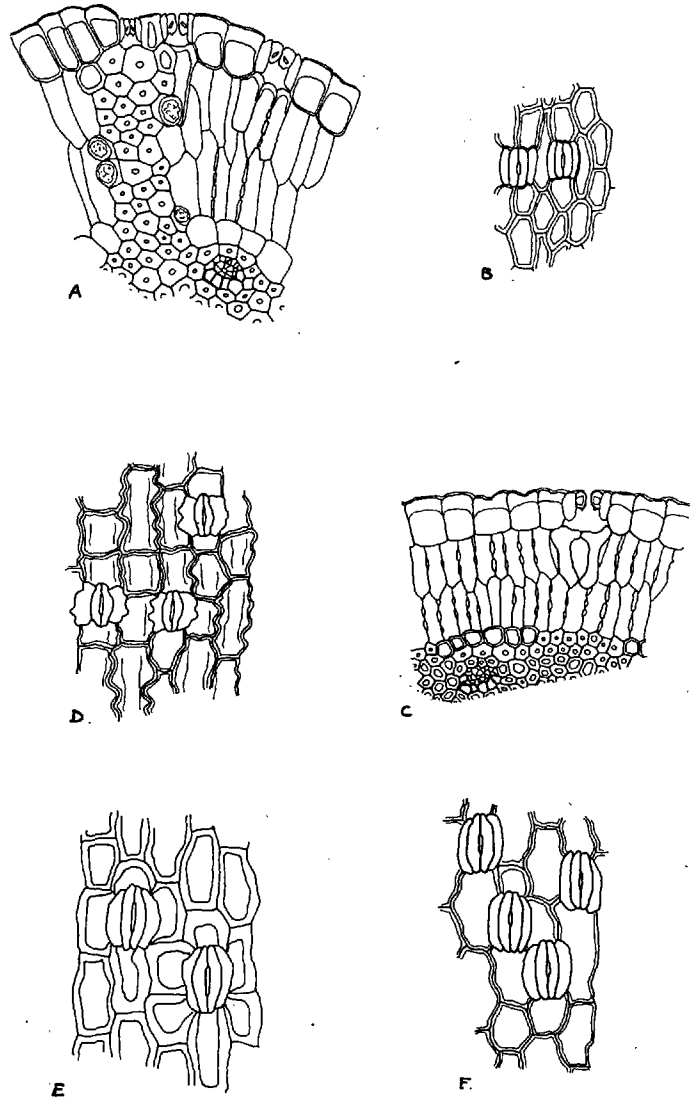


Fig. 21. *Hypodiscus*. A,B, *willdenowia*; D,C, *alboaristatus*; E, *binatus*; F, *striatus*. A,C, outer part of culm T.S. B,D,E,F, culm surface. (x200).

CA824 2a, 5b, 7, 9, 14, 19, 20, 22, 26, 27, 28, 31, 32, 33, 46,  
(basal) 47, 50, 51, 52, 54, 68, 89, 90, 91, 92, 99, 103, 104, 108,  
109, 110, 113, 114, 121, 123, 124.

Culm surface; not seen.

Culm T.S.

Outline; round. Cuticle; moderately thickened.

Epidermal cells; more or less square, outer walls very thick, other walls moderately thickened, not wavy. Stomata; superficial; subsidiary cells of type (j); guard cells with slight lip at inner aperture (8); lumina of type (4a).

Chlorenchyma; cells isodiametric, abnormal. Parenchyma sheath; 1-layered, cells as high as wide or up to about  $1\frac{1}{2}$  times wider than high; interrupted by sclerenchyma girders in CA824. Sclerenchyma sheath; fibres narrow, thick-walled, arranged in up to 9 layers; outline rounded, with slight ridges (CA819) or with rectangular girders (CA824); girders alternating with pvbs., 4-5 cells wide and 6-9 cells high.

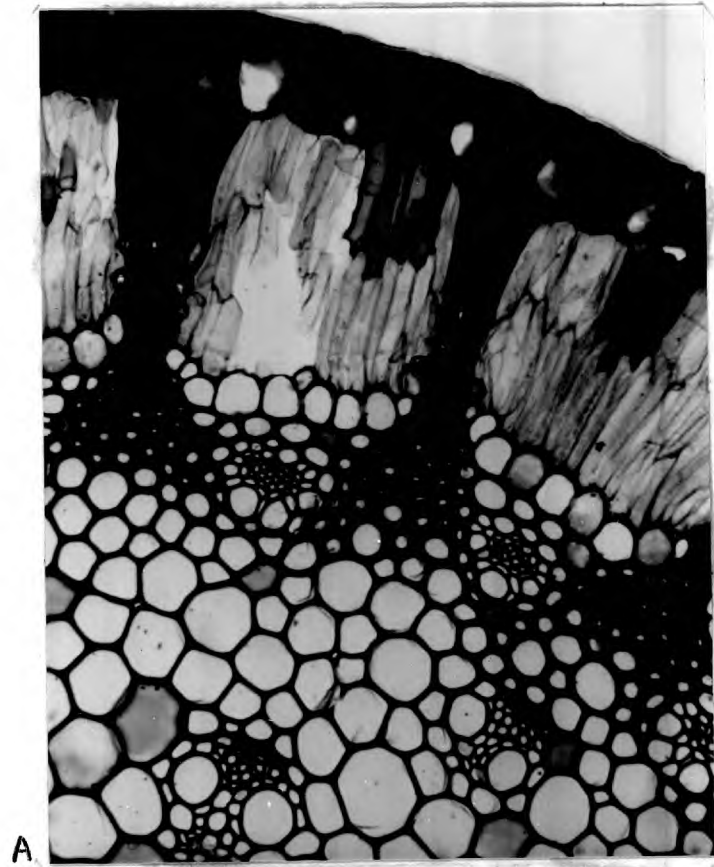
Vascular bundles: (i) peripheral; tracheids wide, angular, thin-walled, arranged in 1-layered arc partially enclosing tangentially oval phloem pole; (ii) medullary; flanking mx. vessels of inner bundles medium-sized, rounded-angular, with slightly thickened walls, separated by 2-4 rows of narrow, thin-walled cells; phloem abutting directly onto xylem in places. Bundle sheaths, central ground tissue; as for genus. Silica, tannin; none seen.

Leaf, rhizome, root; see generic description.

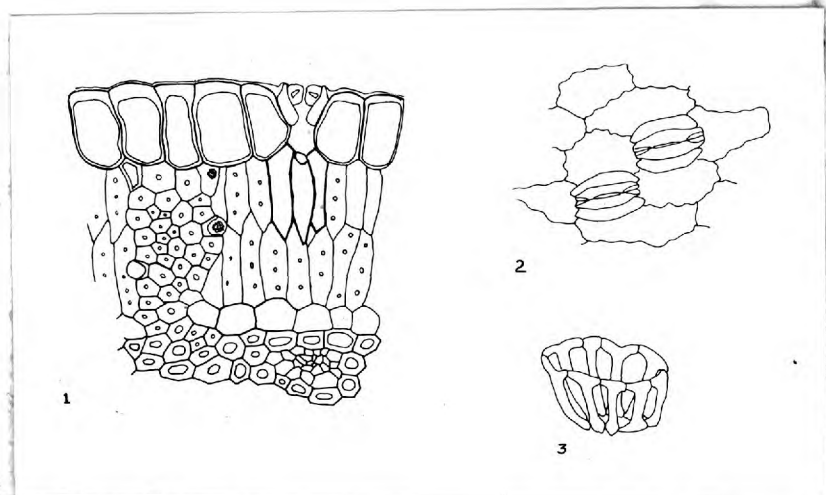
H. binatus Mast.

Culm diameter: 1.3 mm.

Card characters: 2a, 5b, 7, 9, 14, 19, 21, 26, 27, 28, 31, 37, 42, 44, 47, 48, 49, 50, 51, 52, 54, 55, 60, 68, 71, 73, 78, 81, 88, 112, 115, 117, 121, 123, 124.



A



B

Fig. 22. Hypodiscus. A, argenteus; B 1, and 2 striatus, B 3, synchroolepis. A, B 1 outer part of culm T.S. B 2 culm surface. B 3 diagram of protective cells. (x200).

Culm surface

Epidermal cells; mostly 4-sided, those next to stomata slightly wider than or as wide as long, others mainly 2-3 times longer than wide; walls thick, wavy. Stomata; subsidiary cell long anticlinal walls irregularly wavy (xvii) or approaching type (xviii); guard cells of type (x), but with only slightly constricted ends; apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; coarsely granular. (See fig. 21E).

Culm T.S.

Outline; round. Cuticle; moderately thickened. Epidermal cells; 4-sided, as high as to  $1\frac{1}{2}$  times higher than wide; outer walls very thick, outer surface irregular; other walls slightly thickened; anticlinal walls not wavy. Stomata; superficial; subsidiary cells of type (i), but nearly twice as high as guard cells; guard cells with very small lips at outer (7) and inner (8) apertures; lumina of type (4a). Chlorenchyma; composed of 2 similar palisade layers, cells mainly  $2\frac{1}{2}$ -3 times higher than wide, with few pegs; protective cells with expanded ends, of generic type (ii). Parenchyma sheath; 1-layered, cells up to twice as wide as high; layer interrupted in places by cells from sclerenchyma sheath. Sclerenchyma sheath; cells present in about 8 layers; outline rounded with low intrusions, 1 cell high and 2-4 cells wide, into parenchyma sheath between pvbr. Fibres very thick-walled, narrow in outer layers, wider in inner layers. Vascular bundles: (i) peripheral; small; tracheids narrow to medium-sized, angular, arranged in single-layered arc partially enclosing tangentially oval phloem pole;

(ii) medullary; as for genus; flanking mx. vessels of inner bundles medium-sized to wide, angular, separated by 2-4 rows of narrow, thin-walled cells; phloem poles small, abutting directly onto xylem in places, and containing some small sclereids; all bundles attached to culm sclerenchyma sheath by fibres at phloem pole. Bundle sheaths; fibres at phloem pole narrow, thick-walled, in 2 or 3 layers, embedded in culm sclerenchyma sheath; fibres on flanks and at xylem pole in 1 layer, narrow to medium-sized, with moderately thickened or thick walls. Central ground tissue; as for genus. Silica; spheroidal-nodular bodies present in stigmata of outer layer of sclerenchyma sheath, particularly in the ridges from the sheath. Tannin; present in some epidermal cells.

Leaf surface; see generic description.

H. neesii Mast.

Culm diameter: 0.8 mm.

Card characters: 2a, 5b, 7, 9, 12, 14, 19, 20, 21, 22, 26, 27, 28, 31, 32, 33, 37, 42, 43, 44, 45, 47, 48, 49, 50, 51, 52, 55, 56, 57, 58a, 58b, 68, 71, 73, 74, 81, 87, 88, 112, 115, 117, 121, 123, 124.

Culm surface

Epidermal cells; irregular sizes and shapes, 4-, 5- and 6-sided, walls straight, thick. Stomata; subsidiary cells variable, of types (xi), (xii) and (xiii); guard cells of type (x). Tannin; present in many epidermal cells.

Cuticular marks; coarsely granular.

Culm T.S.

Fig. 23A

Outline; rounded, Cuticle; thick, with slight ridges.

Epidermal cells; mainly twice as high as wide, some  $1\frac{1}{2}$  or  $2\frac{1}{2}$ -3



times higher than wide, outer walls very thick, frequently slightly convex; anticlinal walls not wavy, thick at outer ends, thickening tapering, inner half of walls and inner walls moderately thickened. Stomata; sunken; mounted about half way down anticlinal walls of epidermal cells; subsidiary cells of type (i) but extending further to inside of guard cells than normal for this type; guard cells with no lips at outer aperture, but with slight ridge on inner wall (9); lumina of type (4a). Chlorenchyma; composed of 1, 2 or 3 layers of palisade cells with few short pegs; cells mainly 4-6 times higher than wide; cells of outermost layer\* completely encircling culm, those of inner layer(s) interrupted by strong rectangular girders from sclerenchyma sheath. Protective cells present, of generic type (i). Parenchyma sheath; 1-layered, interrupted by girders from sclerenchyma sheath, but extending about half way up flanks of girders; cells rounded, 5-6-sided, mostly about as high as wide, narrowest on flanks of girders, widest opposite to pvbs. Sclerenchyma sheath; outline rounded, with 12 evenly spaced girders radiating into chlorenchyma, but stopping at inner face of outer chlorenchyma layer; girders rectangular in outline, or with slightly expanded, rounded, outer ends, each about 12 cells high, 4-8 cells wide at inner end and 6-9 cells wide at broadest point, near outer end; sheath between girders about 7 layers wide, fibres narrow to medium-sized, very thick-walled. Vascular bundles: (i) peripheral; alternating with girders; (a) small, with 2-4 narrow and medium-sized tracheids arranged in shallow arc, (b) larger,

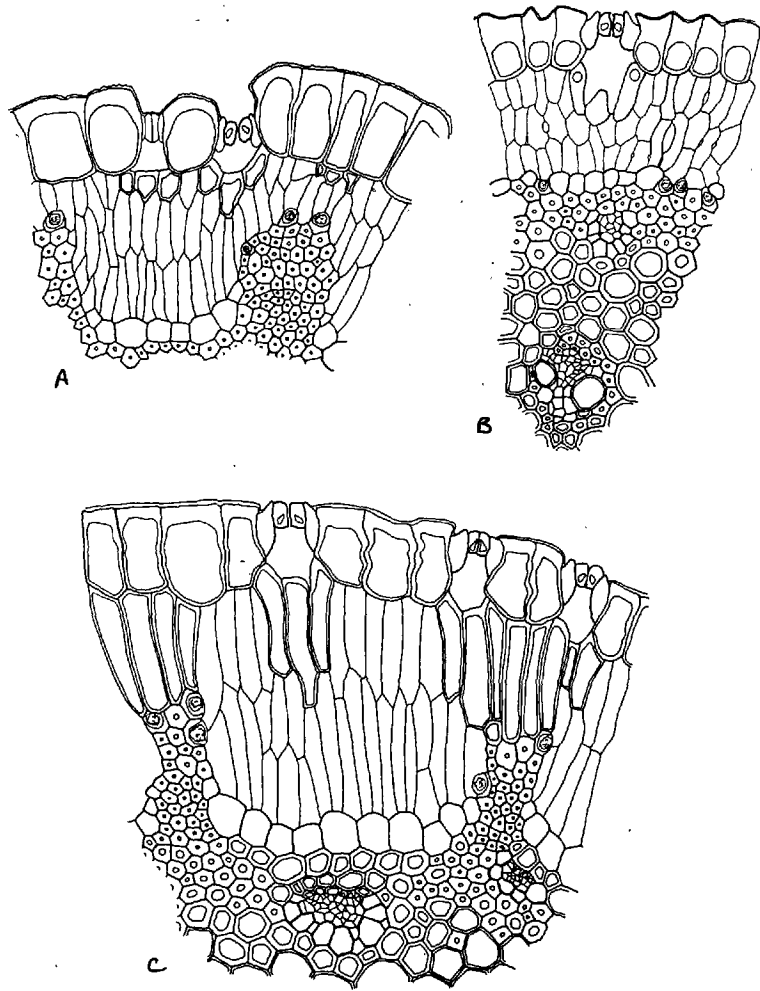


Fig. 23. Hypodiscus. A, neesii; B, alternans;  
C, argenteus. outer part of culm T.S. (x185).

with up to 10 narrow and medium-sized tracheids arranged in dish-shaped arc; phloem 3-4-layered, situated in concavity of arc, with frequent, narrow sclereids; (ii) medullary; flanking mx. vessels of inner bundles medium-sized, rounded-angular, moderately thick-walled, separated by 4-6 files of narrow sclereids and phloem cells to outer side and narrow tracheids to inner side of bundle; phloem divided into several small strands by areas of narrow sclereids, some phloem cells abutting directly onto xylem; no bundles free from culm sclerenchyma sheath. Occasional fusions observed between pvbs. and small, outer mvbs. Bundle sheaths, central ground tissue; as for genus. Silica; spheroidal-nodular bodies present in stigmata in outer layer of sclerenchyma sheath, particularly in rounded ends of girders. Tannin; present in many epidermal cells. Leaf T.S.; see generic description.

H. purpurea Pill. Culm diameter: 1 by 0.8 mm.

Card characters: 2a, 5b, 7, 9, 12, 14, 20, 22, 26, 27, 28, 31, 32, 33, 36, 37, 42, 44, 47, 48, 49, 51, 52, 54, 55, 56, 60, 70, 112, 114, 115, 117, 121, 123, 124.

Culm surface

Epidermal cells; 4-sided, ranging from as long as wide to 3 times longer than wide; walls slightly to moderately thickened, wavy. Stomata; subsidiary cells mostly of types (xviii) and (xix); guard cells of type (ix); apertures of type (ii). Tannin; present in most epidermal cells.

Cuticular marks; granular.

Culm T.S.

Outline; oval. Cuticle; moderately thickened.

Epidermal cells; as high as to slightly higher than wide, those opposite to sclerenchyma girders about  $2/3$  size of others. Outer walls very thick, slightly convex; other walls slightly to moderately thickened, anticlinal walls not wavy. Stomata; superficial; subsidiary cells of type (i), but extending inwards beyond guard cell further than normal for this type; guard cells with slight ridge on inner wall (9); lumina of type (4a). Chlorenchyma; composed of 2 layers of palisade peg-cells; cells  $2\frac{1}{2}$ -4 times higher than wide, pegs sparse; protective cells present, of generic type (i), but apertures elongated, slit-like. Parenchyma sheath; 1-layered, cells as wide as or slightly wider than high, with rounded corners; layer interrupted at irregular intervals by sclerenchyma girders. Sclerenchyma sheath; mainly 2-3-layered, fibres medium-sized to wide, with thick walls; outline oval, with 5 girders, 3 irregularly spaced and one at either end of major radial axis of culm; <sup>girders</sup> / rectangular or inverted wedge-shaped, 3-4 cells wide and 3-4 or 7-8 cells high, 4 extending to epidermis, 1 reaching junction between chlorenchyma layers, composed of narrow fibres with thick walls. Vascular bundles: (i) peripheral; none opposite sclerenchyma girders; as for genus; narrow sclereids present in phloem; (ii) medullary; as for genus; flanking mx. vessels of inner bundles medium-sized, rounded-angular, separated by 4-5 rows of narrow cells; phloem divided into several strands by narrow sclereids; no bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous, joined at phloem pole to culm sclerenchyma sheath; fibres

present in 1-2 layers round flanks and xylem pole. Central ground tissue; as for genus; central cavity wide. Silica; spheroidal-nodular bodies present in stigmata on flanks of sclerenchyma girders. Tannin; present in most epidermal cells, absent from most of those opposite to sclerenchyma girders. .

H. striatus Mast.

Culm diameter: 1 mm.

Card characters: 2a, 5b, 7, 9, 14, 19, 20, 22, 26, 27, 28, 31, 32, 33, 37, 42, 44, 47, 48, 49, 50, 51, 52, 54, 55, 56, 58b, 60, 68, 112, 114, 115, 118, 121, 123, 124.

Culm surface

Figs. 21F (low focus), 22B 2 (high focus)

Epidermal cells; 4-6-sided, as long as wide to 4 times longer than wide; walls moderately thickened to thick, wavy at surface, straighter at slightly lower focus. Stomata; nearest to type (xiii), but sometimes with slightly rounded ends (see fig. 21F); guard cells of type (x); apertures narrow, of type (ii). Tannin; none seen. Cuticular marks; coarsely granular.

Culm T.S.

Outline; round. Cuticle; moderately thickened.

Epidermal cells; all of similar height, 2-2½ times higher than wide; outer walls thick to very thick, slightly convex; anticlinal and inner walls slightly thickened, some anticlinal walls wavy. Stomata; superficial; subsidiary cells of type (i), but about twice as high as guard cells; guard cells with slight lip at inner aperture; lumina of type (4a). Chlorenchyma; composed of 2 similar layers of palisade peg-cells, divided into 17 sectors by radiating girders from

sclerenchyma sheath and their associated pillar cells; individual peg-cells mostly 4-5 times higher than wide, pegs frequent, small, short on side walls (longer on upper and lower walls as seen in L.S.). Protective cells present as modified outer palisade cells, mostly of generic type (ii), but with pointed inner ends. Parenchyma sheath; 1-layered, interrupted by girders; cells between girders mostly as high as wide, not extending up flanks of girders; short pillar cells sometimes present opposite to ends of girders.

Sclerenchyma sheath; 4-5-layered, with 17 fairly regularly spaced girders radiating towards epidermis; girders parallel-sided or wedge-shaped, and widest at outer ends, ranging from 1-3 cells wide, or 1-2 cells wide at inner end and 3-5 cells wide at outer end; normally 12-14 cells high, either reaching epidermis, or separated from it by short pillar cells. Fibres of girders narrow, very thick-walled, with narrow lumina; those of sheath wider, with thick walls and wider lumina; those opposite to and outside pvbs. in 1 layer, with moderately thickened walls. Vascular bundles: (i) peripheral; alternating with sclerenchyma girders; tracheids wide, angular, 4-6 arranged in shallow arc partially enclosing tangentially oval phloem pole; (ii) medullary; as for genus; flanking mx. vessels of inner bundles wide, angular, with moderately thickened walls, separated by 1-4 rows of narrow tracheids to inner side and phloem cells to outer side; phloem abutting directly onto xylem in places; no bundles free from culm sclerenchyma sheath. Bundle sheaths; as for genus. Central ground tissue; as for genus, but central

cells separating from one another, not breaking down. Silica; spheroidal-nodular bodies present in stigmata on flanks of sclerenchyma girders. Tannin; none seen.

H. synchroolepis Mast.

Culm diameter: 1 mm.

Card characters: 2a, 5b, 7, 9, 14, 19, 21, 26, 27, 28, 31, 37, 42, 44, 47, 48, 49, 50, 51, 52, 54, 55, 56, 58b, 60, 68, 112, 114, 115, 117, 118, 121, 123, 124.

Culm surface

Epidermal cells; 4-6 sided, mostly  $1\frac{1}{2}$ -3 times longer than wide, walls thick, wavy. Stomata; subsidiary cells of type (xvii); guard cells narrow, nearest to type (ix); apertures narrow, of type (ii). Tannin; present in some epidermal cells. Cuticular marks; granular.

Culm T.S.

Outline; round. Cuticle; thick. Epidermal cells; all of similar height,  $2\frac{1}{2}$ -3 times higher than wide; outer walls very thick, outer surface concave in some cells; anticlinal walls wavy, very thick at outer ends, thickening tapering rapidly to half way down walls, and inner halves of walls evenly, slightly to moderately thickened; inner walls slightly to moderately thickened. Stomata; superficial; subsidiary cells of type (i) but nearly twice height of guard cells; guard cells with slight lips at outer (7) and inner (8) apertures; lumina of type (4a). Chlorenchyma; composed of 2 similar, uninterrupted layers of palisade peg-cells; individual cells mostly 3-4 times higher than wide, with few pegs; protective cells of generic type (ii). Parenchyma sheath; 1-layered, interrupted in places by 1-2 sclerenchyma

(Fig. 2283)

fibres or stegmata; cells slightly higher than wide.

Sclerenchyma sheath; mainly 2-layered, fibres very thick-walled, with narrow lumina; 1-2 fibres interrupting parenchyma sheath at intervals. Vascular bundles: (i) peripheral; as for genus; occasional sclereids present in phloem; (ii) medullary; as for genus; flanking mx. vessels of inner bundles medium-sized, angular, with slightly thickened walls, separated by 1-3 files of narrow, parenchymatous cells; phloem not normally abutting directly onto xylem; no bundles free from culm sclerenchyma sheath. Unusual fusion observed between pairs of peripheral and medullary bundles.

Bundle sheaths; as for genus. Central ground tissue; as for genus, but with small central cavity, most of central cells remaining intact. Silica; spheroidal-nodular bodies present in isolated stegmata interrupting parenchyma sheath. Tannin; none seen.

H. willdenowia Mast.

Culm diameter: 2.5 by 1 mm.

Card characters: 2a, 5b, 7, 9, 14, 20, 21, 22, 26, 27, 28, 31, 32, 33, 37, 42, 44, 47, 48, 49, 50, 51, 52, 54, 58a, 58b, 70, 104, 105, 106, 114, 115, 117, 121, 123, 124.

Culm surface

Epidermal cells; outlines and sizes irregular; 4-, 5- and 6-sided, some cells wider than long, and some up to 7 times longer than wide, but most between  $1\frac{1}{2}$  and 2 times longer than wide; walls moderately thickened to thick, not or only slightly wavy. Stomata; subsidiary cells mainly of types (xi) and (xii), occasionally of type (xviii); guard cells of type (ix); apertures of type (ii). Tannin; present ~~in~~



in many epidermal cells. Cuticular marks; granular. (See fig. 21B).

Culm T.S.

Outline; flattened-oval. Cuticle; slightly thickened. Epidermal cells; 4-sided, mostly about  $1\frac{1}{2}$  times higher than wide, some, particularly those opposite to sclerenchyma girders, about twice as high as wide; outer walls very thick, outer surface sometimes slightly concave; outermost ends of anticlinal walls thick, but thickening tapering rapidly and remainder of anticlinal walls and inner walls slightly to moderately thickened; anticlinal walls not wavy. Stomata; superficial; subsidiary cells of type (i), but twice as long as guard cells; guard cells with slight ridge on inner wall (9); lumina of type (4a). Chlorenchyma; composed of palisade peg-cells arranged in 2 similar layers; layers interrupted at either angle of flattened culm by girder from sclerenchyma sheath; peg-cells with few, short pegs; protective cells of generic type (i), but with pegs on anticlinal walls, and slit-like apertures; some occasional protective cells elongated, and extending to parenchyma sheath. Parenchyma sheath; 1-layered, interrupted at angles of flattened stem by long sclerenchyma girders, and at other places by low ribs or shorter girders; cells as high as to  $1\frac{1}{2}$  times higher than wide. Pillar cells of normal type not present. Sclerenchyma sheath; 1-3-layered, sometimes 4-5-layered opposite larger mvbs., with 1 girder radiating to epidermis at either angle of flattened culm, and several low ridges or short girders interrupting parenchyma sheath in

other places; flanking girders mainly 3 cells wide, and about 10 cells high; fibres narrow or medium-sized, thick- or very thick-walled, with narrow lumina. Vascular bundles: (i) peripheral; not opposite girders; as for genus; (ii) medullary; as for genus; flanking mx. vessels of inner bundles medium-sized, angular, separated by 4-5 files of narrow tracheids to inner side and phloem cells to outer side; phloem abutting directly onto xylem in places, containing narrow sclereids; no bundles free from sclerenchyma sheath. Bundle sheaths; sclerenchymatous; fibres in 1 layer on flanks and at xylem pole, medium-sized to narrow, with moderately thick to thick-walls; those at phloem pole in contact with culm sclerenchyma sheath. Central ground tissue; as for genus. Silica; spheroidal-nodular bodies present in stigmata on flanks of girders and ridges from sclerenchyma sheath. Tannin; present in many epidermal cells. (See fig. 21A).

Root; see generic description.

Hypolaena R.Br.Generic description

The species fall into 2 distinct geographical and anatomical groups. A. Species from S. Africa; B. Species from Australia and Tasmania.

Group ACulm surface

Hairs, papillae; absent. Epidermal cells; 4-sided, (sometimes 5-6-sided), as long as or up to 2-4 times longer than wide; walls moderately thickened, normally wavy. Stomata; subsidiary cells of types (xi), (xii), (xiii) and (xv); guard cells of types (vii) and (ix); apertures of type (ii). Silica, crystals; absent. Tannin; present in some or most epidermal cells. Cuticular marks; longitudinal striations.

Culm T.S.

Outline; round or oval. Cuticle; slightly to moderately thickened, with slight ridges. Epidermal cells; present in 1 layer, individual cells 4-sided, slightly higher than wide. Outer walls thick; anticlinal walls not wavy, moderately thickened; inner walls moderately thickened. Stomata; superficial; subsidiary cells of types (e), (i); guard cells with lips at outer and inner apertures (7), (8) or with ridge on inner wall (9) and without inner lips; lumina wide, lenticular (1) or of type (4a). Chlorenchyma; composed of palisade peg-cells in 1 or 2 (3) layers; protective cells present. Parenchyma sheath; 1-2-layered; cells mostly slightly to  $1\frac{1}{2}$  times wider than high. Sclerenchyma sheath; 5-6-layered, fibres thick-to very thick-walled, those

of outer layers narrowest. Vascular bundles: (i) peripheral tracheids angular, medium-sized or wide, thin-walled, arranged in arc partially enclosing rounded or tangentially oval phloem pole; (ii) medullary; outline tangentially oval or rounded; some outer bundles with 1 central, medium-sized to wide, rounded mx. vessel, capped by a small phloem pole and without px.; inner bundles with 1 wide rounded-angular or many-sided mx. vessel on either flank, with scalariform wall pitting and simple, more or less transverse, or oblique scalariform-reticulate perforation plates; mx. vessels separated from one another by 1, 2 or 3 rows of narrow cells; phloem overarchng and extending partly between mx. vessels, but separated from xylem by 1 layer of narrow cells with slightly or moderately thickened walls in all spp. but H. spathulata; px. present in inner bundles; some bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous; fibres in 1-2 layers at poles, narrow, with moderately thickened to thick walls; those on flanks in 1 layer, slightly wider, with slightly or moderately thickened walls; weak in H. spathulata, walls slightly thickened. Central ground tissue; parenchymatous; cells surrounding vascular bundles with moderately thickened walls, those of culm centre thin-walled. Silica; present as spheroidal-nodular bodies in stegmata situated in outer layer of culm sclerenchyma sheath. Crystals; none seen. Tannin; present in some epidermal cells. Note: H. graminifolia has unusual features; see species description.

Leaf T.S.

Blade, seen in H. graminifolia.

Outline; parallel-sided, with rounded margins; about 10 times wider than thick. Hairs, papillae; absent.

Epidermal cells; (i) abaxial; cells mostly as high as or slightly higher than wide, about  $\frac{3}{4}$  height of adaxial cells; (ii) adaxial; cells slightly -  $1\frac{1}{2}$  times higher than wide; outer walls moderately thickened to thick, other walls slightly to moderately thickened, in cells of both surfaces.

Stomata; as in culm of same species. Chlorenchyma; as in culm of same species; filling all space between vascular bundle sheaths and epidermis; protective cells similar to palisade peg-cells, but with slightly thickened walls.

Vascular bundles; 13, arranged in 1 row, all orientated with phloem poles facing abaxial surface; of 3 main sizes, small (s), medium (m) and large (l), arranged in the following sequence: s,m,s,l,s,m,s,l,s,l,s,m,s; (a) small, with arc of 5-9 narrow to medium-sized, thin-walled tracheids partially enclosing rounded phloem pole; (b) medium, with 1 medium-sized, angular, thin-walled tracheid on either flank of arc of several narrow tracheids, phloem pole rounded; (c) large, with 1 wide, angular tracheid with slightly thickened walls on either flank of arc composed of up to 5 rows of medium-sized and narrow tracheids, phloem pole with curved outer face and flattened face next to xylem. Bundle sheaths; 0.8 parenchymatous, cells in 1 layer, similar to those surrounding free culm bundles; I.S. sclerenchymatous: (i) in small and medium bundles; fibres narrow, with moderately thickened

walls, in 1-2 layers at phloem pole and 1 layer on flanks and at xylem pole; (ii) in large bundles; fibres narrow, with moderately thickened walls, in 3-4 layers at phloem pole, fibres wider, 1-2-layered on flanks and round xylem pole.

Sclerenchyma; restricted to that of bundle sheaths. Air-cavities; absent. Silica; spheroidal-nodular bodies present in stegmata in outer layer of sclerenchyma bundle sheaths.

Rhizome, root; not seen.

#### Group B

##### Culm surface

Hairs; of 2 types: (i) in H. exsulca; similar to those in Australian Leptocarpus species; (ii) multicellular, peltate or sub-sessile, (See fig. 306.) Epidermal cells; 4-6-sided, as long as wide or up to twice as long as wide; walls slightly to moderately thickened or thick, wavy.

Stomata; subsidiary cells of types (xiii), (xv) and (xvi); guard cells of type (ix); apertures narrow, of type (ii).

Silica; none seen. Tannin; present in some epidermal cells. Cuticular marks; granular, . with or without longitudinal striations.

##### Culm T.S.

Outline; round. Cuticle; granular, slightly to moderately thickened, with or without small ridges. Hairs; see above. Epidermal cells; either (i) all more or less of uniform size, as high as wide, outer walls moderately thickened, other walls slightly thickened, or (ii) of varying sizes, those next to stomata smallest, about  $1\frac{1}{2}$  times higher than

wide, those opposite to pillar cells about  $1\frac{1}{2}$  times higher than smallest cells, twice as high as wide; cells of intermediate sizes present between the two; outer walls thick, other walls moderately thickened. Stomata; superficial or sunken; subsidiary cells of type (f); guard cells either without lips, or with lips at outer aperture (5a); with or without ridge on inner wall; lumina of types (1), wide lenticular, or (4b). Chlorenchyma; composed of 2-3 layers of palisade cells without or with few pegs; layers divided into sectors by ridges from sclerenchyma sheath and their associated pillar cells; individual cells mostly between  $1\frac{1}{2}$ -2 or 2-3 times higher than wide. Protective cells absent. Parenchyma sheath; composed of cells of 2 types: (i) elongated pillar cells, each 2-3 times higher than wide, extending between ridges from sclerenchyma sheath to epidermis; (ii) rounded-hexagonal cells situated in 1 layer on flanks of ridges from culm sclerenchyma sheath; individual cells frequently slightly wider than high; these cells occasionally present in place of pillar cells over sclerenchyma ridges. Sclerenchyma sheath; outline rounded, with low, dome-shaped ridges each opposite to and including a single pvb.; main part of sheath about 7-8-layered; fibres of outer layers narrow, those of innermost layers wider, all very thick-walled. Vascular bundles: (i) peripheral; with 1 wide tracheid on either flank of arc of narrow tracheids, or tracheids narrow and medium-sized, arranged in 1-layered arc partially enclosing rounded or tangentially oval phloem pole; (ii) medullary; outer bundles small, inner bundles large; each with 1 mx.

vessel on either flank, those of outer bundles narrow, those of inner bundles wide, angular, thin-walled; flanking mx. vessels separated from one another by 2-6 layers of narrow cells with slightly thickened walls; phloem pole tangentially oval, separated from xylem by 1 layer of narrow cells with slightly thickened walls; px. present in all but smallest bundles; some bundles free from culm sclerenchyma sheath, except in H. fasciculata. Bundle sheaths; sclerenchymatous; fibres narrow, thick-walled, in 1 or 2 (3) layers at phloem pole, in 1 layer on flanks and round xylem pole. Central ground tissue; parenchymatous; cells surrounding vascular bundles with moderately thickened walls, those at culm centre thin-walled, breaking down. Silica; spheroidal-nodular bodies present in stegmata in outer layer of sclerenchyma sheath. Crystals; none seen. Tannin; present in some epidermal cells.

#### Leaf surface

Abaxial, H. fastigiata only.

Hairs; none seen. Epidermal cells; 4-sided, mostly 5-8 (10) times longer than wide, some shorter, slightly longer than wide; end walls transverse or oblique; walls moderately thickened, wavy. Stomata; subsidiary cells of types (xi, xii); long anticlinal walls frequently slightly wavy; guard cells of type (vii); apertures of type (ii). Silica; none seen. Tannin; present in many epidermal cells. Cuticular marks; granular.

#### Leaf T.S.

Scale leaf, H. fastigiata only.

Epidermal cells; (i) abaxial; 4-5-sided, slightly to



$1\frac{1}{2}$  times wider than high, outer walls thick, other walls moderately thickened; (ii) adaxial; 4-sided, flattened cells, mostly twice as wide as high and about  $1/3$  height of abaxial cells; all walls slightly to moderately thickened. Stomata; present in abaxial surface only, superficial; subsidiary cells of type (c); guard cells of type without lips or ridges; lumina of type (2a). Chlorenchyma; restricted to small areas of more or less isodiametric cells below stomata. Vascular bundles; very small, each composed of several narrow tracheids to adaxial side of small phloem pole. Bundle sheaths; sclerenchymatous; fibres narrow, thick-walled, extending in several layers to abaxial epidermis at phloem pole, indistinguishable from ground sclerenchyma on bundle flanks and at xylem pole. Sclerenchyma; represented by that of bundle sheaths, and by 5 layers of fibres between bundles and 2-3 layers to adaxial side of xylem poles; separated from adaxial epidermis by 1-2 layers of parenchymatous cells and from abaxial epidermis by 1 layer of narrow parenchyma cells or by chlorenchyma. Air-cavities; absent. Silica; present as small spheroidal-nodular bodies in stegmata in outer layer of bundle sheaths at phloem poles. Tannin; present in many epidermal cells.

Rhizome T.S.

H. exsulca only.

Epidermis and outer cortex; not seen. Inner cortex; composed of several layers of loosely packed, lobed, isodiametric and palisade, thin-walled cells. Endodermoid sheath; cells in 1 layer, hexagonal, mostly as high as wide,

thick-walled. Vascular bundles; scattered, mostly concentric but some outer bundles with arc of mx. vessels; mx. vessels wide, angular, moderately thick-walled, with scalariform wall pitting and simple, more or less transverse perforation plates; tracheids wide, present in 1 layer round most mx. vessels, those next to phloem narrow; phloem poles rounded. Bundle sheaths; sclerenchymatous, several-layered, boundaries indistinguishable from ground tissue. Ground tissue; composed of matrix of sclereids with thick walls and scattered lacunae of lobed, more or less isodiametric, thin-walled, parenchymatous cells. Silica; small, spheroidal-nodular bodies present, frequently several per cell, in parenchyma cells bordering lacunae in ground tissue, and also in some inner cortical cells. Crystals, Tannin; none seen.

Root T.S.

H. exsulca only.

Root hairs and epidermis; not seen. Outer cortex; composed of about 3 layers of narrow cells with slightly to moderately thickened walls. Middle cortex; composed of radiating plates of parenchymatous cells separated from one another by lysigenous air-spaces; each plate 2-3-layered and 15-20 cells high. Inner cortex; 1-2-layered, cells narrow, parenchymatous, with thin walls. Endodermis; 1-layered, cells  $1\frac{1}{2}$  times higher than wide, all walls very thick. Pericycle; 1-2-layered, cells slightly wider than high, about  $\frac{1}{4}$  height of endodermal cells, walls slightly thickened. Vascular tissue; phloem and protoxylem poles alternating in ring to inside of pericycle; mx. vessels angular, radially

oval, wide, with slightly thickened walls, situated in 1 ring to inside of phloem and px. poles; each mx. vessel surrounded by 1 layer of flattened tracheids. Central ground tissue; composed of narrow to medium-sized cells with moderately thickened to thick walls. Silica, crystals, tannin; none seen.

Material examined:

Group A S. Africa

H. crinalis Pill.	Esterhuysen 16530, Slanghoek Mts.	11213 (K)
H. graminifolia Pill.	Parker, R.N. 4592 ♂	11212 (K)
"	Schlechter 9255, An.1896	1121B (K)
H. purpurea Pill.	Esterhuysen 4592	1129 (K)
"	Muir 3214 ♂ Dupl.	1123B (K)
H. spathulata Pill.	Esterhuysen 16358	11214 (K)

Group B. Australia, Tasmania

H. exsulca R.Br.	Cheadle CA82 Perth, W. Aust.	(S)
H. fasciculata Fitzgerald	Andrews, C. 1st Coln 1106 Albany, W.Aust.	1651 (K)
"	Baudin An.1801 W. Aust.	1128 (K)
H. fastigiata R.Br.	Curtis, W.M. Blackman's Bay, Hobart, Tasmania	17164 (K)

Species descriptions

Group A

H. crinalis Pill. Culm diameter: 0.5 mm.

Card characters: 5b,6a,7,15,18,21,23,26,27,31,37,42,43,44,47,  
48,49,50,51,54,55,56,60,68,110,112,114,115,  
(basal) 117,121,123,124.

Culm surface

Epidermal cells; 4-sided, mostly 2-4 times longer than wide, walls moderately thickened, wavy. Stomata; subsidiary cells of types (xii) and (xv); guard cells of type (ix); apertures of type (ii). Tannin; present in most epidermal cells. Cuticular marks; fine, longitudinal striations.

Culm T.S.

Outline; terete. Cuticle; moderately thickened, with very small ridges. Epidermal cells; 4-sided, slightly higher than wide; outer walls thick, other walls moderately thickened. Stomata: superficial; subsidiary cells of type (e); guard cells with slight lips at outer and inner apertures (7), (8); lumina wide lenticular (1). Chlorenchyma; composed of 1 or 2 layers of peg-cells; individual cells as high as or up to twice as high as wide, with few pegs, (those on upper and lower walls longest). Protective cells present, extending in 1 layer from epidermis to cells of parenchyma sheath, or inner layer of chlorenchyma; walls moderately thickened, cells otherwise similar to peg-cells. Parenchyma sheath, sclerenchyma sheath, as for group A. Vascular bundles; as for group A, but medullary; tangentially oval in outline, flanking mx. vessels of inner bundles radially oval, perforation plates oblique and scalariform-reticulate or more or less transverse and simple in the same culm; phloem containing several narrow sclereids. Bundle sheaths; as for group A, but fibres in 1 layer. Central ground tissue; as for group A. Silica; spheroidal-nodular bodies present in stigmata in outer layer of culm sclerenchyma sheath. Tannin; present in most epidermal cells.

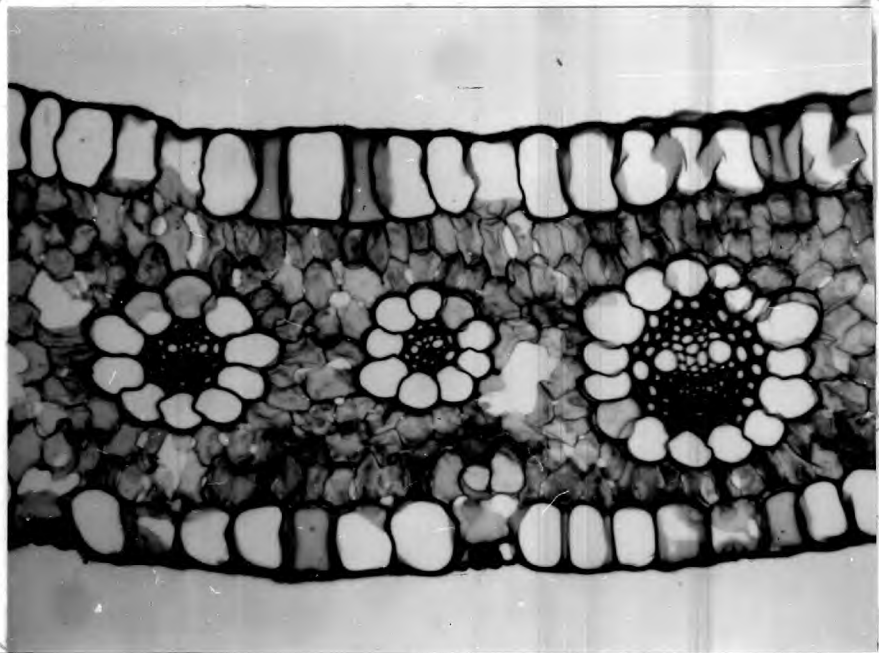
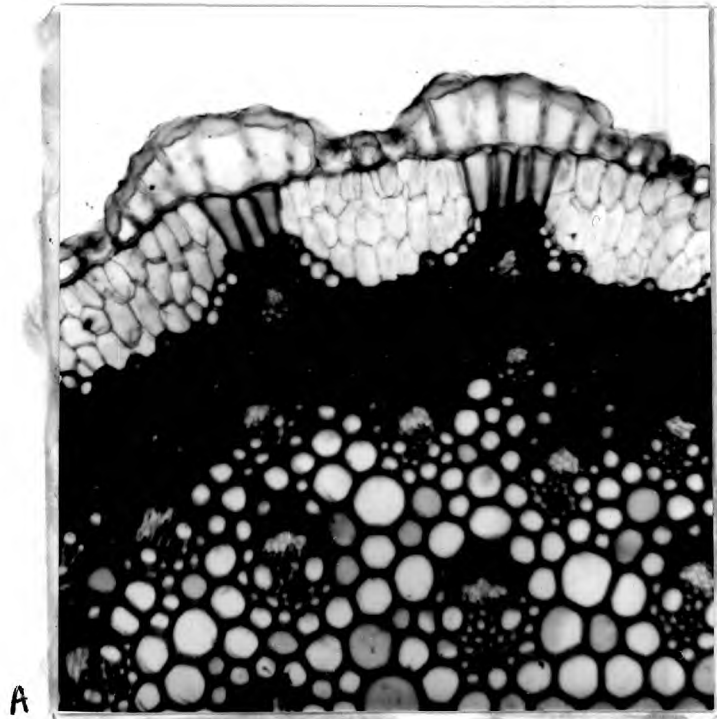


Fig. 24. Hypolaena. A, fastigiata, part of culm T.S.;  
B, graminifolia central part of leaf T.S. (x200).

H. graminifolia Pill.

Culm diameter: 1.5 by 0.5,  
0.75 by 0.25 mm.

Card characters: 2c, 5b, 5c, 6a, 7, 9, 14, 18, 19, 21, 22, 26, 27, 28, 31,  
37, 42, 44, 46, 48, 49, 50, 51, 54, 55, 56, 60, 70, 71, 73,  
Parker 4592 80, 81, 88, 110, 112, 115, 117, 121, 123, 124.  
5b, 6a, 7, 9, 14, 20, 22, 26, 28, 31, 37, 42, 44, 46, 48,  
49, 50, 51, 52, 54, 55, 56, 60, 70, 112, 114, 115, 117,  
Schlechter 9255 121, 123, 124.

Culm surface

**Figs. 24B, 25A, B**

Epidermal cells; 4-sided, as long as wide or up to 4 times longer than wide; walls moderately thickened, wavy. Stomata; subsidiary cells of types (xi) and (xii); guard cells of type (vii); lumina of type (ii). Tannin; present in some epidermal cells. Cuticular marks; fine, longitudinal striations.

Culm T.S.

Outline; oval. Cuticle; with slight ridges. Epidermal cells; mostly nearly twice as high as wide, graded in size, those on flattened faces largest; outer walls thick, with slightly ridged outer surface, other walls slightly to moderately thickened. Stomata; superficial; subsidiary cells of type (i); guard cells with lips at outer aperture (7) and slight ridge on inner wall (9); lumina of type (4b). Chlorenchyma; composed of palisade peg-cells and lobed cells; peg-cells mostly  $1\frac{1}{2}$ -2 times higher than wide, pegs frequent, cells arranged in 1, 2 or 3 layers immediately inside epidermis; lobed cells  $1\frac{1}{2}$  times higher than wide or more or less isodiametric (see fig. 25B), filling all space between bundle parenchyma sheaths and culm parenchyma sheath. Protective cells short, walls next to substomatal cavity slightly

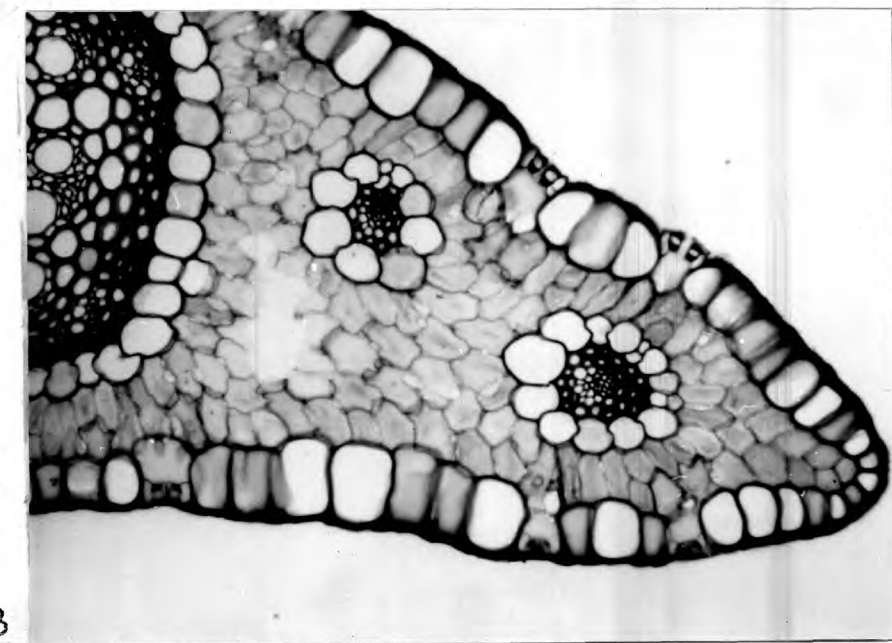
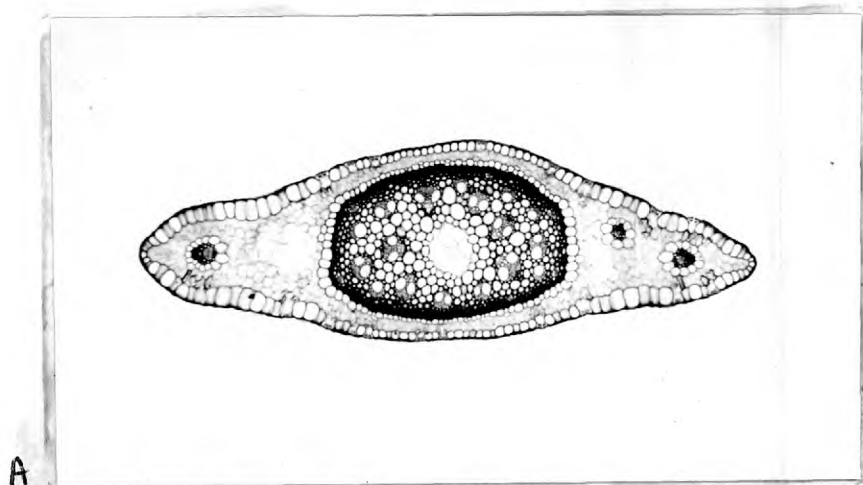


Fig. 25. *Hypolaena graminifolia*. A, culm T.S. (x50);  
B, detail of A (x200)\*

thickened, other walls thin. Parenchyma sheath; 1-layered, cells as high as wide, or slightly higher than wide, smallest  $1/3 - \frac{1}{2}$  height of largest, next to palisade chlorenchyma cells, largest next to lobed chlorenchyma cells (see fig. 25A). Sclerenchyma sheath; 3-5-layered; fibres of outer 1-3 layers narrow, lumina silica-filled, inner fibres wider, with no silica. Vascular bundles; distribution unlike that of any other member of family; most bundles enclosed in, or to inner side of culm sclerenchyma sheath, as usual in group A, but 1 or 2 bundles free, present in either wing of lobed chlorenchyma cells, outside culm sclerenchyma sheath (fig. 25). Bundles outside sclerenchyma sheath each with arc of narrow to medium-sized, angular, thin-walled tracheids arranged in 2-3 layers, partially enclosing rounded phloem pole; orientated with phloem facing culm surface. Bundles within culm sclerenchyma sheath as for group A. Bundle sheaths; (a) round free, outer bundles; O.S. parenchymatous, cells in 1 layer, similar to those of culm parenchyma sheath; I.S. sclerenchymatous, composed of narrow fibres with moderately thick to thick walls, 2-4-layered at phloem pole, 1-layered on flanks and at xylem pole; (b) round mvbs.; as for group A. Central ground tissue; as for group A. Silica; present as: (i) granular material in protective cells and outer cells of sclerenchyma sheath; (ii) spheroidal-nodular bodies in stigmata in outer layer of culm sclerenchyma sheath. Tannin; present in some epidermal cells.

Leaf T.S. see group A description.



H. purpurea Pill.

Culm diameter: 1.2, 1.5 mm.

Card characters: 5b,6a,7,9,14,19,21,26,27,28,31,37,42,44,47,

Esterhuysen 48,49,50,51,52,54,55,56,58a,58b,68,110,112,

4592 114,115,117,121,123,124.

3,5b,5c,7,9,14,19,21,26,27,28,31,37,42,44,47,

48,49,50,51,52,54,55,56,58a,58b,60,68,110,

Muir 3214 ♂ 112,114,115,117,121,123,124.

Culm surface

Epidermal cells; 4-, 5- or 6-sided, cells next to stomata mostly as long as wide, others mostly  $1\frac{1}{2}$ -2 times longer than wide; walls slightly to moderately thickened, straight or slightly wavy. Stomata; longer in 4592 than 3214; subsidiary cells of types (xi), (xii) and (xiii); guard cells of type (vii); lumina narrow, of type (ii). Tannin; present in many epidermal cells. Cuticular marks; granular, and with faint longitudinal striations.

Culm T.S.

Outline; round. Cuticle; moderately thickened with small ridges. Epidermal cells; mostly about  $1\frac{1}{2}$  times higher than wide, outer walls thick, slightly convex, other walls slightly to moderately thickened. Stomata; superficial; subsidiary cells of type (i) but some about twice as high as wide and extending below guard cells; guard cells with slight lips at inner apertures (8); lumina of type (4a). Chlorenchyma; composed of 2 layers of palisade peg-cells; cells of outer layer 2-4 times higher than wide, those of inner layer 3-5 times higher than wide, and about  $\frac{1}{3}$  wider than outer cells; pegs fine, infrequent. Protective cells extending in 1 layer from inner walls of epidermal cells to  $\frac{1}{4}$ - $\frac{1}{2}$  way into inner chlorenchyma layer; walls slightly to moderately .

thickened; apertures between cells oval, elongated, present in inner half of substomatal tube. Parenchyma sheath; 1-layered, following slightly ridged outline of sclerenchyma sheath and interrupted at intervals by groups of 1 or 2 or up to 8 fibres at the ridges; cells opposite ridges smaller than those between them. Sclerenchyma sheath; 3-4- or 4-8-layered, wider at ridges; ridges 3-8 cells wide, extending in 2-3 layers beyond rounded outline of main part of sheath, not opposite to pvbs.; fibres of outer 2-5 (7) layers very thick-walled, with narrow lumina, those of inner layers wider, thick-walled. Vascular bundles, bundle sheaths, central ground tissue; as for group A. Silica; spheroidal-nodular bodies present in stegmata in outer layer of culm sclerenchyma sheath. Tannin; present in many epidermal cells.

H. spathulata Pill.

Culm diameter: 1.5 mm.

Card characters: 3,5b,7,9,11,19,20,21,22,27,28,31,37,42,44,47, 48,49,50,51,52,54,55,56,58b,68,110,112,114, 115,117,121,123,124.

Culm surface

Epidermal cells; mostly 6-sided, twice as long as wide, some cells 4-sided, half as long as others; walls slightly to moderately thickened, straight or slightly wavy. Stomata; subsidiary cells of types (xi), (xii), or (xv); guard cells elongated, of type (ix); lumina narrow, of type (ii).

Tannin; present in most epidermal cells. Cuticular marks; coarsely granular.

Culm T.S.

Outline; round. Cuticle; moderately thickened.

Epidermal cells; 4-sided, mostly about  $1\frac{1}{2}$  times higher than wide, outer walls thick, slightly convex, other walls slightly to moderately thickened. Stomata; superficial; subsidiary cells of type (i); guard cells with slight lips at outer and inner apertures (7), (8); lumina of type (4a). Chlorenchyma; composed of 2 similar layers of palisade peg-cells; individual cells about 4 times higher than wide, pegs fine, short. Protective cells as in H. purpurea, extending through outer chlorenchyma layer only. Parenchyma sheath; 1-layered, cells slightly wider than high, those opposite to short ridges from sclerenchyma sheath smallest. Sclerenchyma sheath; outline rounded, with low ridges between most pvbs.; 5-6-layered. Vascular bundles: (i) peripheral; as for group A, but phloem abutting directly onto xylem; (ii) medullary; all with 1 mx. vessel on either flank; flanking mx. vessels of inner bundles medium-sized, rounded-angular, with slightly thickened walls, separated from one another by 1-3 rows of narrow cells; phloem abutting directly onto xylem, otherwise as for group A. Bundle sheaths; weak; fibres narrow, in 1-2 layers at phloem pole, wider, in 1 layer on flanks and at xylem pole; all walls slightly thickened. Central ground tissue; as for group A. Silica; spheroidal-nodular bodies present in stegmata in outer layer of culm sclerenchyma sheath. Tannin; present in most epidermal cells.

### Group B

H. exsulca R.Br.

Culm diameter: 1.5 mm.

Card characters: 3, 5c, 7, 9, 14, 19, 21, 26, 27, 28, 31, 44, 45, 48, 49, 51, 52, 54, 56, 58b, 60a, 60b, 63, 64, 68, 89, 90, 91, 93, 98, 99, 104, 105, 106, 110, 114, 121, 123, 124.

Culm surface

Hairs; multicellular, each with short, thick-walled basal cell and (2-) several flattened cells forming plate (similar to those in I. tenax in Australia); free flattened portion of hair 1 cell thick, outline difficult to determine because of overlapping of adjacent hair margins, and fragmentation on dissection; plates approximately 10-15 times longer than wide, with parallel sides and pointed ends.

Epidermal cells; 4-, 5-, and 6-sided, mostly as long as wide, some up to twice as long as wide; walls moderately thickened, wavy. Stomata; subsidiary cells of types (xiv) and (xvi); guard cells of type (ix), but shorter and more rounded than normal; lumina of type (ii). Tannin; none seen. Cuticular marks; granular.

Culm T.S.

Outline; round. Hairs; see above. Epidermal cells; mostly as high as wide; outer walls thick, outer surface irregular (granular); other walls moderately thickened.

Stomata; not seen in T.S. Chlorenchyma; composed of 2-3 layers of palisade cells in longitudinal channels, as for group B. Parenchyma sheath, sclerenchyma sheath; as for group B. Vascular bundles: (i) peripheral; each with 1 wide, rounded-angular tracheid on either flank of arc of narrow tracheids; (ii) medullary; as for group B, outline tangentially oval. Bundle sheaths, central ground tissue; as for group B. Silica; spheroidal-nodular bodies present in stegmata in outer layer of culm sclerenchyma sheath, particularly on flanks of sclerenchyma ribs.

Rhizome and root; see group B generic description.

H. fasciculata Fitzgerald Culm diameter: 1.1 mm.

Card characters: 3, 5b, 6, 7, 9, 14, 19, 21, 26, 28, 31, 42, 44, 45, 47, 48,  
49, 50, 51, 52, 54, 55, 56, 60, 63, 64, 68, 112, 114,

Baudin 115, 121, 123, 124.

2b, 5b, 6, 7, 9, 14, 19, 21, 26, 31, 42, 44, 47, 49, 50,  
51, 52, 54, 55, 56, 60, 63, 64, 68, 110, 112, 114, 115,

Andrews 1106 117, 121, 123, 124.

Culm surface

Hairs; multicellular, sparsely distributed, peltate to sessile, each consisting of 1 basal cell and an oval rosette of thick-(cellulose) walled cells, or wedge-shaped and composed of 5-6 rows of short, 4-sided cells, the largest being at the wide (free) end of the wedge; hairs thickest at wide end, but only 1 cell thick throughout.

Epidermal cells; 4-sided, slightly to 4 times longer than wide, walls moderately thickened, wavy. Stomata; subsidiary cells of types (xi), (xii) and (xiii); guard cells of type (ix); apertures of type (ii). Tannin; none seen. Cuticular marks; finely granular, with longitudinal striations.

Culm T.S.

Outline; round. Cuticle; with slight ridges. Hairs; see above. Epidermal cells; mostly as high as wide, outer walls moderately thickened, outer surface with slight ridges corresponding to those in cuticle; other walls slightly to moderately thickened. Stomata; small, very slightly sunken; subsidiary cells of type (h); guard cells with slight lips at outer aperture (5a); lumina wide lenticular (1).

Chlorenchyma; as for group B, cells with few, small pegs.

Parenchyma sheath, sclerenchyma sheath, vascular bundles, bundle sheaths, central ground tissue, silica; as for group B.

H. fastigiata R.Br.

Culm diameter: 1.5 mm.

Card characters: 2b, 5b, 7, 9, 14, 19, 21, 26, 27, 28, 31, 34, 42, 44, 45, 47, 48, 49, 50, 51, 52, 54, 55, 56, 60, 63, 64, 69, 71, 73, 74, 78, 81, 88, 110, 112, 115, 121, 123.

Culm surface

Hairs; multicellular, flattened, plate-like, each with 1 thick-walled, short basal cell; plate-like structure composed of cells with irregular outlines, but mostly about 3 times longer than wide, with pointed ends; margins of hair indistinct. Epidermal cells; as long as wide to twice as long as wide, those next to stomata shortest; walls thick, wavy. Stomata; subsidiary cells of types (xiii) and (xix); guard cells of type (ix); apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; finely granular.

Culm T.S.

Fig. 24A

Outline rounded, with slight ribs. Hairs; see above. Epidermal cells; 4-sided, those opposite pillar cells largest, about twice as high as wide, those next to stomata smallest, slightly higher than wide, about  $\frac{1}{2}$  <sup>$\frac{1}{3}$</sup>  height of tallest, intermediate sizes present. Outer walls very thick, other walls thick; conspicuous, round pits present in anticlinal walls. Stomata; superficial, small; subsidiary cells of type (f); guard cells with slight lips at outer aperture (5b) and slight ridge on inner walls (9); lumina of type (4b). Chlorenchyma, parenchyma sheath; as for group B. Sclerenchyma sheath; 5-8-layered, as for group B. Vascular bundles; as for group B, but: (i) peripheral; all tracheids narrow, arranged in 2-layered arc. Bundle sheaths,

central ground tissue, silica; as for group B. Tannin;  
present in some epidermal cells.

Leaf: see group B description.

Lepidobolus NeesGeneric descriptionCulm surface

Hairs; present in 2 species, multicellular, each composed of a stalk of 2 or 3 square-slightly oblong cells, the lower ones with moderately thickened walls, the end one with thin walls, and several (usually 2-4) radiating branches, each branch consisting of 1 thin-walled, contorted cell, between 6-12 times longer than wide, and with a rounded or pointed free end. Epidermal cells; as long as to 2-3 times longer than wide; walls thick or very thick, wavy. Stomata; subsidiary cells of types (xi), (xii), (xiii) or (xviii); guard cells of types (ix) and (viiib); apertures of type (ii). Silica and Tannin; none seen. Cuticular marks; granular.

Culm T.S.

Outline; rounded in L. drapetocoleus, with frequent, low mounds in other species. Cuticle; thick. Hairs; see above. Epidermal cells; in 1 layer; of equal or unequal heights, ranging from as high as wide to 5 times higher than wide; cells bordering stomata with those anticlinal walls lining substomatal cavity about twice as long as the others, extending into chlorenchyma (fig. 26A). Outer walls very thick, anticlinal walls wavy, very thick at their outer ends, thickening tapering near inner ends of walls, inner ends of walls slightly thickened; inner walls slightly thickened; lumina flask-shaped, base of flask directed inwards, neck narrow to very narrow, wavy. Stomata; superficial;



subsidiary cells of types (m), (i); guard cells often with ridge on outer wall, with lips at outer aperture (7) and ridge on inner wall (9) (at either end, outer lip becoming a ridge on outer wall); lumina of type (4b). Hypodermis; absent. Chlorenchyma; composed of 1 layer of palisade peg-cells, cells mainly between (6) 8 and 10 times higher than wide, with the shorter cells opposite to stomata; pegs small, numerous, mostly arranged in 6 longitudinal files; protective cells absent. Parenchyma sheath; cells in 1 layer, rounded, as wide as to  $1\frac{1}{2}$  (2) times wider than high, sometimes  $1\frac{1}{2}$ -2 times higher than wide (L. preissianus); walls slightly thickened; some stegmata present, with moderately thickened inner and anticlinal walls and slightly thickened outer walls. Sclerenchyma sheath; well developed, outline rounded; fibres very thick-walled, in 6-8 layers, those of outer layers narrow, those of inner layers wider, clearly distinct from ground tissue in 2 species, grading into it in the other. Vascular bundles; (i) peripheral; with single-layered arc of narrow or medium-sized tracheids partially enclosing rounded or tangentially oval phloem pole; flanking tracheids wider than rest in L. drapetocoleus; (ii) medullary; mostly with 1 medium-sized to wide, rounded or oval-angular, thick-walled mx. vessel on either flank, separated by 2-4 rows of narrow cells; mx. vessel wall pitting scalariform, perforation plates simple, slightly oblique; phloem poles tangentially oval, ensheathed by 1 layer of narrow cells with moderately thickened walls; all except smallest, outer bundles with px. pole; some bundles embedded in culm sclerenchyma

sheath, but most scattered in outer region of ground tissue. Bundle sheaths; sclerenchymatous; fibres narrow to medium-sized, with moderately thickened walls, in 1-2 layers at poles, and 1 layer on flanks. Central ground tissue; parenchymatous, cells of outer layers surrounding vascular bundles with slightly or moderately thickened walls; central cells thin-walled, breaking down to form a wide central cavity. Silica; present as (i) spheroidal-nodular bodies in stigmata in parenchyma sheath, and occasional cells of central ground tissue; (ii) granular material in some cells of central ground tissue. Crystals and Tannin; none seen. Leaf surface not seen in L. chaetocephalus

Hairs; absent. Papillae; present as outpushings from occasional cells. Epidermis; (i) abaxial; cells 4-sided, slightly longer than wide, walls thick, not wavy; (ii) adaxial; not seen. Stomata; showing same range as in culm; present in abaxial surface only. Silica, Crystals and Tannin; none seen. Cuticular marks; none; smooth.

#### Leaf T.S.

Not seen in L. chaetocephalus.

Papillae; see above. Epidermis; (i) abaxial; cells 4-5-sided, about as high as wide; outer and anticlinal walls very thick, inner walls slightly or moderately thickened; lumina square to slightly flask-shaped; (ii) adaxial; cells more or less hexagonal, outer walls 2-faced, all walls slightly thickened or thin. Stomata; superficial or slightly sunken, subsidiary cells of type (c); guard cells as in culm. Chlorenchyma; cells lobed, more or less

isodiametric, in 1 layer to inner side of abaxial epidermis. Vascular bundles; small, with few narrow tracheids and phloem cells. Bundle sheaths; O.S. consisting of parenchyma cells in 1 layer; I.S. composed of fibres arranged in 1-2 layers. Sclerenchyma; present in inner bundle sheaths only. Ground tissue; parenchymatous. Air-cavities, crystals and tannin; none present. Silica; spheroidal-nodular bodies present in some cells of parenchyma bundle sheaths.

Rhizome; not seen.

Root T.S.

Not seen in L. chaetocephalus.

Epidermis; cells thin-walled, about as high as wide, root hairs same width as cells from which they arise. Outer cortex; 4-layered, cells slightly larger than those of epidermis, with slightly thickened walls. Middle cortex; 6-8 layers of wide, thin-walled cells, with intercellular spaces. Inner cortex; 2-layered, cells similar in width to those of outer cortex, more or less isodiametric, walls slightly thickened. Endodermis; 1-layered, cells about  $1\frac{1}{2}$  times higher than wide, all walls very thick, lumina medium-sized or narrow. Pericycle; composed of 2-3 layers of hexagonal, thick-walled cells. Vascular tissue; protoxylem and phloem strands alternating in ring to inside of pericycle; mx. vessels wide, rounded, in outer ring and scattered throughout central ground tissue. Central ground tissue; cells narrow, thick-walled. Silica, Crystals and Tannin; none seen.

Material examined:

- L. chaetocephalus F.v.Muell. Pritzel 829 Avon, 25914(K)  
Aust.
- L. drapetocoleus F.v.Muell. Cheadle CA362  
Adelaide, Aust. (S)
- L. preissianus Nees Blake, S.T. 18106  
S.W. Div. 10-20 mls.  
N. of Northampton. 25913(K)
- " Helms, An.1891 Elder  
Exploring Expd. Victoria  
Desert, Aust. 25904(K)
- " Cheadle CA495 Perth,  
Aust. (S)

Species descriptions

L. chaetocephalus F.v.Muell. Culm diameter: 1.5 mm.

Card characters: 2b, 5b, 7, 9, 12, 19, 21, 26, 27, 28, 30, 31, 36, 42, 43,  
47, 49, 50, 51, 52, 54, 55, 56, 60h, 63, 64, 69a, 110,  
112, 114, 115, 118, 121, 124.

Culm surface

Fig. 26 B

Hairs; as for genus. Epidermal cells; mostly as long as wide, walls very thick, wavy. Stomata; subsidiary cells of types (xiii) and (xvi); guard cells of type (viii b) but slightly longer than normal; apertures of type (ii).

Cuticular marks; granular.

Culm T.S.

Fig. 26 A

Hairs; as for genus. Epidermal cells; ranging from twice to 6 times higher than wide, the shorter cells being next to stomata, and having elongated anticlinal walls next to substomatal cavity. Wall thickening as for genus.

Stomata; superficial; subsidiary cells of types (i) to (m); guard cells with slight lip at outer aperture (7), and ridge

on inner wall (9); lumina of type (4b). Chlorenchyma; as for genus, cells 8 to 15 times higher than wide. Parenchyma sheath; as for genus. Sclerenchyma sheath; 6-8-layered, distinct from ground tissue, as for genus. Vascular bundles, Bundle sheaths; as for genus. Central ground tissue; as for genus, outer cells with moderately thickened walls. Silica; spheroidal-nodular bodies present in stigmata of parenchyma sheath.

L. drapetocoleus F.v.Muell. Culm diameter: 1.5 mm.

Card characters: 2b, 5c, 7, 9, 14, 19, 21, 26, 27, 28, 31, 42, 43, 47, 49,  
(within leaf 50, 51, 52, 54, 68, 71, 81, 88, 103, 104, 108, 110,  
sheath) 113, 115, 118, 121, 124.

Culm surface; not seen.

Culm T.S.

Outline; rounded. Hairs; none seen (material from within leaf sheath). Epidermal cells; as high as to  $1\frac{1}{2}$  times higher than wide; anticlinal walls lining substomatal cavity extended into chlorenchyma; wall thickening as for genus. Stomata; superficial; subsidiary cells of type (i); guard cells with slight lip at outer aperture (7), and ridge on inner wall (9); walls to pore concave (10); lumina of type (4b). Chlorenchyma; as for genus, cells <sup>10</sup>6- times higher than wide. Parenchyma sheath; as for genus. Sclerenchyma sheath; 6-8 cells wide, as for genus; clearly distinct from central ground tissue. Vascular bundles: (i) peripheral; flanking tracheids wider than others in arc, otherwise as for genus; (ii) medullary; as for genus. Bundle sheaths, central ground tissue; as for genus.

Silica; present as large, spheroidal-nodular bodies in stegmata of parenchyma sheath.

Leaf. Root; see generic description.

L. preissianus Nees Culm diameter: 0.8 - 1.2 mm.

Card characters: 2b, 5b, 7, 9, 13, 19, 21, 26, 27, 28, 30, 31, 42, 43, 47, 49, 50, 51, 52, 54, 55, 56, 60b, 63, 64, 69a, 110, 112, Blake 18106 114, 115, 118, 121, 124.

2b, 5b, 7, 9, 13, 14, 19, 21, 26, 27, 28, 31, 42, 43, 47, 49, 50, 51, 52, 54, 55, 56, 60b, 63, 64, 69a, 71, 81, Helms 87, 110, 112, 115, 118, 121, 124.

2b, 5b, 7, 9, 14, 26, 27, 28, 31, 42, 43, 47, 49, 50, 51, 52, 54, 63, 64, 69a, 71, 81, 87, 88, 103, 104, 108, 110, Cheadle CA459 113, 115, 118, 121, 124.

Culm surface

Figs. 26 C, F

Hairs; see generic description. Epidermal cells; 4-sided, as long as to twice as long as wide, walls thick or very thick, wavy. Stomata; subsidiary cells variable, of types (xi), (xii), (xiii); guard cells of type (ix); apertures of type (ii). Cuticular marks; granular.

Culm T.S.

Figs. 26 D, E

Outline; rounded, with irregular, low mounds. Hairs; as for genus. Epidermal cells;  $1\frac{1}{2}$ - $2\frac{1}{2}$  times higher than wide, the shorter cells being next to stomata, and with elongated anticlinal walls next to substomatal cavity. Wall thickening as for genus; lumina flask-shaped, flasks with wide necks. Chlorenchyma; as for genus, cells 3-5 times higher than wide in Helms' material, 8-10 times higher than wide in 18106. Parenchyma sheath; as for genus; in 18106, some cells up to twice as high as wide. Sclerenchyma

sheath; fibres in 6-8 layers, boundary with ground tissue indistinct. Vascular bundles, bundle sheaths; as for genus. Central ground tissue; as for genus; central area smaller than in other species. Silica; spheroidal-nodular bodies in stigmata in parenchyma sheath. Leaf and root; see generic description.

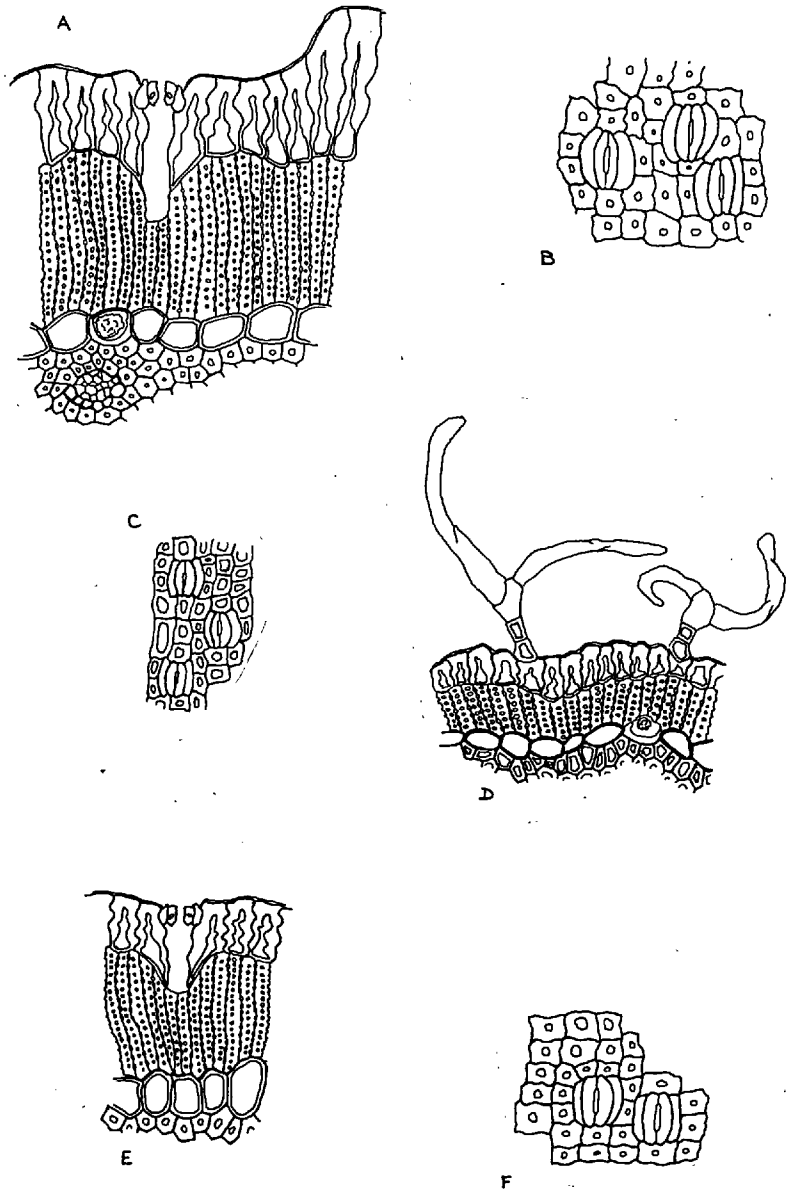


Fig. 26. Lepidobolus. A,B, chaetocephalus, C-F preissianus. (C,D,25904; E,F,25913). A,D,E, outer part of culm T.S. B,C,F, culm surface (x265).



Leptocarpus R.Br.Generic description

The species fall into 2 distinct geographical and anatomical groups: A. species from S. Africa  
 B. species from Australia, New Zealand, Malaysia, Indochina and S. America.

Group ACulm surface

Hairs; absent. Papillae; present on basal material of 1 species; short, rounded. Epidermal cells; 4- or 6-sided, as long as or up to 3 times longer than wide; smallest cells next to stomata. Stomata; subsidiary cells of types (xi), (xii), (xv), (xvi) and (xviii); guard cells of types (viii b) and (ix); apertures of types (ii) or (vi). Silica, absent. Tannin; occasionally present in epidermal cells. Cuticular marks; granular, occasionally with longitudinal striations.

Culm T.S.

Outline; round, or round with irregularly distributed, low, flat-topped mounds. Cuticle; slightly to moderately thickened, granular, occasionally with slight ridges. Papillae; see above. Epidermal cells; in 1 layer, (i) all of similar heights or (ii) with irregular areas of tall cells amongst shorter cells, giving rise to flat-topped mounds; cells as high as wide or up to 5 times higher than wide; outer walls thick; anticlinal and inner walls moderately thickened, anticlinal walls straight or wavy. Stomata; superficial, frequently raised on mounds formed by elongated epidermal cells; subsidiary cells of types (c), (e), (f),

(h), (i) or (m); guard cells with outer lips only (5a), or with outer and inner lips (5a, 8) or with outer lips and ridge on inner wall (5a, 9 or 5b, 9); lumina of types (1), (2a) or (3). Chlorenchyma; composed of palisade peg-cells in 1, 2 or 3 (4) uninterrupted layers; protective cells present round substomatal cavities. Parenchyma sheath; 1-or 2-4-layered. Sclerenchyma sheath: well developed in most species, outline rounded, or with low, dome-shaped ribs present opposite to pvbs.; wide, square-ended ribs alternating with pvbs. and extending well into chlorenchyma present in 1 species; sheath enclosing all pvbs. and all, some or no mvbs. Vascular bundles: (i) peripheral: small, with narrow tracheids arranged in single-layered arc partially enclosing rounded or tangentially oval phloem pole (flanking tracheids occasionally wider than others); (ii) medullary; outer bundles small, with 1 medium-sized vessel on either flank or, occasionally, with 1 central mx. vessel; inner bundles larger, with 1 wide mx. vessel on either flank, vessel wall pitting scalariform, perforation plates simple, transverse, vessels separated by 2-4 narrow cells; phloem pole ensheathed by 1 layer of narrow cells with moderately thickened walls; px. present in all but outer smaller bundles. Bundle sheaths; sclerenchymatous; fibres at poles narrow, thick-walled, in 1-2 (3) layers, those on flanks wider, with slightly or moderately thickened walls, in 1 layer; or sheath weak, <sup>all</sup> fibres with slightly thickened walls. Central ground tissue; parenchymatous, outer cells surrounding vascular bundles with moderately thickened walls, central cells thin-walled,

frequently breaking down to form central cavity; occasional areas of thin-walled cells scattered in outer layers in some species. Silica; spheroidal nodular bodies present in some species in inner chlorenchyma layer or parenchyma sheath; irregularly-shaped bodies present in protective cells in 1 species. Tannin; occasionally present in some epidermal cells.

#### Leaf surface

L. rigoratus only (3911), abaxial.

Hairs; none seen. Epidermal cells; 4-sided, mostly as long as wide, some about  $1\frac{1}{2}$  times longer than wide; walls moderately thickened, very wavy. Stomata; about  $\frac{2}{3}$  of size of those in culm of same species; subsidiary cells of type (xviii) but long anticlinal walls slightly wavy; guard cells of type (x), but shorter than normal; apertures of type (ii). Silica, tannin; none seen. Cuticular marks; granular.

#### Leaf T.S.

L. rigoratus 3911

Epidermal cells; (i) abaxial; cells 4-sided, mostly as high as wide, outer walls very thick; outer halves of anticlinal walls thick, thickening tapering rapidly, inner halves of walls moderately thickened; inner walls moderately thickened; (ii) adaxial; cells 4-sided, very flattened, being about 4 times wider than high and about  $\frac{1}{6}$  of height of abaxial cells; all walls moderately thickened. Stomata; present in abaxial surface only, superficial; subsidiary cells of type (e); guard cells with lips at outer and inner apertures (5a, 8); lumina triangular, narrow. Chlorenchyma;

composed of palisade peg-cells in 1 layer below abaxial epidermis; individual cells about twice as high as wide; protective cells absent. Vascular bundles; large and small alternating in 1 line; smaller with 5-10 narrow tracheids and 8-12 phloem cells, large with 1 medium-sized tracheid on either flank of 4-5 narrow to medium-sized tracheids and 8-20 phloem cells. Bundle sheaths; O.S. parenchymatous, as 1-layered caps at phloem pole, layer extending laterally and forming continuous sheet below chlorenchyma; I.S. sclerenchymatous, completely ensheathing, fibres narrow, thick-walled, arranged in 1 layer; joined on flanks by ground sclerenchyma. Sclerenchyma; present in bundle sheaths and in 1-2 layers between bundles, bounded abaxially by parenchyma layer and adaxially by 1 layer of wide parenchyma cells, these separating it from adaxial epidermis; sclerenchyma continuous to adaxial side of bundle sheaths; fibres either as wide as high, or up to  $1\frac{1}{2}$  times higher than wide, with very thick walls and narrow lumina. Ground tissue; single layer of wide parenchymatous cells next to adaxial epidermis, as described above. Air-cavities; absent. Silica, tannin; none seen. Rhizome and root not seen.

### Group B

#### Culm surface

Hairs; often present; either (i) multicellular, simple, unbranched, uniseriate, basal cell(s) with slightly thickened walls, other cells thin-walled; or (ii) multicellular, plate-like, with 1 short basal cell and flattened, 2-layered plate; cells all with thick or very thick (cellulose) walls,

individual cells elongated, up to 10 times longer than wide; plate 4-5 times longer than wide, one end pointed, other end rounded; basal cell attached near rounded (proximal) end, on median axis; margins of adjacent hairs frequently slightly overlapping one another and completely covering culm in some species (see figs. 2930). Epidermal cells; 4-6-sided, as long as to 5 times longer than wide, walls straight or very wavy, slightly or moderately thickened. Stomata; mainly confined to regions between pillar cells; subsidiary cells of types (xii), (xiii), (xvi) and (xviii); guard cells of types (x) and (ix), occasionally of type (vii); lumina mostly of type (ii), sometimes of types (i) or (iv). Silica crystals; none seen. Tannin; present in epidermal cells of some species. Cuticular marks; granular, frequently with longitudinal striations.

Culm T.S.

Hairs; see above. Outline; round. Cuticle; moderately thickened or thick, frequently ridged, ridges matching grooves between hair-cells. Epidermal cells; in 1 layer; as high as to  $1\frac{1}{2}$  times higher than wide, either all of similar height, or some, next to sunken stomata, shorter; cells next to stomata sometimes very much modified (in L. tenax); outer wall thick or moderately thickened, other walls moderately thickened, anticlinal walls not wavy. Stomata; superficial or sunken, subsidiary cells very variable, of types (a), (b), (e), (f), (h), (i), (k) or (n); guard cells usually without lips or ridges, but occasionally with slight lips at inner aperture (8) or slight ridge on inner wall (9); lumina of

types (1), (2), (4a) or (4b). Chlorenchyma; normally 2-3-, occasionally 4- or 5-layered, layers divided into longitudinal sectors by ridges from sclerenchyma sheath and their associated pillar cells; chlorenchyma cells palisade, occasionally with few pegs; protective cells absent. Palisade cells arranged in chequerboard pattern as seen in T.L.S. Parenchyma sheath; composed of 2 types of cell: (i) thin-walled, narrow, rounded cells in 1 layer between chlor-enchyma and sclerenchyma sheath, often containing stegmata, and frequently interrupted, occurring only on flanks of sclerenchyma ribs; (ii) pillar cells, extending between rounded ribs from sclerenchyma sheath, to epidermis; pillar cells mostly 2-3 (4 or 5) times higher than wide, with slightly or moderately thickened walls; pillar cells arranged in longitudinal files, normally 2-3 cells wide as seen in T.L.S. Sclerenchyma sheath; well developed, 3-4- or 8-10-layered, outline rounded, with dome-shaped ribs opposite to and enclosing 1 pvb.; ribs better developed in some species than others; fibres of ribs and outer layers narrow, with thick or very thick walls, those of inner layers wider, with moderately thickened walls. Vascular bundles: (i) peripheral; tracheids all narrow, forming 1-2-layered arc, or arc with 1 medium-sized tracheid on either flank; phloem pole rounded or tangentially oval, situated in concavity of arc; (ii) medullary; outer bundles small, with 1 narrow mx. vessel on either flank; usually lacking px. pole; inner, larger bundles with 1 medium-sized to wide, rounded or angular mx. vessel on either flank, vessels with scalariform wall pitting

and slightly transverse, simple perforation plates; mx. vessels normally separated by 2-3 files of narrow cells; phloem pole rounded or tangentially oval, abutting directly onto xylem or separated from it by 2 layers of narrow cells with moderately thickened walls next to xylem and thin walls next to phloem; px. present in all inner, larger bundles; some, all or no bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous; fibres at poles narrow, thick-walled, in (1)2-3 layers; those on flanks wider, with slightly or moderately thickened walls, in 1 layer. Central ground tissue; parenchymatous; outer layers composed of cells with slightly to moderately thickened walls, cells of inner layers with thin walls, often breaking down to form central cavity; inner layers separated from outer layers by 1 or 2 layers of narrow, thick-walled cells in some species. Silica; spheroidal-nodular bodies present in stigmata in parenchyma sheath. Crystals; none seen. Tannin; present in some epidermal cells of some species.

#### Leaf T.S.

Seen in L. simplex, L. spathaceus and L. tenax.

Hairs; none seen. Epidermis; (i) adaxial; cells 5-sided, slightly or  $1\frac{1}{2}$  times wider than high, walls very thick, lumina narrow; (ii) abaxial; mostly 4-sided, as high as wide to twice as high as wide, walls slightly or moderately thickened; about twice height of adaxial cells. Stomata; present on abaxial surface only; superficial, subsidiary cells of type (d) or (i); guard cells without lips or ridges; lumina of type (4a). Chlorenchyma; composed of lobed, more or less isodiametric cells present in 1 or 2 layers next to

abaxial epidermis, divided into longitudinal channels by bundle sheaths. Vascular bundles; of 2 main types: (i) with few or several narrow to medium-sized tracheids and phloem cells; (ii) with 1 wider tracheid on either flank of group of several narrow tracheids and phloem cells; bundles of the 2 types alternating. Bundle sheaths; O.S. parenchymatous, present as 1 layer of cells at phloem pole in L. spathaceus only; I.S. sclerenchymatous, fibres narrow, thick-walled, in 2-3 layers. Ground tissue; cells wide in L. simplex and L. tenax, narrow or medium-sized in L. spathaceus (the narrowest being next to chlorenchyma), all thick- or moderately thick-walled; cells filling all space not occupied by bundles and sheaths or chlorenchyma. Air-cavities; absent. Silica; small spheroidal-nodular bodies present in stegmata in outer layer of sclerenchyma sheath in L. spathaceus. Tannin; none seen.

#### Rhizome T.S.

Seen in L. simplex and L. tenax.

Hairs; unicellular, thin-walled, as high as to  $1\frac{1}{2}$  times higher than wide, rounded; and multicellular, short, biseriate, composed of more or less isodiametric cells with thin walls, hair about 3-4 cells long. Epidermal cells; 4-sided, as high as wide, walls thin. Outer cortex; composed of 4-6 layers of moderately thick- or thick-walled sclereids, individual sclereids mostly  $1\frac{1}{2}$  times wider than high. Inner cortex; 5-7 (10)-layered, cells parenchymatous, lobed, loosely packed, more or less isodiametric. Endodermoid sheath; 1-2-layered, cells with moderately thickened walls



in L. simplex, outer walls moderately thickened and other walls thick in L. tenax. Vascular bundles; outer with arc of mx. vessels, inner amphivasal; vessels narrow to medium-sized, angular, with thick walls; phloem pole rounded. Bundle sheaths; indistinguishable from ground tissue. Central ground tissue; cells round bundles narrow, with moderately thickened walls; areas of thin-walled cells dispersed amongst thicker cells. Silica; small spheroidal-nodular bodies present in some thin-walled cells of central ground tissue. Crystals, tannin; none seen.

Root T.S.

Fig. 288

Seen in L. aristatus, L. canus, L. simplex and L. tenax.

Root hairs; infrequent, arising from cells similar to those of remainder of epidermis. Epidermal cells; 5-sided. outer wall convex; all walls thin. Outer cortex; composed of outer 4 layers of 4-5-sided cells, each as wide as or slightly wider than high, with thin walls and inner 3-5 layers of cells mostly as high as wide, with moderately thickened walls. Middle cortex; consisting of radiating plates of parenchymatous cells, plates separated by air-spaces, cells of plates widest at outer ends, narrowest at inner ends of plates. Inner cortex; 1-layered, cells narrow, as high as wide, thin-walled. Endodermis; 1-layered, cells slightly or  $1\frac{1}{2}$ -2 times higher than wide, walls very thick, lumina narrow. Pericycle; composed of 1 layer of narrow, parenchymatous cells. Vascular system; phloem and px. strands alternating in outer ring, to inside of pericycle; mx. vessels wide, angular, radially oval, mostly in 1 ring immediately to inside

of that formed by phloem and px. Central ground tissue;  
 cells narrow to medium-sized, hexagonal, with moderately  
 thickened walls. Silica, crystals, tannin; none seen.

Material examined

Group A species from S. Africa.

L. asper Pill.	Burchell, An. 1815	
	Niew Kloof	31 (K)
"	Burchell, no number. Museum	32 (M)
L. burchellii Mast.	Burchell 7185, An. 1874	33 (K)
L. esterhuysianae Pill.	Esterhuysen 8770, paratype	
	An. 1942	1116A (K)
L. impolitus Pill.	Bolus, H. 12895 ♀ Hopefield	38 (K)
L. membranaceus Pill.	Schlechter 7765 ♀	2631B (K)
L. parkeri Pill.	Parker, R.N. 4695 ♂ An.1951	
	Caledon Div.	112A (K)
L. rigoratus Mast.	Parker, R.N. 3911 ♀ An.1944	
	Fairre, Stellenbosch Div.	41 (K)
"	Parker, R.N. 3914 ♂ An.1944	
	Fairre, Stellenbosch Div.	(K)
L. vimineus Pill.	Zeyher 4989 ♂	49 (K)
"	Matching 63a! in Drège's	
	Herb.	921B (K)
"	Received from Reichenbach	
	fil. in 1865, Worcester Div.	922B(K)
"	Parker, R.N. 3456 ♂, An.1940	
	Somerset West	50 (K)

Group B

L. aristatus R.Br.	Andrews, C. 1st col. 1100,	
	An.1902 Torbay Junction,	
	Nr. Albany, Austr.	3 (K)
"	Cheadle, V.I. CA71 Perth.	
	Austr.	(S)
"	Gardner, CA. An.1936 ♂	
	Kenwick, Austr.	1 (K)

L. aristatus R.Br.	Mueller, F. An. 1876 (in Kew Herb. as L. anomalus, mss. name, C.A. Gardner)	16(K)
L. brownii Hk.fl.	Willich ♂ Boston Pt. S.W.Austr.	9(K)
"	Hicks, A.J. 47, ♀ Little Desert, Victoria, Austr.	10(K)
L. canus Nees	Andrews, C. 1097 ♂ Midland Junction, Perth, Austr.	(K)
"	Andrews, C. 1098 ♀ Midland Junction, Perth, Austr.	6(K)
L. chilensis Mast.	Hook. Herb. 853, An. 1867 Valdivia, S. America	5118(K)
L. coangustatus Nees	2662 ♂ Austr.	34(K)
"	2662 ♀ Austr.	35(K)
L. disjunctus Mast.	Vestal An. 1917 Tringganu, Malaya	2672(K)
"	Poilane, M.E. 23177 Indochina	2673(K)
L. erianthus Benth.	Gardner, C.A. An. 1924 ♀ Hill River, Austr.	5(K)
"	Meebold, A. An. 1928 Kenwick, Austr.	4(K)
L. ramosus R.Br.	Specht, R.L. 932 ♂ An. 1948 <del>Ameland</del> , Austr.	8(K)
L. simplex A.Rich.	Moore, G. 3704 Spencerville, Canterbury, Salt Marsh, New Zealand	44(S)
"	Anderson, A.W. 199 ♂ New Zealand	13(K)
"	Wallace, E.H. 4551 ♀ Timani S. Island, New Zealand	14(K)
L. spathaceus R.Br.	Specht, R.L. 1053 ♂ An. 1948 Austr.	15(K)
"	No. 428 Austr.	12(K)
L. tenax (Labill.) R.Br.	Rodway 334, An. 1931 Austr.	48(K)
"	Cheadle, V.I. CA 94 Grampians Austr.	46(S)

- L. tenax* (Labill.) R.Br. Curtis, W.M. Blackman's Bay,  
Hobart, Tasmania 17164(K).
- " Drummond An. 1843 (in Kew  
Herb. as *Restio amblycoleus*)  
Swan R., Austr. 20216(K)
- " Hubbard, C.E. 2631 (in Kew  
Herb. as *Restio gracilis*  
R.Br.) Bribie Is., Austr. 20212(K)
- " Main & Constable N.H. N.S.W.  
16416 (in Kew Herb. on sheet  
of *Calorophus minor* Hk.f.)  
Austr. 14117(K)

### Species descriptions

#### Group A

*L. asper* Pill.

Culm diameter: 2 mm.

Card characters: 5b, 6, 7, 9, 14, 19, 20, 21, 26, 31, 37, 42, 44, 47, 48,  
Burchell; Niew 50, 51, 52, 54, 55, 60, 66, 69, 110, 112, 114, 115, 117,  
Kloof (basal) 124.  
Burchell; 2b, 5b, 7, 9, 15, 31, 37, 42, 44, 48, 50, 51, 54, 55, 69,  
no. L.S. 110, 112, 114, 115, 124.

#### Culm surface

Papillae; 1 present on each of several isolated cells,  
short, rounded. Epidermal cells; 4-sided,  $1\frac{1}{2}$ -2 times longer  
than wide, walls slightly thickened, wavy; those round  
stomata taller than others. Stomata; subsidiary cells of  
types (xii) to (xviii), or long anticlinal wall slightly  
wavy; guard cells of type (viiib). Tannin; present in few  
epidermal cells. Cuticular marks; granular; longitudinal  
striations present over papillae.

#### Culm T.S.

Outline; round, with irregularly spaced, flat-topped  
emergences. Epidermal cells; of 2 types: (i) between

stomata, slightly wider than high; (ii) next to stomata, 2-3 times higher than wide, and 2-3 times higher than shorter cells; outer walls very thick, other walls slightly thickened. Stomata; raised on tall cells, superficial; subsidiary cells narrow, of type (e); guard cells with slight ridge on inner wall (9); lumina of type (3). Chlorenchyma; mostly 2-layered; peg-cells 2-3 times higher than wide; protective cells with slightly thickened walls, extending from about half way up substomatal tube lined by epidermal cells to part way into inner chlorenchyma layer; apertures between cells rounded, at inner end of substomatal tube. Parenchyma sheath; 1-layered, cells thin-walled, mostly slightly wider than high. Sclerenchyma sheath; rounded, with slight ribs opposite to pvbs., 10-12-layered, fibres very thick-walled, lumina narrow. Vascular bundles; as for group A; most medullary bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous, 1-layered; fibres at phloem pole narrow, with moderately thick to thick walls, others with slightly thickened walls. Central ground tissue; as for group A, with outer areas of thin-walled cells. Silica; none seen. Tannin; present in few epidermal cells.

L. burchellii Mast.

Culm diameter: 0.7 mm.

Card characters: 2b, 2c, 5b, 7, 9, 14, 19, 21, 26, 28, 30, 31, 36, 37, 42, 44, 47, 48, 50, 51, 54, 55, 56, 60, 68, 110, 112, 114, 115, 117, 118, 124.

Culm surface

Epidermal cells; 4(-6)-sided, as long as or up to twice as long as wide, walls slightly to moderately thickened, wavy

at surface, straight at lower focus. Stomata; subsidiary cells of types (xii) and (xviii); guard cells of type (ix); apertures of type (ix). Tannin; present in few epidermal cells. Cuticular marks; granular.

Culm T.S.

Outline; round, with slight mounds irregularly distributed. Epidermal cells; 4-sided, from  $1\frac{1}{2}$ -2 times higher than wide, those next to stomata tallest; outer walls thick; anticlinal walls thick at outer ends, thickening tapering rapidly, and inner  $\frac{2}{3}$  of walls slightly thickened, wavy; inner walls very slightly thickened. Stomata; superficial; subsidiary cells of type (i); guard cells with lips at outer aperture (5a) and ridge on inner wall (9); walls to pore concave (10); lumina of type (2a). Chlorenchyma; 2-layered; cells of outer layer about 10 times higher than wide, with numerous, small pegs, cells of inner layer about 8 times higher than wide, as high as, but slightly wider than outer cells and with fewer, larger pegs; protective cells extending in 2 layers, each layer corresponding in height to adjacent peg-cells; walls slightly thickened; apertures irregular in shape, occurring mainly between cells of inner layer. Parenchyma sheath; 1-2-layered, cells rounded, slightly higher than wide. Sclerenchyma sheath; 5-6-layered, outline round, with slight ribs opposite to pvbs.; fibres very thick-walled. Vascular bundles; as for group A, but some outer mvbs. with 1 central mx. vessel; some bundles free from culm sclerenchyma sheath. Bundle sheaths; weak, 1-layered, fibres with slightly thickened walls. Central ground tissue; walls of

outer cells slightly thickened, otherwise as for group A.  
Silica; none seen. Tannin; present in few epidermal cells.

L. esterhuysianae Pill. Culm diameter: 2.0 mm.

Card characters: 2b, 5c, 7, 9, 14, 20, 22, 26, 31, 37, 42, 44, 47, 48, 50,  
 51, 52, 54, 55, 56, 57c, 58a, 69, 110, 112, 114, 115,  
 117, 118, 124.

Culm surface

Epidermal cells; 4-sided, mostly as long as wide, those flanking stomata frequently up to twice as long as wide, those at ends of stomata frequently twice as wide as long; walls thick or very thick, not wavy; cells of unequal heights, being tallest next to stomata. Stomata; closer together than normal; subsidiary cells of type (xviii); guard cells wider and shorter than normal type (ix), but with rounded ends; apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; granular.

Culm T.S.

Fig. 28A

Outline; round, with frequent, shallow depressions.  
Epidermal cells; 4-sided, 5-6 times higher than wide, shorter cells occurring irregularly in small groups between stomata; outer walls very thick, outer surface irregular, roughly granular, particularly in shorter cells; anticlinal walls wavy, with thick outer ends, thickening tapering gradually and inner ends moderately thickened; inner walls moderately thickened. Stomata; superficial, subsidiary cells of type (h), but shorter and narrower than usual and with slightly thickened walls; guard cells with pronounced cuticular lips at outer aperture (5a); lumina of type (3). Chlorenchyma; composed of 2 layers of palisade peg-cells; cells of outer

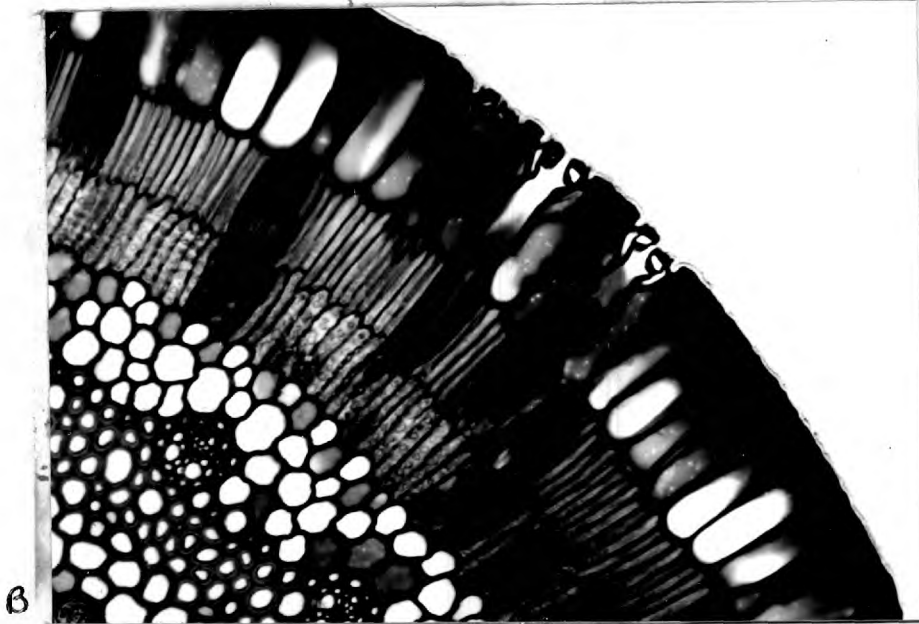
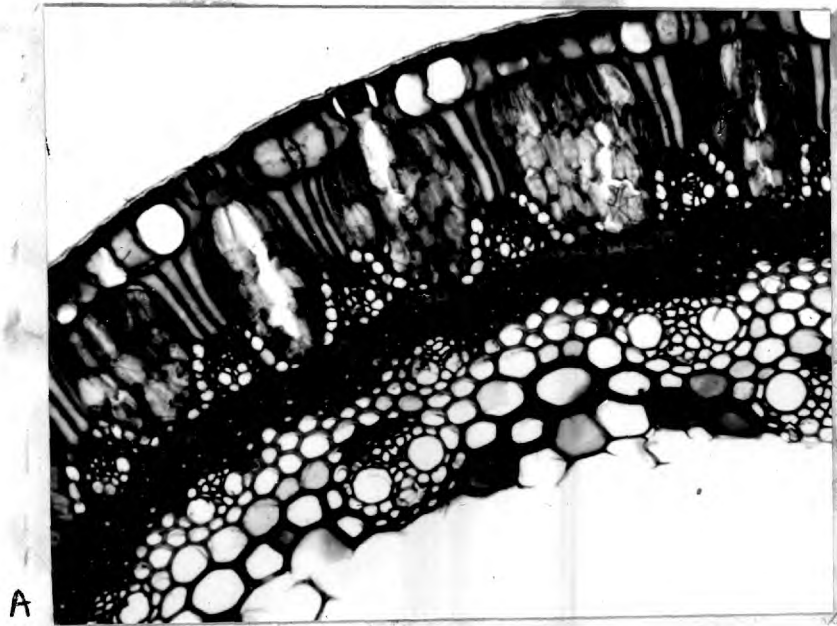


Fig. 27. *Leptocarpus*. A, *disjunctus*, B, *parkeri*.  
part of culm T.S. (x200).



layer, 8-9 times higher than wide with numerous small pegs, cells of inner layer about  $2/3$  height of and  $1/3$  wider than cells of outer layer, each being 5-6 times higher than wide, with fewer, wider pegs. Protective cells extending from about  $1/3$  of way up substomatal tube lined by epidermal cells to parenchyma sheath; walls moderately thickened, cells of inner layer only slightly modified peg-cells; apertures between cells rounded, occurring mainly between cells of inner layer, and at junction between outer and inner layers.

Parenchyma sheath; mostly 2-layered, 3-layered on either side of pvbs., but only 2-layered between them; cells rounded, with slightly to moderately thickened walls. Vascular bundles; as for group A, but peripheral bundles with arc of 1, 2 or 3 wide central tracheids and narrow flanking tracheids; many medullary bundles free from culm sclerenchyma sheath. Bundle sheaths; fibres at phloem poles narrow, thick walled, in 2 layers; those on flanks in 1 layer, and those at xylem pole in 2 layers, with moderately thickened walls. Central ground tissue; as for group A. Silica; none seen. Tannin; present in some epidermal cells.

L. impolitus Pill.

Culm diameter: 1.0 mm.

Card characters: 2b, 5b, 7, 9, 12, 14, 19, 20, 21, 26, 27, 28, 31, 37, 42, 44, 47, 48, 50, 51, 52, 54, 56, 58a, 60b, 69, 110, 112, 114, 115, 117, 124.

Culm surface

Epidermal cells; mostly 4-sided and as long as wide; those next to stomata extending above others and with irregular outlines; walls moderately thickened, wavy.

Stomata; subsidiary cells of type (xvi); guard cells of type (ix); apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; granular.

Culm T.S.

Fig. 29c

Outline; rounded, with irregular, flat-topped mounds, each bearing a stoma. Epidermal cells; of 2 main sizes: (i) about  $1\frac{1}{2}$  times higher than wide, between stomata; (ii) taller, surrounding stomata, up to  $3\frac{1}{2}$  times higher than wide; cells of intermediate heights present, with sloping outer walls, linking the 2 types. Outer walls very thick, other walls slightly thickened, not or only slightly wavy.

Stomata; superficial, raised on mounds; subsidiary cells of types (e) and (f), with moderately thickened walls; guard cells with pronounced outer cuticular lips (5) and slight ridge on inner wall (9); walls to pore convex (12); lumina of type (3); substomatal cavities unusually wide at outer end. Chlorenchyma; consisting of 2 (3) similar layers of palisade peg-cells; individual cells mostly 8-10 times higher than wide, pegs large, sparse. Protective cells extending in 2 layers from inner end of substomatal cavity lined by epidermal cells to parenchyma sheath; walls slightly to moderately thickened; apertures between cells very wide, occurring mainly in inner half of substomatal tube (fig. 29c). Parenchyma sheath; 1-2-layered, cells rounded. Sclerenchyma sheath; 5-6-layered, outline round, slightly ribbed opposite pvbs.; fibres very thick-walled, lumina narrow. Vascular bundles: (i) peripheral; xylem composed of narrow and medium-sized tracheids arranged in single-layered arc, phloem

pole rounded to tangentially oval, partially enclosed by arc;  
(ii) medullary; outer bundles small, with 2-3 narrow, angular, moderately thick-walled vessels arranged side by side, or with 1 narrow to medium-sized vessel on either flank; flanking mx. vessels of inner bundles medium-sized, rounded-angular, walls moderately thickened, vessels separated from one another by 2-3 rows of narrow, parenchymatous cells; phloem ensheathed; px. present in larger bundles only; some inner bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous, 1-layered; fibres narrow, with moderately thickened walls, except those at phloem pole, where very thick-walled. Central ground tissue; as for group A. Silica; irregularly shaped silica bodies present in many protective cells. Tannin; present in some epidermal cells.

I. membranaceus

Culm diameter: 1.5 mm.

Card characters: 2b,5b,6,7,9,15,19,21,26,27,28,31,34,37,42, 45,47,48,50,51,52,54,55,56,59b,68,112,114, 115,117,118,124.

Culm surface

Epidermal cells; mostly hexagonal,  $1\frac{1}{2}$  times wider than long, those flanking stomata slightly longer than wide, walls thick, wavy at culm surface, but straight at lower focus; some cells not reaching same level as majority. Stomata; subsidiary cells of type (xviii); guard cells of type (ix); apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; granular, with slight longitudinal striations.

Culm T.S.

Outline; round. Epidermal cells; mostly 3-4 times higher than wide, occasional cells only twice as high as wide; outer walls very thick, more or less straight or concave; anticlinal walls wavy, very thick at outer ends, thickening tapering and inner 1/3 of walls only slightly thickened; inner walls slightly thickened. Stomata; superficial; subsidiary cells of type (f); guard cells with pronounced cuticular lips at outer aperture (5a); walls to pore convex (12); lumina of type (2a). Chlorenchyma; peg-cells present in 3-4 layers; those of outer 2 layers about 5 times higher than wide, those of inner layer(s) slightly wider, ranging from slightly higher than wide to 4 or 5 times higher than wide. Protective cells well developed, with slightly thickened walls, extending in 2 or 3 layers from about 1/3 of way up substomatal cavity lined by epidermal cells to inner chlorenchyma layer, or to cells of parenchyma sheath; apertures between cells rounded; most frequent at inner end of substomatal tube, but occurring along its whole length; walls of protective cells <sup>adjacent</sup> to peg-cells with numerous thickened pegs of similar dimensions to those of peg-cells.

Parenchyma sheath; 1-2-layered, cells rounded-hexagonal, as high as or up to twice as high as wide; some cells, particularly in outer layer, with lignified thickenings on inner and anticlinal walls. Sclerenchyma sheath; 6-7-layered, outline rounded, with slight dome-shaped ridges opposite to pvbs; most fibres very thick-walled, occasional fibres of inner layers with moderately thickened walls. Vascular bundles;

as for group A. Bundle sheaths; sclerenchymatous; fibres at phloem pole in 2-3 layers, narrow, thick-walled; flanking fibres 1-layered, those at xylem pole 2-layered, with moderately thickened walls. Central ground tissue; as for group A, but with scattered areas of thin-walled cells in outer region. Silica; spheroidal-nodular bodies present in very few cells of inner chlorenchyma layer. Tannin; present in some epidermal cells.

L. parkeri Pill.

Culm diameter: 1 mm.

Card characters: 2b, 5b, 5c, 6, 7, 9, 14, 18, 19, 21, 26, 27, 28, 31, 36, 37, 42, 43, 47, 48, 49, 50, 51, 52, 54, 55, 56, 60, 68, 110, 112, 114, 115, 117, 124.

Culm surface

Epidermal cells; 4-sided, from 3-6 times longer than wide, walls moderately thickened, wavy. Stomata; subsidiary cells of types (xi) and (xii); guard cells of type (ix); apertures narrow, of type (vi). Tannin; present in some epidermal cells. Cuticular marks; granular.

Culm T.S.

Outline; round. Epidermal cells; mostly <sup>c. 5 times</sup> ~~of~~ higher than wide, outer walls very thick, dome-shaped; anticlinal and inner walls moderately thickened. Stomata: superficial; subsidiary cells of type (e), but with ridges on outer walls; guard cells with cuticular lips at outer apertures (5a), and slight lips at inner aperture (8); walls to pore of type (12); lumina of type (2a). Chlorenchyma; composed of peg-cells in 2 layers, cells 4-8 times higher than wide; protective cells extending from inner walls of epidermal

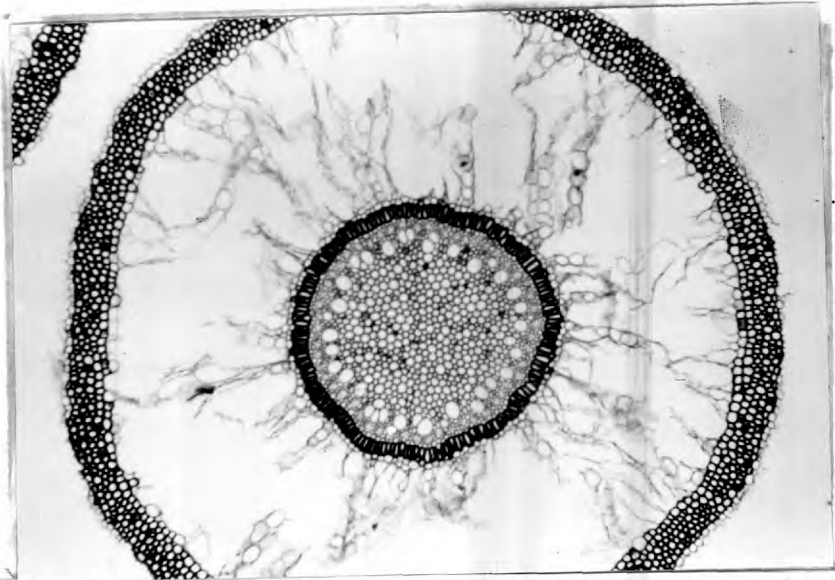
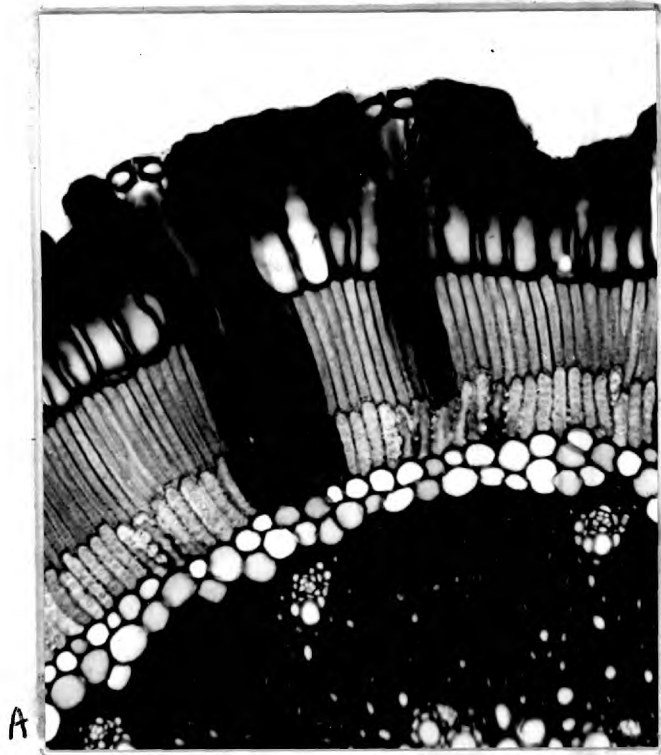


Fig. 28. Leptocarpus. A, esterhuysianae, part of culm T.S. (x200); B, tenax root T.S. (x65).

cells to parenchyma sheath, walls slightly to moderately thickened, pegs large, 1 or 2 rounded apertures present between most cells. Parenchyma sheath; 2-3-layered, partially interrupted in places by **ridges of** fibres from sclerenchyma sheath; cells as wide as to  $1\frac{1}{2}$  times **high** than **wide**, with rounded corners. Sclerenchyma sheath; 3-6-layered, with very low ridges **opposite** pvbs.; fibres of outer 1-2 layers very thick-walled, other fibres with thick or moderately thickened walls, those of innermost layer difficult to distinguish from central ground tissue. Vascular bundles: (i) peripheral; small, with 2 or 3 narrow tracheids arranged in arc, or with 1 wider tracheid on either flank; (ii) medullary; some outer bundles with 1 central mx. vessel, otherwise as for group A. Bundle sheaths; sclerenchymatous; fibres arranged in 1 layer, those at phloem pole thick-walled, others moderately thick-walled. Central ground tissue; parenchymatous, as for group A. Silica; spheroidal-nodular bodies present in some cells of parenchyma sheath. Tannin; present in some epidermal cells.

L. rigoratus Mast.

Culm diameter: 1 and 1.2 mm

Card characters: 2b, 5b, 7, 9, 12, 19, 20, 21, 22, 25, 26, 27, 28, 29, 31,  
 Parker 3911 37, 42, 44, 47, 48, 50, 51, 52, 54, 55, 56, 58, 60, 68, 74,  
 (nodal) 72, 74, 78, 81, 88, 110, 117, 124.  
 2b, 5b, 7, 9, 12, 20, 22, 26, 31, 37, 42, 44, 47, 48, 50,  
 Parker 3914 51, 54, 55, 56, 58, 60, 68, 110, 112, 114, 115, 124.

Culm surface

Epidermal cells; 4-, 5- and 6-sided, as long as or up to  $1\frac{1}{2}$  times longer than wide, walls moderately thickened, slightly wavy. Stomata; subsidiary cells of types (xv) and

(xviii); guard cells of type (ix); apertures of type (ii). Tannin; present in some epidermal cells. Cuticular marks; granular, and irregularly striate.

Culm T.S.

Epidermal cells; 4-sided, mostly  $1\frac{1}{2}$  times higher than wide; outer walls very thick, outer part of anticlinal walls thick, thickening tapering and inner halves of walls slightly to moderately thickened; inner walls slightly to moderately thickened. Stomata; superficial; subsidiary cells of type (m); guard cells with lips at outer and inner apertures (5, 8); lumina of type (1). Chlorenchyma; composed of 2 similar layers of peg-cells, each cell about 4 times higher than wide; protective cells extending through 1 or both layers, with moderately thickened walls; apertures between cells rounded, occurring at intervals down substomatal tube. Parenchyma sheath; 2- or, occasionally, 3-layered, cells of unequal sizes, mostly slightly wider than high, some as wide as high. Sclerenchyma sheath; 6-8-layered, fibres very thick-walled; those of outer 2-3 layers about  $1\frac{1}{2}$  times higher than wide, others as high as wide. Vascular bundles; as for group A, but medullary bundles of 3911 with many medium-sized, rounded-angular, mx. vessels, typical of bundle entering node. Bundle sheaths; sclerenchymatous, well developed; fibres thick- or very thick-walled, present in 3-4 layers at phloem pole, 1 layer on flanks and 2 layers at xylem pole in 3914, and in 1 layer in 3911. Central ground tissue; as for group A. Silica; none seen. Tannin; present in some epidermal cells.

Leaf surface and T.S., see generic description A.



L. vimineus Pill.

Culm diameter: 1, 0.8 and 1 mm.

Card characters: 2b, 5b, 7, 9, 14, 19, 20, 21, 22, 24, 25, 26, 27, 31, 37, 42, 44, 47, 48, 50, 51, 52, 54, 55, 56, 58b, 68, 110, Zeyher 4989 112, 114, 115, 124. 2b, 2c, 5b, 7, 9, 12, 20, 22, 24, 26, 31, 37, 42, 44, 47, Drège 63a! 48, 50, 51, 52, 55, 56, 58b, 68, 112, 114, 115, 117, 124. Reichenbach 2b, 5b, 7, 9, 14, 31, 37, 42, 44, 47, 48, 50, 51, 52, 54, (L.S. not seen) 68, 110, 112, 113, 114, 115, 124. 2b, 5b, 7, 9, 14, 20, 22, 24, 26, 31, 34, 37, 42, 44, 47, 48, 50, 51, 52, 54, 55, 56, 58b, 68, 110, 112, 114, 115, Parker 3546 117, 124.

Culm surface

Epidermal cells; mostly 6-sided, those next to stomata about as long as wide, others about  $1\frac{1}{2}$  times longer than wide; walls slightly or moderately thickened, slightly wavy.

Stomata; subsidiary cells of type (xviii); guard cells of type (ix); apertures of type (ii). Tannin; present in epidermal cells of some samples. Cuticular marks; granular.

Culm T.S.

Outline; round. Epidermal cells; 4-sided, slightly higher or  $1\frac{1}{2}$  times higher than wide in 3456, twice as high as wide in other specimens; outer walls thick, other walls slightly thickened or thin. Stomata; superficial, except in 63a! where slightly sunken; subsidiary cells of types (f to m) except in 63a! where of type (c); guard cells with pronounced lips at outer aperture (5b) and ridge on inner wall (9); walls to pore of type (12); lumina of type (2a). Chlorenchyma; 2-layered, cells of outer layer 6-10 times higher than wide, with numerous, small pegs, cells of inner layer mostly 5 times higher than wide, with fewer, larger pegs, except in 3546, where cells of both layers about 5 times

higher than wide. Protective cells extending in 2 layers from epidermis to parenchyma sheath; walls slightly thickened, apertures wide, rounded, present mainly between cells at junctions of inner and outer layers. Parenchyma sheath; 1-2-layered, cells mostly slightly wider than high. Sclerenchyma sheath; 4-5-(8)-layered, fibres of 2 types: (i) those of outer layers wide, 2-3 times higher than wide, mostly hexagonal, with very thick walls; (ii) those outside and opposite pvbs., and of inner 2-3 layers, narrower, mostly as wide as high, with thick or moderately thick walls (all of type (ii) in 4989 and 63a!). Vascular bundles; as for group A; some outer medullary bundles in some specimens with 1 central mx. vessel. Bundle sheaths; sclerenchymatous; fibres thick-walled, in 2 layers at phloem pole; with moderately thickened walls and in 1 layer on flanks and at xylem pole. Central ground tissue; as for group A. Silica; none seen. Tannin; present in some epidermal cells in some samples.

#### Group B

L. aristatus R.Br.

Culm diameter: 0.5 - 1.0 mm.

Card characters: 3, 5c, 7, 9, 14, 19, 20, 21, 26, 27, 28, 31, 44, 45, 48,  
 Andrews 1100 49, 50, 51, 52, 55, 56, 60, 68, 112, 114, 115, 124.  
 2b, 5c, 7, 9, 14, 19, 21, 26, 27, 28, 31, 46, 47, 48, 49, 50,  
 Cheadle 51, 52, 55, 56, 60, 63, 64, 68, 104, 105, 106, 114, 115,  
 CA71 124.  
 5c, 6b, 7, 9, 12, 19, 20, 21, 22, 26, 31, 45, 47, 48, 49,  
 50, 51, 52, 55, 56, 60, 63, 64, 68, 104, 105, 106, 114,  
 Gardner 115, 117, 124.  
 3, 5c, 7, 9, 14, 20, 21, 25, 27, 28, 30, 31, 44, 47, 48,  
 49, 50, 51, 52, 55, 56, 60, 63, 64, 68, 112, 114, 115,  
 Mueller 124.

Culm surface

Hairs; of group B type (ii). Epidermal cells; as long as wide to 3-5 times longer than wide; walls slightly thickened, very wavy. Stomata; subsidiary cells shorter than guard cells, of types (xii) or (xvi); guard cells of type (x); apertures of type (ii). Tannin; present in some epidermal cells in 1 specimen. Cuticular marks; granular with longitudinal striations.

Culm T.S.

Outline; round. Cuticle; moderately thickened, with ridges. Hairs; see above. Epidermal cells; 4-sided, as high as or slightly higher than wide, largest over pillar cells; outer walls moderately thickened, other walls slightly thickened. Stomata; small, slightly sunken; subsidiary cells of type (b); guard cells with no pronounced lips or ridges; lumina of type (2a). Chlorenchyma; 2-3-layered, cells  $1\frac{1}{2}$ -2 times higher than wide, as for group B. Parenchyma sheath; as for group B, pillar cells strongly developed (see fig. 29D). Sclerenchyma sheath; 5-6-layered, fibres very thick-walled; outline rounded, with ribs opposite pvbs. Vascular bundles; peripheral with 1 medium-sized angular tracheid on either flank, no medullary bundles free from culm sclerenchyma sheath, otherwise as for group B. Bundle sheaths; sclerenchymatous, difficult to distinguish from culm sclerenchyma sheath. Central ground tissue; as for group B, <sup>but</sup> without inner sclerenchyma sheath. Silica; present as (i) spheroidal-nodular bodies in stigmata of outer layer of sclerenchyma sheath, and (ii) granular, in some pillar cells. Tannin; present in some epidermal cells

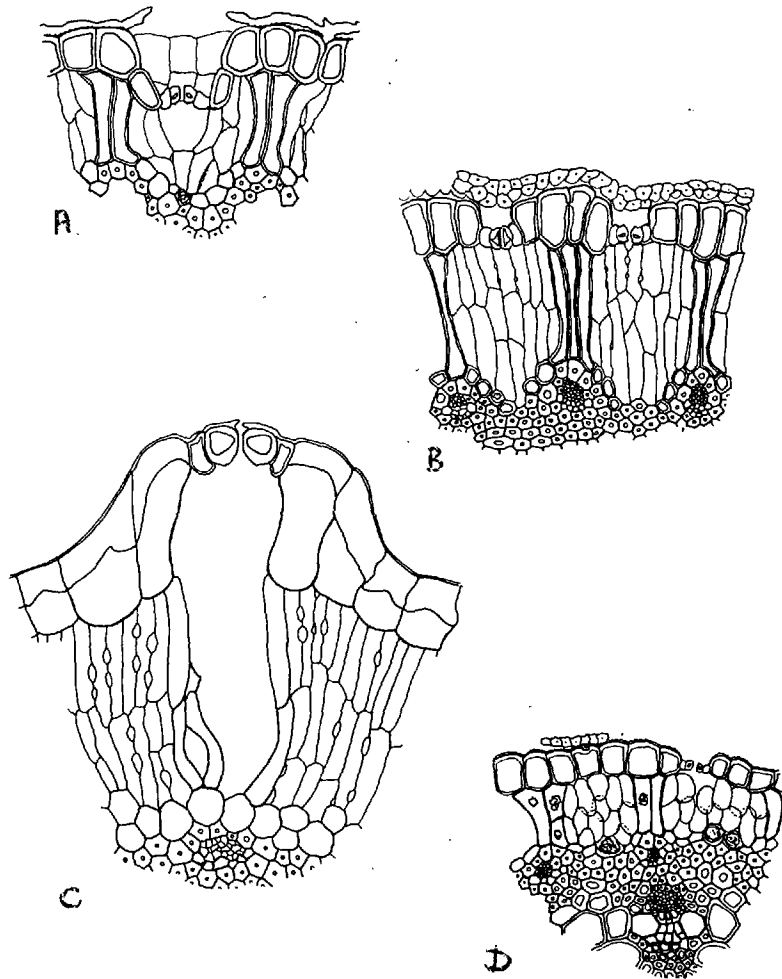


Fig. 29. Leptocarpus. A, tenax; B, chilensis;  
C, impolitus; D, aristatus; part of culm T.S. (x185).

in 1 specimen. Root; see group B generic description.

L. brownii Hk. fl.

Culm diameter: 1.0, 0.8 mm.

Card characters: 2b, 5b, 7, 9, 14, 19, 21, 26, 27, 28, 31, 44, 47, 48, 49,  
50, 51, 52, 55, 56, 58, 63, 64, 68, 110, 112, 114, 115,

Willich 124.

Hicks 47 2b, 5b, 7, 9, 14, 26, 27, 28, 31, 44, 47, 48, 49, 50, 51,  
(no L.S.) 52, 63, 64, 68, 110, 112, 113, 114, 115, 124.

#### Culm surface

Hairs; of group B type (ii). Epidermal cells; mostly 6-sided, some 4- or 5-sided, 2-4 times longer than wide, walls thick, end walls transverse or oblique. Stomata; subsidiary cells of type (xiv); guard cells of type (vii); apertures narrow, of type (ii). Silica; granular material present in some hair-cells. Tannin; none seen. Cuticular marks; wavy, longitudinal striations.

#### Culm T.S.

Outline; round. Cuticle; moderately thickened, with pronounced ridges. Hairs; see above. Epidermal cells; all of about same height,  $1\frac{1}{2}$ -2 times higher than wide (according to plane of section); outer walls thick, other walls moderately thickened; anticlinal walls not wavy, but with conspicuous, simple, rounded pits. Stomata; sunken; attached to innermost end of epidermal cell anticlinal wall; subsidiary cells of type (f); guard cells without conspicuous lips or ridges; lumina of type (1). Chlorenchyma; 2-layered, as for group B. Parenchyma sheath; as for group B. Sclerenchyma sheath; 5-6-layered, fibres thick-walled; outline round, with ridges opposite to pvbs., fibres of inner layers difficult to distinguish from central ground tissue.

Vascular bundles; as for group B, but some outer medullary bundles with 1 narrow, central mx. vessel only; some inner bundles free from culm sclerenchyma sheath. Bundle sheaths, central ground tissue; as for group B, no inner sclerenchyma sheath. Silica; present as (i) spheroidal-nodular bodies in stigmata in outer layer of sclerenchyma sheath, and (ii) irregularly-shaped bodies in some pillar cells

L. canus Nees

Culm diameter: 1 mm.

Card characters: 2b,5c,7,9,12,19,20,21,25,26,27,28,30,31,45,  
47,48,49,50,51,52,55,56,58b,60,63,64,68,104,  
1097 (♂) 105,106,114,115,124.  
2b,5c,7,9,12,14,19,20,21,26,31,45,47,48,49,  
50,51,52,55,56,58b,60,63,64,68,112,114,115,  
1098 (♀) 124.

Culm surface

Hairs; of group B type (ii). Epidermal cells; 4- or 6-sided, mostly  $1\frac{1}{2}$ -2 times longer than wide, those above pillar cells slightly larger than others; walls moderately thickened, wavy. Stomata; subsidiary cells of type (xviii); guard cells of type (x); apertures of type (ii). Tannin; none seen. Cuticular marks; granular.

Culm T.S.

Outline; round. Cuticle; moderately thickened. Hairs; see above. Epidermal cells; mostly  $1\frac{1}{2}$  times higher than wide, but taller over pillar cells and shorter next to guard cells; outer walls moderately thickened, other walls slightly to moderately thickened. Stomata; slightly sunken; subsidiary cells of type (i); guard cells with slight ridges on inner walls (9); lumina of type (2a). Chlorenchyma;

cells 2-3 times higher than wide, in 3-4 layers; as for group B. Parenchyma sheath; as for group B. Sclerenchyma sheath; 6-9-layered, outline rounded, with ridges opposite to pvbs.; fibres thick-walled. Vascular bundles; as for group B, but peripheral bundles with 1 wide tracheid on either flank, and no medullary bundles free from culm sclerenchyma sheath. Bundle sheaths; as for group B. Central ground tissue; as for group B, but with 1-layered, inner sclerenchyma sheath separating outer and inner cells. Silica; spheroidal-nodular bodies present in stigmata of culm sclerenchyma sheath and also in some pillar cells.

Root T.S. as for group B.

L. chilensis Mast.

Culm diameter: 1.5 mm.

Card characters: 2b, 3, 5b, 7, 9, 14, 31, 44, 45, 47, 48, 49, 50, 51, 52, (no L.S. or 63, 64, 68, 112, 113, 114, 124. epidermis)

Culm surface: not seen

Culm T.S.

Outline; round. Cuticle; thick, with pronounced ridges. Hairs; of group B type (ii). Epidermal cells; those next to stomata about as high as <sup>to twice as high as</sup> wide, those over pillar cells slightly more than twice as high as wide; all walls moderately thickened to thick, outer walls slightly thicker than others. Stomata; sunken, attached to inner ends of anticlinal walls of adjacent epidermal cells; subsidiary cells of types (a-b); guard cells with slight ridge on outer wall, and small lip at inner aperture (8).

Chlorenchyma; palisade cells in 2-3 layers, some cells with

few, short pegs; individual cells 3-7 times higher than wide; occasional areas of cells with moderately thickened, lignified walls, otherwise as for group B; most pillar cells about 10 times longer than wide. Sclerenchyma sheath; mainly 4-layered, with pronounced ridges enclosing pvbs. Vascular bundles; as for group B, but peripheral bundles with medium-sized tracheids flanking arc of narrow tracheids; no medullary bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous; all fibres with moderately thickened walls, in 2 layers at phloem pole and 1 layer on flanks and at xylem pole. Central ground tissue; as for group B, without inner sclerenchyma sheath. Silica; present as: (i) spheroidal-nodular bodies in stigmata in outer layer of culm sclerenchyma sheath, and (ii) granular material in some cells of chlorenchyma and central ground tissue. Tannin; none seen.

L. coangustatus Nees

Culm diameter: 1-1.5 / 0.75 mm  
by

Card characters: 2b, 3, 5b, 5c, 7, 9, 15, 19, 21, 26, 27, 28, 31, 45, 47, 2662 ♀ 48, 49, 50, 51, 52, 63, 64, 70b, 112, 113, 114, 115, 124, 2b, 5b, 5c, 7, 9, 14, 15, 18, 19, 21, 26, 27, 28, 31, 34, 45, 46, 47, 48, 49, 50, 51, 52, 55, 56, 58, 63, 64, 70b, 2662 ♂ 110, 112, 114, 115, 124.

Culm surface

Hairs; of group B type (ii). Epidermal cells; 4-5- and 6-sided, mostly as long as wide, but those over pillar cells larger and frequently up to  $1\frac{1}{2}$  times longer than wide; walls moderately thickened. Stomata; subsidiary cells variable, but mainly of types (xvi) and (xviii); guard cells of type (x); apertures short, of type (i). Tannin; none



seen. Cuticular marks; finely granular.

Culm T.S.

Outline; semicircular to kidney-shaped. Hairs; see above. Epidermal cells; those next to stomata about  $1\frac{1}{2}$  times higher than wide, others reaching 2-3 times higher than wide, about  $1\frac{1}{2}$  times higher than shortest; cells of intermediate height present; outer walls thick, other walls moderately thickened; outer walls of cells adjacent to stomata curving down sharply towards stoma, anticlinal wall next to stoma about half height of others in same cell. Stomata; sunken, inner walls level with inner walls of epidermal cells; subsidiary cells of types (h) and (i); guard cells without pronounced lips or ridges; lumina of type (1). Chlorenchyma; cells in 4-5 layers, without pegs, cells mostly twice as high as wide, with acute ends except where bordering onto epidermis or sclerenchyma. Parenchyma sheath; as for group B; pillar cells sometimes in files of 4. Sclerenchyma sheath; as for group B, 6-7-layered, thick-to very thick-walled. Vascular bundles: (i) peripheral; as for group B, with or without wider flanking tracheids; (ii) medullary; outer bundles smaller, flanking mx. vessels narrow or medium-sized, phloem abutting directly onto xylem, lacking px. poles; larger, inner bundles with wide, flanking, angular to many-sided mx. vessels; phloem poles ensheathed; px. present; no bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous; composed of 2-3 layers of narrow, thick-walled fibres at poles and 1 layer of wider, moderately thick-to thick-walled fibres on flanks. Central

ground tissue; as for group B; without inner sclerenchyma sheath. Silica; spheroidal-nodular bodies present in stigmata in outer layer of sclerenchyma sheath and also in some pillar cells. Tannin; none seen.

L. disjunctus Mast.

Culm diameter: 1.5 mm.

Card characters: 2c, 3, 5b, 7, 9, 15, 19, 21, 26, 27, 28, 30, 31, 42, 45, 47, 48, 49, 50, 51, 52, 54, 55, 56, 60, 63, 64, 68, 110, 2672 (Malaya) 112, 114, 115, 117, 124.  
2c, 3, 5b, 7, 9, 14, 19, 21, 26, 27, 28, 31, 45, 47, 48, 2673 (Cochin- 49, 50, 51, 52, 54, 55, 56, 60, 63, 64, 68, 110, 112, china) 114, 115, 117, 124.

Culm surface

Hairs; of group B type (ii). Epidermal cells; mostly 4-sided,  $1\frac{1}{2}$ -2 times longer than wide, some as long as wide; walls slightly to moderately thickened, wavy. Stomata; arranged in longitudinal files; subsidiary cells slightly longer than guard cells, of type (xii) but long anticlinal walls sometimes slightly wavy; guard cells of type (x); apertures of type (iv). Tannin; present in some epidermal cells. Cuticular marks; granular.

Culm T.S.

Fig. 27A

Outline; round. Hairs; see above. Epidermal cells; 4-sided, as high as to  $1\frac{1}{2}$  times higher than wide, those over pillar cells up to twice as wide as, and  $1\frac{1}{2}$  times higher than those next to stomata. Outer walls thick to very thick, other walls slightly thickened. Stomata; superficial; subsidiary cells of type (i), but adjacent epidermal cell anticlinal walls as for types (l) and (m); guard cells without pronounced lips or ridges; walls to pore of type 10;

lumina of type (4a). Chlorenchyma; mainly 4-layered, as for group B; cells 2-4 times higher than wide; infrequent, short pegs on anticlinal walls of some cells. Parenchyma sheath; as for group B; pillar cells mostly 7-8 times higher than wide, with slightly to moderately thickened walls. Sclerenchyma sheath; 5-6 (8)-layered, as for group B. Vascular bundles: (i) peripheral; as for group B; (ii) medullary; some outer bundles with 1 central, medium-sized mx. vessel, others with 1 medium-sized, angular mx. vessel on either flank; phloem pole small, abutting directly onto xylem; px. poles absent; inner bundles about twice size of outer, tangentially oval in outline, flanking mx. vessels wide, angular, with slightly thickened walls, separated from one another by 2-5 rows of narrow cells; phloem pole ensheathed, overarching and extending partly between flanking vessels; px. pole present in most inner bundles; some bundles free from culm sclerenchyma sheath. Bundle sheaths; as for group B. Central ground tissue; as for group B, with inner sclerenchyma sheath, 1 layer wide, separating outer from inner region. Silica; spheroidal-nodular bodies present in stigmata in outer layer of sclerenchyma sheath. Tannin; present in some epidermal cells.

L. erianthus Benth.

Culm diameter: 1.1, 1.0 mm.

Card characters: 2b, 5c, 7, 9, 12, 14, 19, 21, 26, 27, 28, 31, 45, 47, 48, 49, 50, 51, 52, 55, 56, 58, 60, 63, 64, 68, 112, 114,

Meebold 115, 124.

2b, 5c, 7, 9, 12, 14, 19, 21, 26, 27, 28, 31, 45, 47, 48, 49, 50, 51, 52, 54, 58, 60, 63, 64, 68, 112, 114, 115,

Gardner 124.

Culm surface

Hairs; of group B type (ii). Epidermal cells; 4-6-sided, as long as wide to 3 times longer than wide, those over pillar cells sometimes larger than others; walls moderately thickened, wavy. Stomata; subsidiary cells of type (xvi); guard cells sometimes slightly longer than subsidiary cells, of types (ix) or (x); apertures of type (ii).

Tannin; absent. Cuticular marks; granular.

Culm T.S.

Outline; round. Hairs; see above. Epidermal cells: mostly  $1\frac{1}{2}$  times higher than wide, largest opposite pillar cells; outer walls thick, other walls moderately thickened. Stomata; superficial; subsidiary cells of type (k), but wider than normal; guard cells without lips or ridges; walls to pore of type (ll); lumina of type (4a). Chlorenchyma; 2-3-layered, as for group B. Parenchyma sheath; as for group B. Sclerenchyma sheath; 6-7-layered, fibres thick-walled, ribs pronounced. Vascular bundles; peripheral bundles with wide flanking tracheids; no medullary bundles free from culm sclerenchyma sheath, otherwise as for group B. Bundle sheaths; sclerenchymatous, indistinguishable from culm sclerenchyma sheath. Central ground tissue; as for group B, without inner sclerenchyma sheath. Silica; spheroidal-nodular bodies in stegmata in outer layer of sclerenchyma sheath. Tannin; none seen.

L. ramosus R.Br.

Culm diameter: 0.8 mm.

Card characters: 2, 5c, 7, 9, 15, 20, 22, 26, 27, 28, 31, 42, 45, 47, 48, 49, 50, 51, 52, 54, 55, 56, 58b, 68, 110, 112, 114, 115, 124.

Culm surface

Hairs; none seen. Epidermal cells; mostly hexagonal, but some 4- or 5-sided, mostly 2-3 times longer than wide, those opposite to ends of stomata often shorter than wide; walls slightly to moderately thickened, wavy at surface only, straight at lower focus. Stomata; subsidiary cells of types (xiii) and (xv); guard cells of type (ix); apertures of type (ii). Tannin; none seen. Cuticular marks; granular, with close, fine, longitudinal striations.

Culm T.S.

Hairs; none seen. Epidermal cells; as high as to slightly higher than wide; outer walls very thick, other walls slightly to moderately thickened. Stomata; superficial; subsidiary cells of type (e); guard cells without conspicuous lips or ridges; walls to pore of type (10); lumina of type (2a). Chlorenchyma; 3-4-layered, as for group B; cells of outer layers 2-3 times higher than wide, those of inner layers mostly  $1\frac{1}{2}$  times higher than wide; pegs few, short. Parenchyma sheath; as for group B. Sclerenchyma sheath; 3-layered, fibres very thick-walled, otherwise as for group P. Vascular bundles: (i) peripheral; with 1 wide, angular tracheid on either flank of arc of several narrow tracheids; (ii) medullary; as for group B; flanking mx. vessels of inner bundles wide, many-sided; separated by 4-5 rows of narrow cells; phloem abutting directly onto xylem in some bundles; some inner bundles free from culm sclerenchyma sheath. Bundle sheaths; as for group B. Central ground tissue; as for group B; with inner sclerenchyma sheath. Silica; (i) as spheroidal-nodular bodies in

stigmata in outer layer of culm sclerenchyma sheath; (ii) as granular material filling lumina of some pillar cells.

Tannin; none seen.

L. simplex A. Rich.

Culm diameter: 1.5-2 mm.

Card characters: 2b, 5b, 7, 9, 14, 19, 21, 26, 31, 42, 45, 48, 49, 50, 51, 52, 55, 56, 60, 63, 64, 68, 89, 90, 93, 100, 112, 114,

Moore G3704 124.

2b, 5b, 7, 9, 14, 19, 21, 26, 27, 28, 31, 46, 47, 48, 49,

Anderson 199 50, 51, 55, 56, 60, 63, 64, 68, 110, 112, 115, 124.

2b, 5b, 7, 9, 14, 19, 21, 26, 27, 28, 31, 45, 47, 48, 49,

50, 51, 52, 55, 56, 58b, 60, 68, 71, 74, 81, 110, 112,

Wallace 4551 115, 124.

Culm surface

Hairs: of group B type (ii), some cells containing silica. Epidermal cells: mostly 4-sided,  $1\frac{1}{2}$ -2 (3) times longer than wide, those at ends of stomata frequently as long as wide; walls moderately thickened, wavy at surface, straight at lower focus. Stomata: subsidiary cells of types (xiii) to (xvi); guard cells of type (vii). Tannin; none seen.

Cuticular marks; granular, with longitudinal striations.

Culm T.S.

Outline; round. Cuticle; thick, with pronounced ridges. Hairs; see above. Epidermal cells; 4-sided; those over pillar cells slightly higher than wide, those over chlorenchyma as high as or slightly wider than high or higher than wide; outer walls thick to very thick, slightly concave; other walls moderately thickened. Stomata; sunken; subsidiary cells of type (f); guard cells without pronounced lips or ridges; walls to pore of type (12); lumina of type (4b). Chlorenchyma; 2-3-layered, as for group B; cells

2-3 times higher than wide, with few, short, wide pegs.

Parenchyma sheath; as for group B; pillar cells about 5-6 times higher than wide. Sclerenchyma sheath; 3-4-layered (5-6-layered in 199); walls of fibres thick or very thick, otherwise as for group B. Vascular bundles; as for group B; some inner bundles free from culm sclerenchyma sheath.

Bundle sheaths; as for group B. Central ground tissue; as for group B; inner sclerenchyma sheath present in 199 only.

Silica; present as (i) spheroidal-nodular bodies in stigmata in outer layer of culm sclerenchyma sheath; (ii) irregular, granular inclusions in some hair-cells. Tannin; none seen.

Leaf, rhizome; see group B generic description.

L. spathaceus R.Br.

Culm diameter: 1,1.2 mm.

Card characters: 3,5c,7,9,12,19,20,21,22,26,27,28,29,31,45,  
47,48,49,50,51,52,54,55,56,60,63,64,69,71,  
428 73,74,81,88,110,112,115,117,124.  
3,5c,7,9,12,19,21,22,26,27,28,31,46,47,48,  
49,50,52,54,55,56,60,63,64,68,110,112,114,  
1053 (Basal) 115,124.

Culm surface

Hairs; of group B type (i). Epidermal cells; mostly 4- or 6-sided, some 5-sided, as long as or up to twice as long as wide, those over pillar cells about 3 times longer and  $1\frac{1}{2}$  times wider than other cells; cells at ends of stoma rounded, as long as wide, with thick walls; walls of other cells slightly to moderately thickened, wavy. Stomata; subsidiary cells of type (xviii), but long anticlinal walls irregularly wavy at culm surface; guard cells of type (x). Tannin; present in some epidermal cells. Cuticular marks;

granular, with longitudinal striations.

Culm T.S.

Outline; rounded. Cuticle; ridged. Hairs; see above. Epidermal cells; 4-sided; those above pillar cells about  $1\frac{1}{2}$  times wider and higher than others in 428; all cells more or less square or slightly wider than high; outer walls thick, straight in smaller cells, convex in larger cells; other walls thin. Stomata; superficial; subsidiary cells of type (i); guard cells without pronounced lips or ridges; lumina of type (4b). Chlorenchyma; as for group B, 3-layered, cells 2-3 times higher than wide, with few, small pegs on side walls. Parenchyma sheath; as for group B; pillar cells 4-5 times higher than wide, walls slightly thickened (1053) or slightly to moderately thickened (428).

Sclerenchyma sheath; 4-5-layered, fibres of outer 3-4 layers very thick-walled, narrow, those of inner layers wider with moderately thickened walls, otherwise as for group B.

Vascular bundles: (i) peripheral; each with 1 or 2 wide tracheids on either flank of arc of narrower ones; (ii) medullary; outline tangentially oval; mx. vessels rounded-angular, with moderately thickened walls; phloem ensheathed; most bundles free from culm sclerenchyma sheath, otherwise as for group B. Bundle sheaths, central ground tissue; as for group B, inner sclerenchyma sheath present. Silica; spheroidal-nodular bodies present in stegmata in outer layer of culm sclerenchyma sheath. Tannin; present in some epidermal cells.

Leaf T.S.; see group B generic description.



L. tenax (Labill.) R.Br. Culm diameter: 0.8 - 1.4 mm.

Card characters: 2b, 5b, 7, 9, 14, 19, 21, 26, 27, 28, 30, 31, 34, 44, 48, 49, 50, 51, 52, 55, 56, 63, 64, 68, 110, 112, 113, 114, 115, 117, 124.  
 Rodway 334 2b, 5b, 7, 9, 12, 19, 20, 21, 31, 42, 44, 45, 47, 48, 49, 50,  
 Cheadle 51, 52, 63, 64, 68, 71, 72, 78, 86, 93, 100, 104, 105,  
 CA94 (no L.S.) 106, 110, 111, 114, 117, 124.  
 2b, 5b, 7, 9, 14, 19, 21, 26, 27, 28, 31, 36, 44, 48, 49,  
 50, 51, 52, 55, 56, 58, 63, 64, 68, 73, 74, 77, 81, 110,  
 Curtis 112, 115, 117, 124.  
 2b, 5b, 7, 9, 14, 20, 22, 26, 27, 28, 31, 44, 47, 48, 49,  
 50, 51, 52, 55, 56, 58, 63, 64, 68, 110, 112, 114, 115,  
 Drummond 124.  
 2b, 5b, 7, 9, 14, 20, 22, 26, 27, 28, 31, 42, 45, 47, 48,  
 49, 50, 51, 52, 55, 58, 68, 71, 73, 74, 81, 88, 110, 112,  
 Hubbard 2631 115, 124.  
 2b, 5b, 7, 9, 14, 19, 20, 21, 22, 24, 26, 27, 28, 30, 31,  
 Mair & 42, 44, 47, 48, 49, 50, 51, 52, 55, 56, 58, 63, 64, 68,  
 Constable 110, 112, 114, 115, 124.

Culm surface

Hairs; as for group B type (ii). Epidermal cells; mostly hexagonal, as long as to twice as long as wide, those flanking stomata often about 3 times longer than wide, those at ends of stomata frequently about twice as wide as long; walls moderately thickened, not wavy. Stomata; subsidiary cells of types (xiv) and (xvi); guard cells of type (ix); apertures of type (ii). Tannin; present in many epidermal cells. Cuticular marks; granular, with longitudinal striations, and marked wavy lines above epidermal cell anticlinal walls.

Culm T.S.

**Figs. 28B, 29A, 30A, B**

Outline; rounded. Hairs; see above. Epidermal cells; of 2 main types: (i) between stomata; 4-sided;

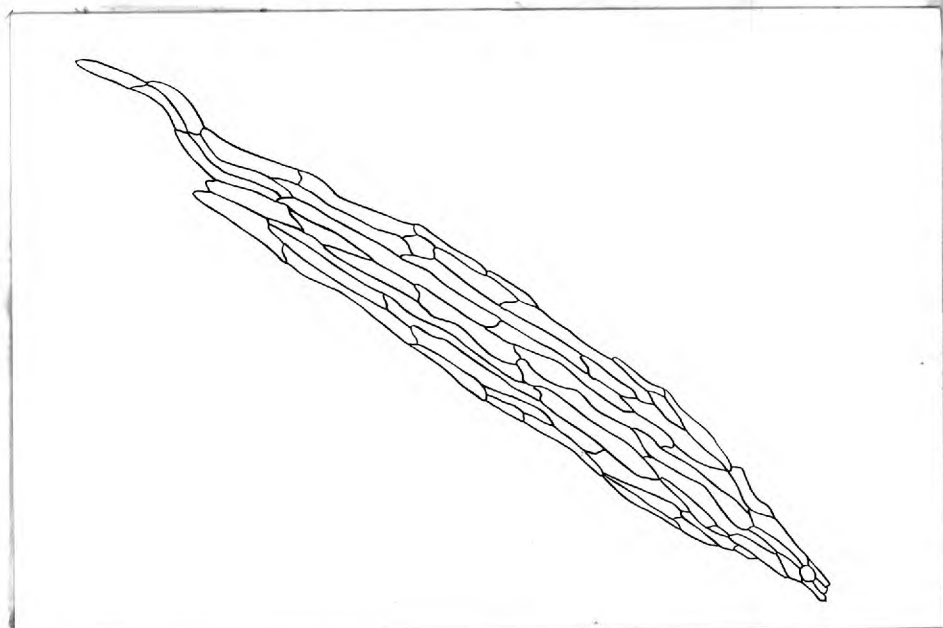
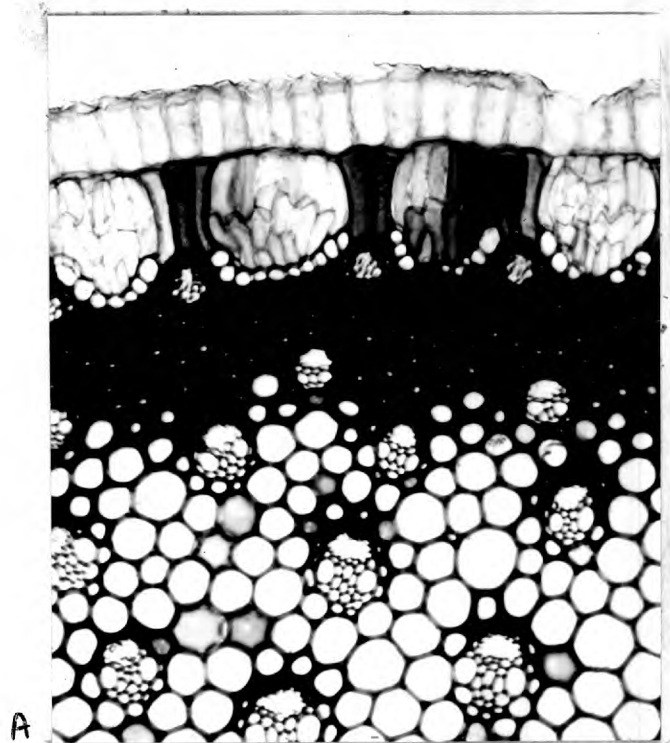


Fig. 30. *Leptocarpus tenax*, A, part of culm T.S. (x200); B, hair, surface view (x190).

-2½

mostly slightly to  $1\frac{1}{2}$  times higher than wide; outer walls moderately thickened or thick, anticlinal walls not wavy; (ii) next to stomata; 4-sided, 2-3 times wider than high, with rounded corners, about  $\frac{1}{4}$ - $\frac{1}{2}$  height of cells of type (i), walls slightly to moderately thickened; attached at one side to adjacent epidermal cells at angle between anticlinal walls, inclined inwards towards culm centre at angle of  $160^{\circ}$ - $180^{\circ}$  to culm surface and attached at other side to subsidiary cell of stoma (see fig. 29A). Stomata; deeply sunken; subsidiary cells of types (h) or (n); guard cells with slight ridge on inner wall (9); lumina of type (4a). Chlorenchyma; as for group B, but with air-cavity opposite stomata; those cells surrounding substomatal cavity with few, long pegs, remaining cells with few, short pegs. Parenchyma sheath; as for group B. Sclerenchyma sheath; as for group B; fibres in 6-12 layers, those of outer 5-9 layers very thick-walled with narrow lumina, those of inner layers wider, walls very thick, lumina wider. Vascular bundles; as for group B; phloem ensheathed; some inner bundles free from culm sclerenchyma sheath. Bundle sheaths, central ground tissue; as for group B; no inner sclerenchyma sheath. Silica; spheroidal-nodular bodies present in stigmata in parenchyma sheath. Tannin; present in many epidermal cells. Leaf, rhizome, root; see group B generic description. (Fig. 29B)

Lepyrodia R.Br.Generic description

The genus is divided into 3 groups for clarity of description.

Group I

L. caudata L. Johnson + O.Evans, L. gracilis R.Br., L. interrupta F. Muell., L. stricta R.Br., and L. tasmanica Hk.f.

Culm surface

Hairs, papillae; absent. Epidermal cells; square, rectangular or hexagonal, as long as wide or up to twice as long as wide; walls moderately thick or thick, wavy or only wavy at surface but straight at slightly lower focus; lumina rectangular, rounded or oval. Stomata; subsidiary cells of types (xiii) and (xviii), as long as guard cells in all spp. but, L. tasmanica, where slightly longer; guard cells of type (ix); apertures of type (ii). Silica; granular, filling entire lumen of some epidermal cells in L. stricta, and present to a lesser extent in L. tasmanica and L. caudata. Crystals; absent. Tannin; seen only in some cells of L. caudata. Cuticular marks; granular; with straight or slightly wavy longitudinal striations in all species except L. tasmanica.

Culm T.S.

Outline; round or oval, or with slight mounds (L. tasmanica). Cuticle; thick, frequently with slight ridges. Epidermal cells; in 1 layer, cells 4-sided, mostly as high as to  $1\frac{1}{2}$ -2 times higher than wide, those next to stomata often higher (up to 4 times higher than wide in L. caudata), projecting into chlorenchyma. Outer walls thick or very thick,

outer surface concave in L. stricta and L. caudata; anticlinal walls wavy, moderately thickened or thick at outer ends, thickening tapering rapidly and inner halves of walls and inner walls slightly or moderately thickened. Stomata; superficial; subsidiary cells of types (a) or (f); guard cells with outer lips (5a) in all species, inner lips (8) present in L. caudata, with ridge on inner wall in L. interrupta; lumina of type (3). Chlorenchyma; composed of palisade cells with occasional pegs; cells arranged in 2 layers, or, very occasionally, in 3-4 layers; adjacent cells separated from one another by air-spaces equivalent to slightly less than their width; cells of inner and outer layers shortly interdigitating (cells arranged in longitudinal, 1-layered plates as seen in T.L.S.). Protective cells moderately thick-walled, extending in 2-3-layers from epidermis to parenchyma sheath, those of outer layer frequently twice as long as those of other layers; as seen in T.L.S., walls of substomatal tube lined by 1-3 layers of protective cells at either end of stoma and 1-5 layers on flanks, substomatal tubes of adjacent stomata frequently touching. Apertures between protective cells of 2 types: (i) small, rounded, at junctions between inner and outer cell layers; (ii) narrow, elongated, between cells of inner layers. Parenchyma sheath; 1-3-layered, continuous, cells rounded hexagonal, with slightly thickened walls. Sclerenchyma sheath; 2-8-layered; outline rounded, with low, dome-shaped ridges opposite to pvbs. Fibres of outer 2-5 layers thick- to very thick-walled, except when to outer side of pvbs. where moderately thick-walled, all narrow; those of inner layers

wider, with wider lumina. Vascular bundles: (i) peripheral; tangentially oval in outline, each with 1 medium-sized angular, thin-walled tracheid on either flank, and 2-3 narrow (or, infrequently, medium-sized) tracheids in 1 or 2-3 layers between them; phloem pole tangentially oval; (ii) medullary; outer smaller than inner, frequently with 1 central mx. vessel and without px. poles; inner bundles with 1 wide, many-sided, thin-walled vessel on either flank, these separated by 1-3 files of narrow parenchymatous cells; mx. vessels with scalariform wall pitting and oblique, scalariform or transverse, simple perforation plates; phloem pole overarching and abutting directly onto xylem; px. present in most larger bundles; most medullary bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous, poorly developed, 1-(2)-layered; fibres at poles narrow, with moderately thick to thick walls, those on flanks wider, with slightly to moderately thickened walls. Central ground tissue; parenchymatous; cells surrounding vascular bundles with slightly to moderately thickened (lignified) walls, those of inner layers free from bundles wider, with cellulose wall-thickening, innermost cells breaking down to form central cavity. Silica; present in epidermal cells of some species as amorphous material. Crystals; absent. Tannin; present in some mx. vessels of L. stricta (possibly pathological). Leaf, rhizome and root not seen.

Group II(a)

L. anarthria F. Muell. ex Benth., L. drummondiana Steud., L. flexuosa (Benth.) L. Johnson & O. Evans,

L. hamaphrodita R.Br., L. leptocaulis L. Johnson & O. Evans, L. macra Nees, L. monoica F. Muell., L. monoica var. foliosa F. Muell., L. muelleri Benth., L. muirii F. Muell., L. scariosa R.Br., and L. valliculata J.M. Black.

Culm surface

Hairs, papillae; absent. Epidermal cells; 4-sided, most frequently as long as wide, occasionally  $1\frac{1}{2}$ -2 times longer than wide and sometimes  $1\frac{1}{2}$  times wider than long; walls slightly - moderately thickened, wavy. Stomata; subsidiary cells of types (xv), (xvi), (xi) and (xii); guard cells of types (ix) and (x); apertures of type (ii). Silica; present as solitary, spheroidal-nodular bodies in specialised cells; cells as long as wide with thick anticlinal walls, either solitary or arranged in longitudinal files of up to 5. Tannin; present in some epidermal cells. Cuticular marks; granular; often with longitudinal striations.

Culm T.S.

Outline; round or oval. Cuticle; slightly to moderately thickened, often with small ridges. Epidermal cells; in 1 layer, cells 4-sided, as high as wide or slightly higher than wide; occasionally  $1\frac{1}{2}$  times higher than wide; outer walls moderately thickened to thick, curving inwards slightly at cell margins; anticlinal walls moderately thickened, wavy, characteristically with few, conspicuous undulations; inner walls moderately thickened. Some cells modified, with <sup>very</sup> thick inner and anticlinal walls and thin or slightly thickened outer walls, each cell containing 1 spheroidal-nodular silica body. Stomata; superficial (slightly sunken in

L. muirii); subsidiary cells of types (e), (f), (i) or (1) (if of type (1), often with slight ridge on outer wall); guard cells with pronounced, beak-like lips at outer aperture (5b); lumina of type (3). Chlorenchyma; composed of 2 dissimilar layers of peg-cells; those of outer layer about 8 times higher than wide, with numerous, small pegs arranged in 4-6 longitudinal files; cells of inner layer frequently 2-3 times wider than, and only  $\frac{3}{4}$  height of outer cells, individual cells normally 2-3 times higher than wide and having 4-6 longitudinal files of 3-4 wide pegs; air-spaces between cells of inner layer much wider than those between cells of outer layer. Cells arranged in reticulate manner as seen in T.L.S. Protective cells present in some species as little modified cells of outer chlorenchyma layer, with slightly thickened walls; substomatal tube opening to chlorenchyma, near its inner end, by rounded apertures; walls of substomatal tube consisting of 1 layer of protective cells as seen in T.L.S. Parenchyma sheath; 1-3-layered, uninterrupted, cells up to twice as high as wide, walls normally slightly thickened. Sclerenchyma sheath; 3-9-layered, outline rounded with slight, dome-shaped ridges opposite to pvbs.; fibres of outer 2-7 layers thick- or very thick-walled, narrow, those of inner layers wider, with moderately thickened walls; innermost layer difficult to distinguish from central ground tissue. Vascular bundles: (i) peripheral; outline more or less rounded, all tracheids narrow, or with 1 or 2 medium-sized, angular, thin-walled tracheids on either flank of arc of narrow tracheids; phloem



pole rounded, situated in concavity of arc; (ii) medullary; outer bundles smaller, with no px., inner bundles round or radially oval in outline, each with 1 narrow or medium-sized, angular mx. vessel on either flank, mx. vessels separated by 2-3 rows of narrow cells; vessel wall pitting scalariform, perforation plates oblique, scalariform; phloem poles rounded, separated from xylem by single layer of narrow cells with slightly thickened walls or with thin walls next to phloem, and slightly thickened walls next to xylem; px. poles well developed; many bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous; fibres at bundle poles narrow, thick-walled, normally in 1-2 layers; those on flanks wider, with moderately thickened walls, in 1 layer. Central ground tissue; parenchymatous; cells surrounding vascular bundles with moderately thickened walls, central cells thin-walled, frequently breaking down to form central cavity. Silica; present as spheroidal-nodular bodies as described in some epidermal cells, and as granular material in some cells of central ground tissue. Tannin; present in some epidermal cells.

Leaf; seen only in L. scariosa R.Br.

Leaf surface

(abaxial)

Hairs; absent. Epidermal cells; hexagonal, 2-3 times wider than long, transverse walls wide, longitudinal walls composed of 2 short sides; all walls very thick, slightly wavy. Stomata; sparse; subsidiary cells of types (xii) and (xviii), most longer than guard cells; guard cells of type (x); apertures of type (ii). Silica; solitary,

spheroidal-nodular bodies present in many cells. Tannin; none seen.

Leaf T.S.

Epidermal cells; (i) abaxial;  $1\frac{1}{2}$  times higher than wide, all walls thick, anticlinal walls very wavy; (ii) adaxial; not seen. Stomata; superficial; subsidiary cells of type (i); guard cells with lips at outer aperture (7b) and ridge on inner wall (9). Chlorenchyma; composed of 1 layer of peg-cells to inside of abaxial epidermis; cells 4-5 times higher than wide; other, more or less isodiametric cells with pegs (possibly chlorenchyma) present in 1-2 layers between palisade chlorenchyma and parenchymatous ground tissue. Vascular bundles; each with 1-2 wide, angular thin-walled tracheids on either flank, large bundles also with several narrow, central tracheids; phloem poles rounded, ensheathed by 1 layer of narrow cells with thin walls next to phloem and thick walls next to xylem. Bundle sheaths; O.S. parenchymatous, 1-2-layered, extending over phloem pole and round flanks, but not round xylem pole; O.S. extended laterally and forming layer between adjacent bundles; I.S. sclerenchymatous, completely encircling bundles; fibres narrow, thick-walled, in 1-2 layers; I.S. continuous laterally with 1-2 layers of fibres lying to adaxial side of parenchyma sheath extensions. Sclerenchyma; present as described above. Ground tissue; parenchymatous, comprising: (a) that of bundle sheath extensions, (b) 1-2 layers of thin-walled, flattened cells between sclerenchyma and adaxial epidermis. Air-cavities; absent. Silica; see abaxial epidermis,

surface view. Crystals, tannin; none seen.

Rhizome T.S.; seen in L. muirii and L. scariosa.

Epidermal cells; 4-5-sided, slightly wider than high, narrow; walls slightly thickened. Outer cortex; composed of 3 layers of moderately thick-walled, hexagonal cells in L. muirii and 6-7 layers of hexagonal cells with slightly thickened walls in L. scariosa. Inner cortex; cells parenchymatous; hexagonal, thin-walled in outer 4-5 layers and rounded in inner 7-8 layers in L. muirii, and hexagonal, very thin-walled, in 6-8 layers in L. scariosa; innermost 1-2 layers in both species hexagonal, with slightly thickened walls. Endodermoid sheath; 1-layered; cells with thin outer walls and slightly thickened inner and anticlinal walls in L. scariosa, and with thin outer walls but other walls thick in L. muirii. Vascular bundles; outer bundles with arc of mx. vessels and rounded phloem pole; inner bundles concentric, those of L. muirii with several layers of narrow mx. vessels, L. scariosa with 1 (2) layer(s) of wide, angular mx. vessels. Central ground tissue; composed of thick-walled sclerenchymatous cells surrounding vascular bundles in L. muirii, parenchymatous, cells with moderately thickened walls in L. scariosa; some thin-walled cells present in lacunae in both species. Silica, crystals, tannin; none seen.

Root T.S.; seen in L. muirii only.

Epidermis and root hairs; not seen. Outer cortex; consisting of 2 outer layers of rectangular, thin-walled cells each about  $1\frac{1}{2}$  times wider than high, followed to inside by

1-2 layers of similar cells with slightly thickened walls. Middle cortex; composed of single-layered, radiating plates of rounded cells, 6-8 cells deep, with wider cells between them. Inner cortex; 2-3-layered, cells mainly  $1\frac{1}{2}$  times wider than high, with rounded corners and intercellular spaces. Endodermis; mostly 1-, occasionally 2-layered, cells nearly square, outer walls thin, inner and anticlinal walls heavily thickened; lumina very reduced. Pericycle; 1-layered, cells narrow, hexagonal, walls moderately thickened. Vascular system; phloem strands alternating with px. poles in 1 ring to inner side of pericycle; mx. vessels mostly in 1 ring to inside of that formed by phloem and px., vessels solitary or in radial pairs, oval-angular. Central ground tissue; sclerenchymatous, cells hexagonal, thick-walled. Silica, tannin; none seen.

#### Group IIb

L. glauca F. Muell. and L. heleocharoides Gilg.

Similar in most respects to group IIa, except:

#### Culm surface

Stomata; subsidiary cells; wall next to anticlinal wall of guard cell produced into 2 short papillae extending over guard cell.

#### Culm T.S.

Chlorenchyma; composed of 1 layer of palisade peg-cells; individual cells about 6 times higher than wide, with numerous pegs; protective cells seen only in L. glauca. Parenchyma sheath; 1-layered.

Group IIIL. anaectocolea F. Muell.Culm surface

Epidermal cells; rectangular, mostly between 2-4 times longer than wide; walls moderately thickened, wavy. Stomata; subsidiary cells of types (xi) and (xii); guard cells of type (viib); apertures of type (ii). Silica; none seen. Tannin; present in some epidermal cells. Cuticular marks; granular.

Culm T.S.

Outline; semi-circular. Cuticle; moderately thickened. Epidermal cells; in 1 layer, cells 4-sided, slightly to  $1\frac{1}{2}$  times higher than wide; cells bordering stomata with papillae overarching stomata; outer walls very thick, other walls slightly thickened. Stomata; sunken, mounted low down on anticlinal walls of epidermal cells; subsidiary cells similar to type (c), but inner wall deeply concave; guard cells with walls to pore of type (12); lumina of type (1). Chlorenchyma; mainly 3-layered, peg-cells between as high as to  $2\frac{1}{2}$  times higher than wide; no protective cells present. Parenchyma sheath; 1-2-layered, cells 6-sided, rounded; some oval and nearly twice size of smallest cells. Sclerenchyma sheath; 8-10-layered, outline rounded, with low, dome-shaped ridges opposite to pvbs.; fibres of outer layers narrow, those of inner layers wider; walls very thick; innermost layer difficult to distinguish from central ground tissue.

Vascular bundles: (i) peripheral; outline tangentially oval; tracheids narrow, forming 2-layered arc partially enclosing phloem pole; (ii) medullary; outline tangentially oval;

outer bundles small, without px.; inner bundles with 1 medium-sized to wide, angular mx. vessel on either flank, these separated by 6-10 layers of narrow cells; phloem poles tangentially oval, separated from xylem by 1-4 rows of narrow cells with slightly thickened walls; px. present; some of inner bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous; fibres narrow, moderately thick-to thick-walled, in 2-3 layers at poles; those on flanks wider, in 1 layer, with moderately thickened walls. Central ground tissue; parenchymatous; composed of matrix of thick-walled cells with lacunae of thin-walled cells. Silica, crystals; none seen. Tannin; present in some epidermal cells.

Leaf surface; not seen.

Leaf T.S.

Epidermis; (i) abaxial; cells similar to those of culm surface; (ii) adaxial; cells flattened, 4-5 times wider than high, walls slightly thickened. Stomata; superficial, otherwise similar to those of culm. Chlorenchyma; cells more or less isodiametric, with pegs; present in 1-2 layers next to abaxial epidermis. Vascular bundles; largest with group of 6-8 narrow tracheids at xylem pole and phloem pole composed of 25-30 cells; smallest with 1-3 narrow tracheids and with 4-5 phloem cells; intermediate sizes present, but larger and smaller bundles normally alternating. Bundle sheaths; O.S. parenchymatous, present as 1-layered caps at phloem poles only, but with lateral extensions forming 1-layered sheet between bundles, next to chlorenchyma; I.S.

sclerenchymatous, fibres in 1-2 layers at poles, continuous on flanks with ground sclerenchyma. Sclerenchyma; present in 3-4 layers between vascular bundles, and in bundle sheaths; fibres narrow, thick-walled. Ground tissue; composed of 2 layers of narrow, thin-walled parenchymatous cells present between sclerenchyma and adaxial epidermis. Air-cavities; absent. Silica, crystals, tannin; none seen.

Material examined

Group I

- |                                       |  |           |
|---------------------------------------|--|-----------|
| L. caudata L. Johnson<br>and O. Evans | No number Aust.                                | 2056 (K)  |
| L. gracilis R.Br.                     | Forsyth W., Kneucker<br>distrib. no.117, Aust. | 20515 (K) |
| L. interrupta F.Muell.                | Hubbard, C.E. 3904, An.<br>1930 Aust.          | 2052 (K)  |
| L. tasmanica Hk.f.                    | Rodway 2480 Tasman.                            | 20514 (K) |

Group IIa

- |   |  |                      |
|---|--|----------------------|
| L. <del>anarthria</del> <sup>anarthria</sup> F. Muell.<br>ex Benth. | Johnson & Constable<br>17760 An. 1951 Aust.              | 20516 (K)            |
| L. drummondiana Steud.  | Drummond 347 Aust.                                       | 20518 (K)            |
| L. flexuosa (Benth.)<br>L. Johnson & O. Evans                       | Sutton 847, An.1904<br>Grampians, Aust.                  | 2053 (K)             |
| L. hermaphrodita R.Br.  | Andrews 1st coln. 1080,<br>An.1902 Aust.                 | 20513 (K)            |
| L. leptocaulis L. Johnson<br>& O. Evans                             | Constable, E.F. N.S.W.<br>56903, An. 1962 Aust.          | 31101A(K)            |
| L. macra Nees   | Drummond No number<br>Swan R., W. Aust.                  | 20510 (K)            |
| L. monoica F.Muell.<br>" var. foliosa F.Muell.                      | Drummond 447 Aust.<br>Mueller, F.<br>An. 1876 Porongerup | 2055 (K)<br>3721 (K) |
| L. muelleri Benth.  | Constable 22088, An.1953,<br>Hat Head, N.S.W., Aust.     | 20517 (K)            |
| L. muirii F.Muell.  | Blake, S.T., 18039, An.1947<br>Kirup, S.W.Div., Aust.    | 20512 (K)            |





higher than wide, those next to stomata projecting further into chlorenchyma, being  $2\frac{1}{2}$ -4 times higher than wide. Outer walls thick, occasionally with shallow depressions, outer surface irregular; anticlinal walls moderately thickened, very wavy; inner walls slightly to moderately thickened. Stomata; superficial; subsidiary cells of type (a); guard cells with lips at outer and inner apertures (5a), (8); lumina of type (3). Chlorenchyma, parenchyma sheath; as for group I. Sclerenchyma sheath; mainly 4-layered, fibres of outer 2 layers thick-walled, those of inner layers moderately thick-walled. Vascular bundles, bundle sheaths, central ground tissue; as for group I. Silica; granular, present in occasional epidermal cells. Tannin; present in occasional epidermal cells.

L. gracilis R.Br.

Culm diameter: 1.0 mm.

Card characters: 2c, 3, 5c, 7, 9, 15, 18, 21, 26, 31, 37, 44, 47, 48, 50, 51, 52, 54, 57a, 58a, 68, 110, 112, 114, 115, 118, 121, 124.

Culm surface

Epidermal cells; 4-sided, as long as to twice as long as wide, the shorter cells frequently next to stomata; walls thick, wavy at surface, straight at slightly lower focus.

Stomata; subsidiary cells of type (xiii); guard cells of type (ix), apertures of type (ii). Silica, tannin; absent.

Cuticular marks; granular, with slight longitudinal striations.

Culm T.S.

Outline; round. Epidermal cells; mostly as high as to  $1\frac{1}{2}$  times higher than wide, those next to stomata twice as

high as wide, projecting into chlorenchyma. Stomata; superficial; subsidiary cells of type (a); guard cells with outer lips (5a); lumina of type (3). Chlorenchyma, parenchyma sheath; as for group I. Sclerenchyma sheath; 7-8-layered, fibres of outer 4-5 layers very thick-walled, those of inner layers wider, with moderately thick to thick walls. Vascular bundles, bundle sheaths and central ground tissue; as for group I. Silica, tannin; none seen.

L. interrupta F. Muell.

Culm diameter: 1 by 0.75 mm.

Card characters: 2c, 3, 5b, 5c, 7, 9, 14, 19, 22, 25, 27, 28, 29, 31, 34, 37, 44, 48, 50, 51, 52, 54, 55, 56, 58b, 70a, 112, 114, 115, 118, 121, 124.

Culm surface

Epidermal cells; hexagonal, mostly about as long as wide, walls slightly to moderately thickened, wavy at surface, straight at slightly lower focus. Stomata; subsidiary cells of type (xiii); guard cells of type (ix); apertures of type (ii). Cuticular marks; fine, slightly wavy, longitudinal striations.

Culm T.S.

Outline; oval. Epidermal cells; mostly slightly or  $1\frac{1}{2}$  times higher than wide; those next to stomata often twice as high as wide. Outer walls moderately thickened, occasionally with shallow, irregular depressions in outer surface; anticlinal walls slightly to moderately thickened, sometimes wavy; inner walls slightly to moderately thickened. Stomata; superficial; subsidiary cells of type (a); guard cells with lips at outer aperture (5a) and very slight ridge

on inner wall (9); lumina of type (3). Chlorenchyma, parenchyma sheath; as for group I. Sclerenchyma sheath; 5-6-layered, fibres of outer 2-3 layers very thick-walled, those of inner layers with moderately thickened walls. Vascular bundles: (i) peripheral; as for group I; (ii) medullary; as for group I, but flanking mx. vessels of inner bundles medium-sized. Bundle sheaths; fibres wide, with slightly to moderately thickened walls, in 1 layer. Central ground tissue; parenchymatous, all cells thin-walled. Silica, tannin; none seen.

L. tasmanica Hook.f.

Culm diameter: 0.8 mm.

Card characters: 2c, 5b, 5c, 6, 7, 9, 14, 20, 22, 23, 26, 31, 36, 37, 44, 47, 48, 50, 51, 52, 54, 55, 56, 57c, 60, 68, 86, 110, 112, 114, 115, 118, 121, 124.

Culm surface

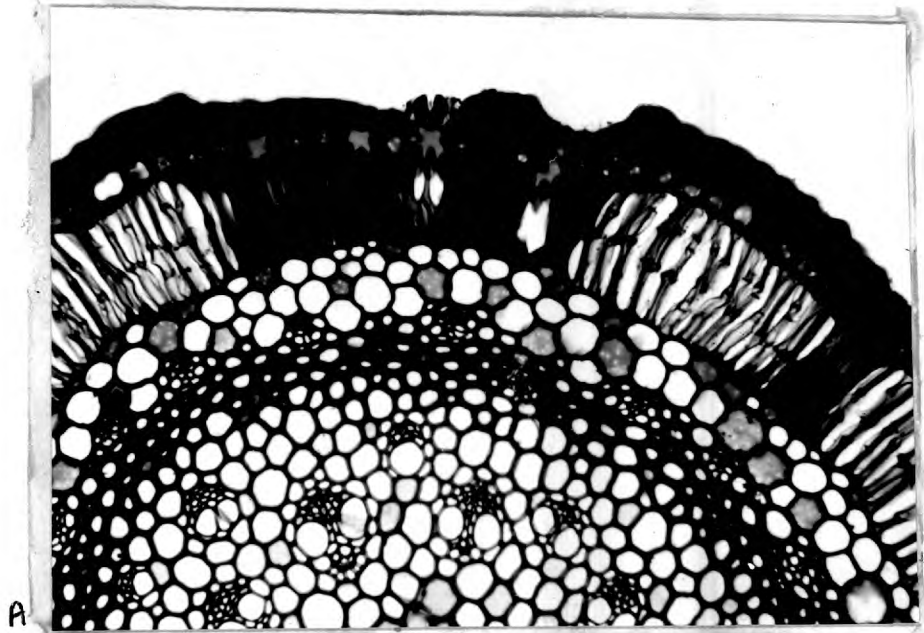
Fig. 32F

Epidermal cells; those next to stomata mostly as long as wide, others up to twice as long as wide; walls moderately thickened, wavy. Stomata; subsidiary cells frequently longer than guard cells, nearest to type (xii), but with slightly expanded ends; guard cells of type (ix); apertures of type (ii). Silica; granular to spheroidal-nodular, present in some epidermal cells. Tannin; none seen.

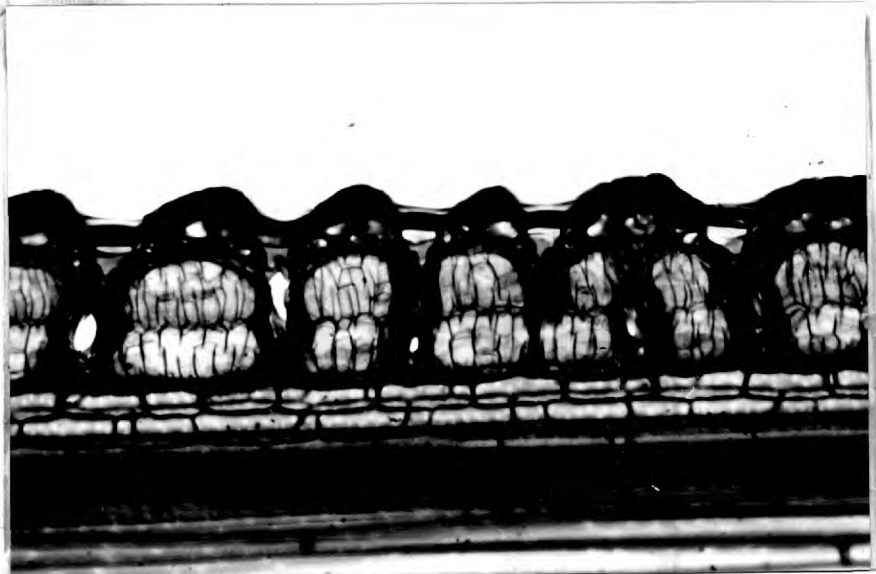
Culm T.S.

Figs. 31A, B, 32E

Outline; rounded, with slight mounds. Epidermal cells; ranging from  $1\frac{1}{2}$ - $2\frac{1}{2}$  times higher than wide; those next to stomata frequently extending further into chlorenchyma than others, those between stomata frequently extended outwards and forming low mounds. Outer walls very thick; anticlinal



A



B

Fig. 31. *Lepyrodia tasmanica*. A, part of culm T.S.;  
B, part of culm L.S. (x200).

walls very wavy, thick at outer ends, thickening tapering rapidly and inner halves of walls moderately thickened; inner walls moderately thickened. Stomata; superficial; subsidiary cells of type (f); guard cells with lips at outer and inner apertures (5a), (8); lumina of type (3). Chlorenchyma, parenchyma sheath; as for group I. Sclerenchyma sheath; 4-5-layered, walls of fibres moderately thickened to thick, inner fibres difficult to distinguish from cells of central ground tissue. Vascular bundles: (i) peripheral; as for group I; (ii) medullary; as for group I, outline of inner bundles round, flanking mx. vessels wide, angular. Bundle sheaths, central ground tissue; as for group I. Silica; present in some epidermal cells.

#### Group IIa

L. anarthria F. Muell. ex Benth. Culm diameter: 0.8 mm.

Card characters: 2b, 5b, 7, 9, 14, 20, 22, 26, 31, 37, 42, 44, 47, 48, 49, 50, 51, 52, 54, 55, 56, 60, 68, 86, 110, 112, 114, 115, 118, 121, 124.

#### Culm surface

Epidermal cells; as long as to up to twice <sup>or five times</sup> as long as wide, shorter cells next to stomata; walls moderately thickened, wavy. Stomata; subsidiary cells of types (xi) and (xii) <sup>but with wavy anticlinal walls</sup>; guard cells of type (ix); apertures of type (ii).

Silica; as for group IIa. Tannin; present in some epidermal cells.

#### Culm T.S.

Outline; round. Epidermal cells; slightly higher than wide, outer walls slightly to moderately thickened, other

walls thin to slightly thickened, otherwise as for group IIa. Stomata; subsidiary cells of type (i), otherwise as for group IIa. Chlorenchyma, parenchyma sheath; as for group IIa. Sclerenchyma sheath; 3-4-layered, walls of outer 2-3 layers thick. Vascular bundles, bundle sheaths; as for group IIa. Central ground tissue; as for group IIa but without central cavity. Silica; present as: (i) spheroidal-nodular bodies in some epidermal cells; (ii) granular material in some cells of central ground tissue. Tannin; present in some epidermal cells.

L. drummondiana Steud.

Culm diameter: 0.1 mm.

Card characters: 2b, 5b, 5c, 7, 9, 14, 19, 21, 22, 23, 26, 27, 28, 31, 42, 44, 45, 47, 49, 50, 51, 52, 54, 55, 56, 57c, 60, 68, 86, 112, 114, 115, 117, 121, 124.

#### Culm surface

Epidermal cells; mostly slightly wider than long, some nearly as wide as long; walls moderately thickened, very wavy. Stomata; subsidiary cells of type (xvi); guard cells of type (ix). Silica; as for group IIa. Tannin; present in some epidermal cells. Cuticular marks; finely granular; occasional fine, longitudinal striations also present.

#### Culm T.S.

Outline; round. Epidermal cells; about  $1\frac{1}{2}$  times higher than wide, all walls moderately thickened, otherwise as for group IIa. Chlorenchyma; as for group IIa, but with 1 or 2 inner layers; protective cells absent.

Parenchyma sheath; as for group IIa. Sclerenchyma sheath; 8-9-layered; fibres of outer 6-7 layers with very thick walls, others thick-walled. Vascular bundles, bundle sheaths,

central ground tissue; as for group IIa. Silica; as for group IIa, present in few epidermal cells. Tannin; present in some epidermal cells.

L. flexuosa (Benth.) L. Johnson & O. Evans

Culm diameter: 0.8 mm.

Card characters; 2a, 2c, 5b, 5c, 7, 9, 14, 20, 22, 24, 26, 27, 28, 31, 37, 42, 44, 47, 48, 49, 50, 51, 52, 54, 55, 56, 60b, 68, 86, 112, 114, 115, 118, 121, 124.

Culm surface

Epidermal cells; mostly as long as wide, some, particularly those next to stomata, slightly wider than long; walls moderately thickened, wavy. Stomata; subsidiary cells of type (xviii), but long anticlinal walls slightly wavy at high focus; guard cells of type (x); apertures of type (ii). Silica; as for group IIa. Tannin; none seen. Cuticular marks; granular, slight longitudinal striations present, particularly over transverse walls.

Culm T.S.

Outline; round. Epidermal cells; about  $1\frac{1}{2}$  times higher than wide, as for group IIa. Stomata; superficial; subsidiary cells of type (e), but with ridge on outer walls; guard cells and lumina as for group IIa. Chlorenchyma; cells of inner layer  $\frac{3}{4}$  of height of, or as high as, outer cells; protective cells with slightly thickened walls, often containing irregularly shaped silica bodies. Parenchyma sheath; as for group IIa. Sclerenchyma sheath; 2-3-layered; fibres thick-walled. Vascular bundles; as for group IIa, except: perforation plates scalariform fenestrate; flanking mx. vessels of inner bundles medium-sized; no

bundles free from culm sclerenchyma sheath. Bundle sheaths, central ground tissue; as for group IIa. Silica; present: (i) in some cells of epidermis; (ii) as irregular bodies in many protective cells; (iii) in some cells of parenchyma sheath; several small, irregular bodies per cell.

L. hermaphrodita R.Br.

Culm diameter: 0.6 mm.

Card characters: 2b, 5b, 5c, 7, 9, 14, 20, 22, 23, 26, 27, 28, 31, 42, 44, 49, 50, 51, 52, 54, 55, 60b, 68, 86, 112, 114, 115, 117, 118, 121, 124.

#### Culm surface

Epidermal cells; mostly as wide as long, walls slightly thickened, wavy. Stomata; subsidiary cells of type (xviii), but long anticlinal wall of many cells slightly concave; guard cells of type (ix), but long anticlinal wall with 3 faces; apertures wide, of type (ii). Silica; as for group IIa. Tannin; present in few epidermal cells. Cuticular marks; slight longitudinal striations.

#### Culm T.S.

Outline; round. Epidermal cells; about  $1\frac{1}{2}$  times higher than wide, outer walls moderately thickened to thick, other walls thin, otherwise as for group IIa. Stomata; superficial; subsidiary cells of type (f); guard cells with outer lips (5b) and slight ridge on inner walls (9). Chlorenchyma; as for group IIa, but protective cells thin-walled, with wide, rounded apertures at their junction with cells of inner chlorenchyma layer. Parenchyma sheath; as for group IIa. Sclerenchyma sheath; 2-3-layered, fibres moderately thick-walled; those next to phloem poles of larger bundles narrowest, with thick walls. Vascular bundles;



as for group IIa, but flanking mx. vessels of inner bundles narrow to medium-sized; no bundles free from culm sclerenchyma sheath. Bundle sheaths, central ground tissue, silica; as for group IIa. Tannin; present in few epidermal cells.

L. leptocaulis L. Johnson & O. Evans Culm diameter: 0.4 mm.  
Card characters: 2b, 5b, 7, 9, 14, 20, 22, 26, 27, 28, 31, 37, 42, 44, 47, 48, 49, 54, 55, 56, 60b, 68, 86, 112, 114, 115, 118, 121, 124.

#### Culm surface

Epidermal cells; mostly as wide as long, those next to stomata smaller than others; walls moderately thickened, wavy. Stomata; subsidiary cells of type (xviii), long anticlinal walls slightly wavy at high focus; guard cells of type (ix); apertures of type (ii). Silica; as for group IIa. Tannin; none seen. Cuticular marks; granular, with longitudinal striations.

#### Culm T.S.

Outline; round. Cuticle; with minute ridges. Epidermal cells; as for group IIa, mostly as high as wide, outer walls moderately thickened; anticlinal walls moderately thickened at outer ends, but rapidly thinning, inner halves slightly thickened; inner walls slightly thickened. Stomata; superficial; subsidiary cells of type (f); guard cells with lips at outer aperture (5b) and slight ridge on inner wall (9); lumina of type (3). Chlorenchyma, parenchyma sheath; as for group IIa. Sclerenchyma sheath; 5-6-layered; fibres very thick-walled. Vascular bundles:

(i) peripheral; all tracheids narrow; (ii) medullary; as for group IIa, but flanking mx. vessels of inner bundles medium-sized; no bundles free from culm sclerenchyma sheath. Bundle sheaths; as for group IIa. Central ground tissue; all cells with moderately thickened walls; no central cavity. Silica; as for group IIa.

L. macra Nees

Culm diameter: 1 mm.

Card characters: 3, 5b, 7, 9, 12, 20, 22, 25, 27, 28, 30, 31, 36, 37, 42, 44, 48, 49, 50, 51, 52, 54, 55, 60b, 68, 86, 112, 114, 115, 118, 121, 124.

Culm surface

Epidermal cells; mostly as long as wide, walls moderately thickened, wavy. Stomata; subsidiary cells of type (xvi); guard cells of type (ix); apertures of type (ii). Silica; as for group IIa. Tannin; none seen. Cuticular marks; pronounced longitudinal striations.

Culm T.S.

Outline; round. Cuticle; with slight ridges. Epidermal cells; slightly higher than wide, outer walls moderately thickened, outer surface with minute ridges; other walls slightly to moderately thickened, otherwise as for group IIa. Stomata; superficial; subsidiary cells of type (f); guard cells with lips at outer apertures (5b); lumina of type (3). Chlorenchyma, parenchyma sheath; as for group IIa. Sclerenchyma sheath; 4-5-layered; fibres very thick-walled. Vascular bundles; as for group IIa, but outline of medullary bundles tangentially oval; flanking mx. vessels medium-sized; all bundles attached to culm sclerenchyma sheath. Bundle sheaths, central ground tissue; as for

group IIa. Silica; as for group IIa, also some granular material present in some cells of central ground tissue,

L. monoica F. Muell.

Culm diameter: 2 by 1.2 mm

Card characters: 2b, 3, 5b, 5c, 7, 9, 12, 19, 21, 25, 26, 27, 28, 30, 31, 42, 44, 49, 50, 51, 52, 54, 55, 56, 60b, 70a, 86, 112, 114, 115, 118, 121, 124.

Culm surface

Epidermal cells; as long as wide or slightly wider than long; walls moderately thick, wavy. Stomata; subsidiary cells of type (xviii); guard cells of type (ix); apertures of type (ii). Silica; as for group IIa. Tannin; none seen. Cuticular marks; longitudinal striations.

Culm T.S.

Outline; oval. Cuticle; with marked ridges.

Epidermal cells; mostly as wide as high, all walls moderately thickened, otherwise as for group IIa. Stomata; superficial; subsidiary cells of type (f); guard cells with lips at outer aperture (5b); lumina of type (3). Chlorenchyma; as for group IIa, but without protective cells; cells opposite to stomata with wider air-spaces than usual. Parenchyma sheath; as for group IIa. Sclerenchyma sheath; 3-4-layered; fibres thick-walled, inner layers difficult to distinguish from central ground tissue. Vascular bundles; as for group IIa, but: (i) peripheral; all tracheids medium-sized, with thick walls; (ii) medullary; outer bundles tangentially oval, inner bundles radially oval; flanking mx. vessels of inner bundles medium-sized, moderately thick-walled, rounded; all bundles attached to culm sclerenchyma sheath. Bundle sheaths, central ground tissue,

silica; as for group IIa.

L. monoica var. foliosa F. Muell. Culm diameter: 0.7 by 0.5mm.

Card characters: 3,5b,5c,7,9,14,20,24,26,27,28,30,31,36,42,  
44,49,50,51,52,54,55,56,60b,70a,86,112,114,  
115,117,118,121,124.

Similar to L. monoica, but mx. vessels with fenestrate-scalariform perforation plates; and some pvbs. with wide flanking tracheids. Tannin; present in some epidermal cells.

L. muelleri Benth. Culm diameter: 1.5 by 1 mm.

Card characters: 2b,5b,7,9,14,19,23,26,27,28,31,36,42,44,49,  
50,51,52,54,55,56,60b,70a,86,112,114,115,  
118,121,124.

#### Culm surface

Epidermal cells; mostly as long as wide, some wider than long, particularly next to stomata; walls moderately thickened, wavy. Stomata; subsidiary cells of type (xviii); guard cells nearest to type (ix), but tending to type (x); apertures of type (ii). Silica; as for group IIa. Tannin; none seen. Cuticular marks; longitudinal striations.

#### Culm T.S.

Outline; oval. Cuticle; with small ridges. Epidermal cells; nearly  $1\frac{1}{2}$  times higher than wide, all walls slightly to moderately thickened, otherwise as for group IIa. Stomata; superficial; subsidiary cells of type (f); guard cells with lips at outer aperture (5b) and slight ridge on inner wall (9); lumina of type (3). Chlorenchyma; as for group IIa, but protective cells not developed; cells opposite to stomata with wider air-spaces between them than normal.

Parenchyma sheath; as for group IIa. Sclerenchyma sheath; 3-4-layered; fibres very thick-walled. Vascular bundles: (i) peripheral; with several narrow, thin-walled tracheids arranged in 2-layered arc; (ii) medullary; flanking mx. vessels of inner bundles medium-sized to wide, angular, perforation plates reticulate; no bundles free from culm sclerenchyma sheath; otherwise as for group IIa. Bundle sheaths, central ground tissue, silica; as for group IIa.

L. muirii F. Muell.

Culm diameter: 1.0 mm.

Card characters: 2b, 5b, 5c, 7, 9, 14, 19, 20, 21, 22, 26, 27, 28, 31, 37, 42, 44, 48, 49, 50, 51, 52, 55, 56, 60b, 68, 86, 89, 90, 92, 101, 104, 105, 106, 114, 118, 121, 124.

#### Culm surface

Epidermal cells; mostly as long as wide, walls moderately thickened, wavy. Stomata; subsidiary cells of type (xvi); guard cells of type (ix); apertures of type (ii). Silica; as for group IIa. Tannin; none seen. Cuticular marks; slight longitudinal striations.

#### Culm T.S.

Fig. 34A

Outline; round. Cuticle; without pronounced ridges. Epidermal cells; mostly slightly higher than wide, with moderately thickened walls, otherwise as for group IIa. Stomata; slightly sunken; susidiary cells of type (f), but with very pronounced ridge on outer walls; guard cells with slight ridge on inner walls (9); lumina of type (3). Chlorenchyma; as for group IIa, but 3-layered in places; cells of all layers of similar heights; pegs on outer cells larger and fewer than normal; protective cells with slightly thickened walls. Parenchyma sheath; 1-layered.

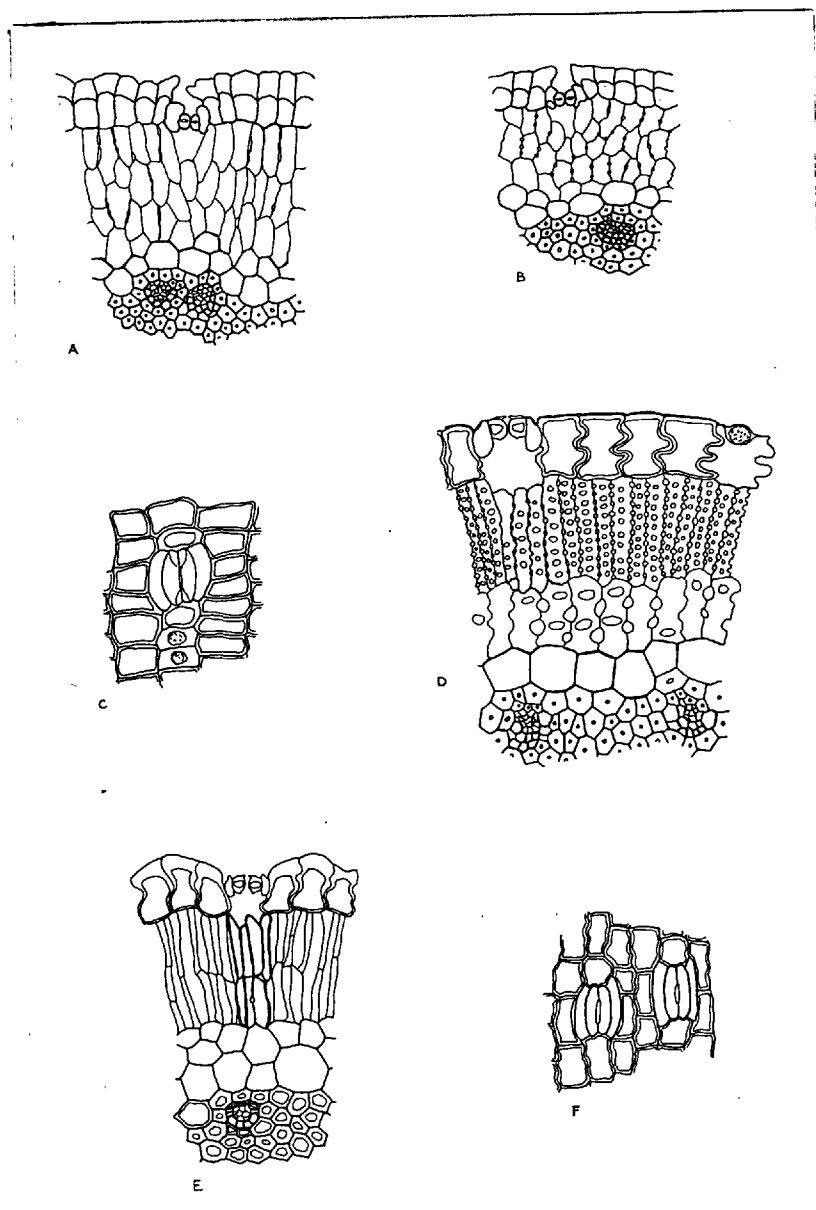


Fig. 32. A, Hopkinsia calovaginata, part of culm T.S.; B-F, Lepyrodia, B, anaetodolca (Type); C, D, scariosa; E, F, tasmanica; G, H, E, part of culm T.S.; I, J, culm surface (x185).

Sclerenchyma sheath; 2-3-layered; fibres very thick-walled.  
Vascular bundles; as for group IIa, but flanking mx. vessels  
of inner bundles medium-sized; no bundles free from culm  
sclerenchyma sheath. Bundle sheaths, central ground tissue,  
silica; as for group IIa.

Rhizome and Root; see group IIa description.

L. scariosa R.Br.

Culm diameter: 1.2 and 2.1 mm.

Card characters: 2b, 5b, 5c, 7, 9, 14, 20, 22, 23, 25, 26, 27, 28, 31, 36,  
37, 42, 44, 47, 48, 49, 51, 52, 54, 55, 56, 60b<sup>⊕</sup>, 68, 86,  
Cheadle 71, 72, 73, 76, 81, 86, 88, 89, 93, 94, 98, 110, 112,  
CA178 118, 121, 124.  
2b, 5c, 7, 9, 14, 20, 21, 22, 25, 26, 31, 37, 42, 44, 48,  
Stephenson 49, 50, 51, 52, 54, 55, 56, 60b<sup>⊕</sup>, 68, 86, 112, 114,  
338 115, 117, 118, 121, 124.

Culm surface

Fig. 32c

Epidermal cells<sup>⊕</sup>; 4-sided, mostly twice as wide as long  
(not strictly of type 60b); those next to stomata smaller  
than remainder; walls moderately thickened, wavy. Stomata;  
subsidiary cells mostly of types (xii) and (xiii), long anti-  
clinal walls occasionally slightly wavy; guard cells of type  
(ix); apertures of type (ii). Silica; as for group IIa.  
Tannin; present in occasional epidermal cells. Cuticular  
marks; granular, with longitudinal striations.

Culm T.S.

Figs. 32D, 33A, B

Outline; round. Cuticle; with slight ridges.  
Epidermal cells; mostly about  $1\frac{1}{2}$  times higher than wide,  
walls moderately thickened, otherwise as for group IIa.  
Stomata; superficial; subsidiary cells of type (f); guard  
cells with lips at outer aperture (5b) and slight ridge on  
inner walls (9). Chlorenchyma;

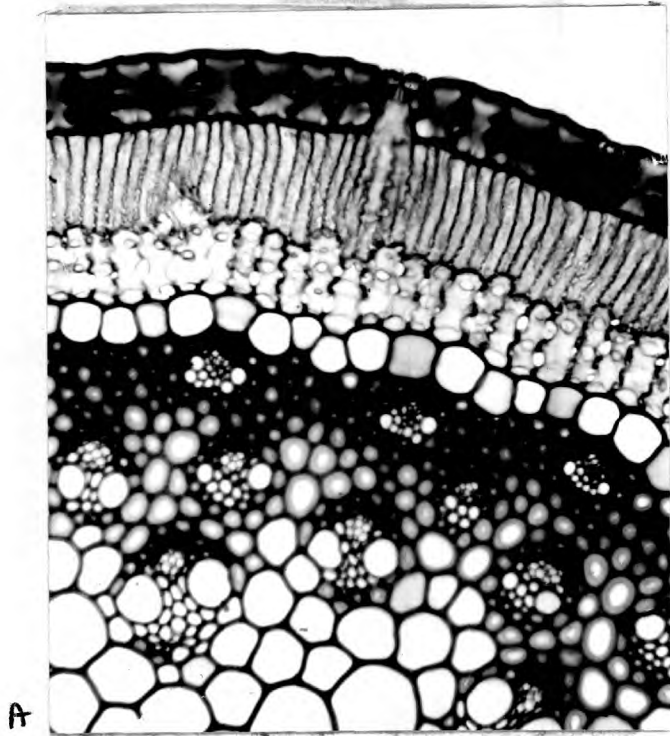


Fig. 33. Lepyrodia scariosa, part of culm T.S.,  
A x200, B x700; note silica body in epidermal cell of B.



as for group IIa, but protective cells with slightly thickened walls lining substomatal cavity, other walls thin. Parenchyma sheath; 1-layered in 338, 3-layered in CA178. Sclerenchyma sheath; 4-6-layered, fibres very thick-walled. Vascular bundles; as for group IIa, except medullary with medium-sized to wide flanking mx. vessels in inner bundles. Bundle sheaths, central ground tissue; as for group IIa. Silica; present as bodies, as for group IIa, and also as granular material in some cells of central ground tissue. Tannin; present in occasional epidermal cells. Leaf and rhizome; see group IIa description.

L. valliculae J.M. Black Culm diameter: 0.7 mm.

Card characters: 2b, 5c, 7, 9, 14, 20, 22, 26, 27, 28, 31, 42, 44, 47, 49, 50, 51, 52, 54, 55, 60b, 68, 86, 110, 112, 114, 115, 118, 121, 124.

#### Culm surface

Epidermal cells; mostly as long as wide, those next to stomata sometimes shorter than wide; walls moderately thickened, wavy. Stomata; subsidiary cells of type (xiii), but long anticlinal walls slightly wavy; guard cells of type (ix); apertures of type (ii). Silica; as for group IIa. Tannin; none seen. Cuticular marks; granular.

#### Culm T.S.

Outline; round. Cuticle; not ridged. Epidermal cells; mostly as high as wide, walls moderately thickened, otherwise as for group IIa. Stomata; superficial; subsidiary cells of type (f); guard cells with outer lips (5b); lumina of type (3). Chlorenchyma; as for group IIc,

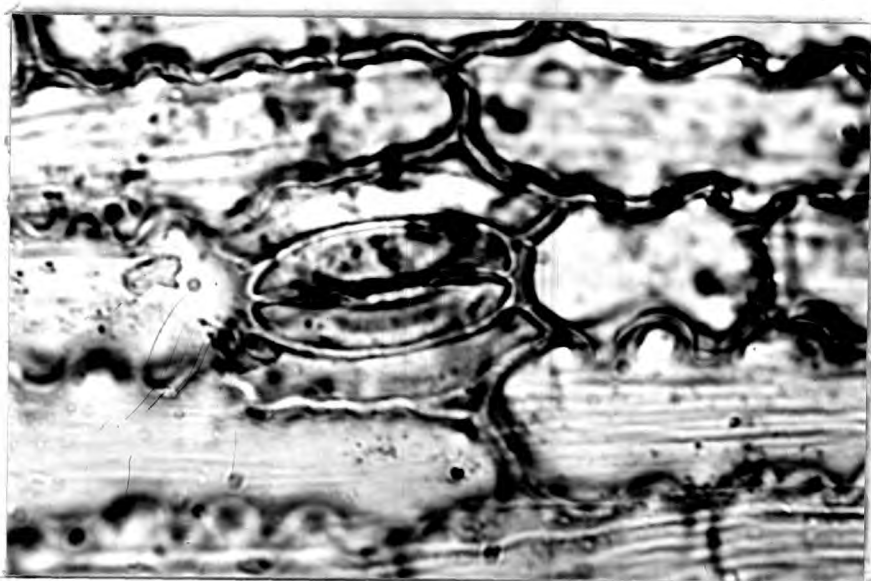
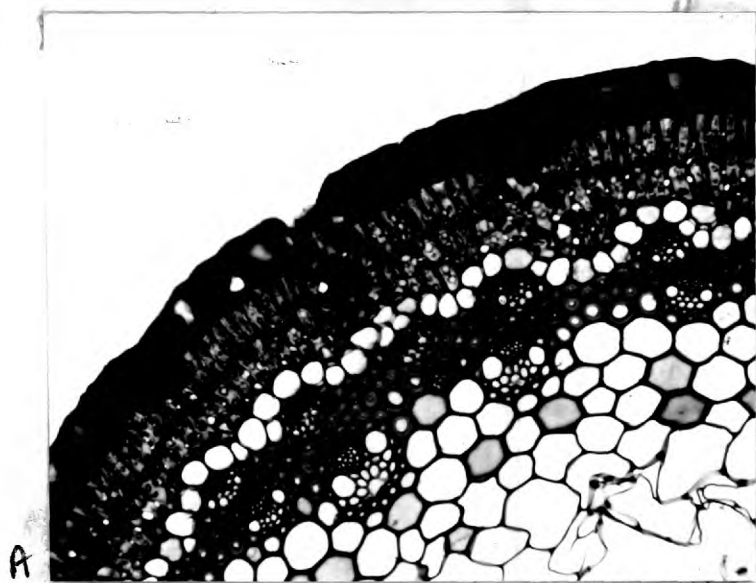


Fig. 34. Lepyrodia. A, muirii (x200); B, anarthria, culm surface (x700).

but without protective cells. Parenchyma sheath; as for group IIA. Sclerenchyma sheath; 3-4-layered, fibres very thick-walled. Vascular bundles; as for group IIA; flanking mx. vessels medium-sized.

#### Group IIb

L. glauca F. Muell. Culm diameter: 5 mm.

Card characters: 2b,5c,7,9,12,18,21,26,27,28,30,31,37,42,43,48,49,50,51,54,55,56,60b,68,86,110,112,114,115,118,121,124.

#### Culm surface

Epidermal cells; irregular, but mostly as long as wide or slightly shorter than wide; walls moderately thickened, wavy. Stomata; subsidiary cells as for group IIb; guard cells of type (ix); apertures of type (ii). Silica; as for group IIA. Tannin; none seen. Cuticular marks; granular.

#### Culm T.S.

Outline; round. Cuticle; without ridges. Epidermal cells; slightly higher than wide, walls moderately thickened, otherwise as for group IIA. Stomata; subsidiary cells reaching surface, but with guard cells mounted near their inner ends; subsidiary cells of type (g), outer portion projecting over guard cells; guard cells without lips or ridges; lumina of type (3). Chlorenchyma; as for group IIb.

Parenchyma sheath; 1-layered. Sclerenchyma sheath; 8-9-layered; fibres narrow, thick-walled. Vascular bundles; as for group IIa, but: (i) peripheral; phloem ensheathed by 1 layer of narrow cells with thin walls next to phloem, and slightly thickened walls next to xylem; (ii) medullary; flanking mx. vessels of inner bundles wide, rounded. Bundle sheaths, central ground tissue; as for group IIa. Silica; present as bodies as in IIa, and granular material in some cells of parenchyma sheath and central ground tissue.

L. heleocharoides Gilg

Culm diameter: 0.8 mm.

Card characters: 2b,5b,7,9,14,20,22,23,26,31,42,43,49,50,51,52,54,55,60b,68,86,112,114,115,118,121,124.

Culm surface

Epidermal cells; irregular, mostly as long as wide, some shorter than wide, walls moderately thickened, wavy.

Stomata; subsidiary cells as for group IIb; guard cells of type (ix); apertures of type (ii). Silica; as for group IIa. Tannin; none seen. Cuticular marks; granular.

Culm T.S.

Outline; round. Cuticle; without ridges. Epidermal cells; mostly  $1\frac{1}{2}$  times higher than wide, walls moderately thickened, otherwise as for group IIa. Stomata; superficial; subsidiary cells of type (g), with outer projection overarch-ing adjacent guard cells; guard cells without lips or ridges; lumina of type (3). Chlorenchyma; as for group IIb.

Parenchyma sheath; 1-layered. Sclerenchyma sheath; 3-4-layered; fibres very thick-walled. Vascular bundles; as for group IIa, but: medullary; flanking mx. vessels of

inner bundles medium-sized; no bundles free from culm sclerenchyma sheath. Bundle sheaths, central ground tissue; as for group IIa. Silica; bodies as for group IIa, granular material present in some cells of central ground tissue.

Group III

L. anaetocolea F. Muell.

Culm diameter: 1 by 0.7 mm.

1.5 by 1 mm.

Card characters: 5b, 6b, 7, 9, 15, 19, 20, 21, 22, 26, 27, 28, 31, 42, 45,

Drummond 50, 51, 52, 55, 56, 60, 68<sup>⊕</sup>, 110, 112, 114, 115, 117,  
(type) 121, 124.

5b, 6b, 7, 9, 14, 19, 20, 21, 22, 26, 30, 31, 42, 45, 50,  
51, 52, 55, 56, 60, 68<sup>⊕</sup>, 71, 74, 81, 88, 110, 112, 115,

Drummond 117, 121, 124.

⊕ semicircular.

Description as for group III, p.323, Fig. 32B.

Loxocarya R. Br.

Generic description

Culm surface

Hairs; multicellular, composed of short stalk and 1 or several elongated branch cells; see individual species. Epidermal cells; 4- 6-sided, frequently of 2 main sizes: (i) those next to stomata, and in groups of 4-20, about as long as wide; (ii) those between stomata and the groups of short cells,  $1\frac{1}{2}$ -2 or 2-6 times longer than wide; walls slightly to moderately, or moderately thickened (occasionally thick), straight or wavy, or wavy at surface only. Stomata; subsidiary cells including types (xi), (xii), (xiii), (xv), and (xviii); guard cells of types (vii), (viii), (viiib), (ix) and (x); apertures of type (ii). Silica crystals; absent. Tannin; present in epidermal cells of 1 species. Cuticular marks; granular, with or without longitudinal striations.

Culm T.S.

Outline; rounded or kidney-shaped, with low emergences. Cuticle; slightly or moderately thickened, occasionally thick. Hairs; see individual species. Epidermal cells; arranged in 1 layer; 4-sided, short and elongated; (i) short cells normally as high as  $1\frac{1}{2}$  times higher than wide, present near to stomata; cells next to stomata in all species except L. pubescens extending inwards into chlorenchyma, forming walls of substomatal cavity; (ii) taller cells, normally between stomata (occasionally next to them), often up to 5 times higher than wide, forming mounds (appearing as groups of

smaller cells as seen in surface view), cells in centre of mounds tallest, those on flanks of intermediate height, with inclined outer walls (occasional, multicellular, round-topped emergences present in some species); outer walls very thick; anticlinal walls often wavy, moderately or slightly thickened, or thick at outer ends and slightly thickened at inner ends, thickening tapering gradually; inner walls slightly or moderately thickened. Stomata; superficial, raised on tall cells in 1 species; subsidiary cells of types (c), (e), (g), (h), <sup>(i)</sup>(m) and (o); guard cells with outer lips (5a), (5b) or (7) and inner lips (8); lumina of types (1) and (4b). Chlorenchyma; (a) 1- or 2-layered in most species, peg cells slightly to  $1\frac{1}{2}$ ,  $1\frac{1}{2}$ -2, or 5-6, or 6-10(12) times higher than wide, those between stomata normally longest, layers uninterrupted; (b) 3- 4-layered in L. pubescens, cells with few pegs, mostly slightly to 2(3) times higher than wide, layers interrupted by sclerenchyma girders and their associated pillar cells. Parenchyma sheath; 1-layered, cells all as wide as to slightly or  $1\frac{1}{2}$ -2 times wider than high, except in L. pubescens, where cells of 2 types: (i) rounded, more or less as high as wide, on flanks of ridges from sclerenchyma sheath; (ii) pillar cells, extending from ridges from sclerenchyma sheath to epidermis; individual cells 2-4(5) times higher than wide, with slightly to moderately thickened walls. Sclerenchyma sheath; well developed in all species, outline rounded with low ridges opposite to pvbs. in all species except L. pubescens, this having pronounced ridges opposite pvbs. Outer fibres narrow, very thick-walled; inner

fibres frequently wider, with thick or very thick walls.

Vascular bundles; (i) peripheral; each with arc of narrow or medium-sized tracheids, sometimes with 1 wider tracheid on either flank; phloem pole situated in concavity of arc; (ii) medullary; outer bundles smallest, inner largest; outline radially or tangentially oval; each with 1 mx. vessel on either flank; flanking mx. vessels rounded or angular, narrow, medium-sized or wide, with slightly or moderately thickened walls; phloem poles rounded or tangentially oval, separated from xylem by 1-layered sheath of narrow cells with thin walls next to phloem, and slight or moderately thickened walls next to xylem. Bundle sheaths; sclerenchymatous, 1- 2-layered<sup>at</sup> poles, usually 1-layered on flanks; fibres narrow, with thick or very thick walls at poles; wider, with slightly thickened, moderately thickened or thick walls on flanks. Central ground tissue; parenchymatous, outer cells round vascular bundles with slightly or moderately thickened walls, those in culm centre with moderately or slightly thickened walls, or thin-walled, and breaking down. Silica; spheroidal-nodular bodies present in stegmata in parenchyma sheath or outer layer of sclerenchyma sheath. Crystals; none seen. Tannin; present in epidermal cells of 1 species.

Leaf surface; not seen.

Leaf T.S.

Seen in L. cinerea and L. flexuosa.

Hairs; none seen. Cuticle; thick, with small ridges on abaxial surface, thin on adaxial surface. Epidermis; (i) abaxial; cells 4-sided, as wide as high to twice as wide as



high; outer walls thick, other walls slightly thickened or thin; (ii) adaxial; cells 4-sided, 8-10 times wider than high, about  $\frac{1}{4}$  -  $\frac{1}{5}$  of the height of abaxial cells; walls slightly thickened. Stomata; present in abaxial surface only, superficial; subsidiary cells of type (c); guard cells with lips at outer aperture (5a) and slight lips at inner aperture (3); walls to pore concave (10); lumina of type (1). Chlorenchyma; 1- or 1-3-layered, next to abaxial epidermis, cells mostly as wide as high, some slightly higher than wide, all with wide, oval pegs. Vascular bundles; each with tangentially oval phloem pole and group of narrow and medium-sized tracheids; some bundles small, with few phloem and xylem cells, these alternating with larger bundles; all bundles orientated with phloem pole facing abaxial epidermis. Bundle sheaths; O.S. parenchymatous, cells wide, with slightly thickened walls; arranged in 1 layer at phloem pole, and with lateral extensions in L. cinerea; arranged in 1 layer on bundle flanks, interrupted at poles by fibres from inner sheath in L. flexuosa; I.S. sclerenchymatous; fibres narrow, in 1-3 layers at phloem pole; wider in 1-2 layers on flanks; and 2-3-layered at xylem pole, fibres of outermost layer wide, those of inner layers narrow; all fibres thick-walled. Sclerenchyma; restricted to that of bundle sheaths. Ground tissue; parenchymatous, cells wide, thin-walled, in 1-2 layers filling space between bundle-sheaths and adaxial epidermis, and in 3-4 layers between individual bundles, bounded abaxially by chlorenchyma or O.S. parenchyma layer, and adaxially by adaxial epidermis. Air-cavities absent. Silica; spheroidal-nodular bodies present in stigmata in outer layer of sclerenchyma of bundle sheath at phloem poles. Crystals, tannin; none seen.

Material examined

All species Australian

- L. cinerea* R. Br. Andrews, C. 1st coln. 1112 ♂ An.1900,  
100M1. E. of Perth 191112 (K)  
" Mueller, F. ♂ Upper Hay River  
191111 (K)  
" Blake, S.T. 18153, An.1947, open Eucalypt,  
on granite hillside 191113 (K)
- L. fasciculata* Benth. Koch, M. 1887 ♂ An.1911, Lowden,  
S.W. Aust. 19115 (K)  
" Carter, C.B. ♂ An.1915, Westbourne  
19116 (K)
- L. flexuosa* Benth. Brown, R. Bennet Distrib. No.5849, type  
2032B (K)  
" Andrews, C. 1st coln. 1110 ♂ Limestone,  
rocky ground, Cottesloe, Nr. Perth  
19118 (K)  
" Drummond 96, Swan River 19119 (K)
- L. pubescens* Benth. Brown, R. Bennet Distrib. No.5852 King  
George's Sound, type 2031B (K)  
" Pries Busselton. ♂ 5112 (K)  
" Koch, M. ♀ An.1911, Lowden 19114 (K)
- L. vestita* Benth. Oldfield, Murchison Estuary. 25917 (K)
- L. virgata* R. Br. Steward, F. 63, An.1914, Narrogin Exptal.  
Farm. 5111 (K)

Species descriptions

- L. cinerea* R. Br. Culm diameter: 0.9, 0.9, 0.5 mm.
- Card characters: 2b, 5b, 7, 9, 12, 19, 20, 21, 22, 23, 26, 27,  
Andrews 1112 28, 30, 31, 42, 43, 47, 49, 50, 51, 52, 54,  
55, 56, 58, 60, 63, 64, 69, 110, 112, 114,  
115, 118, 121, 124  
2b, 5b, 7, 9, 12, 19, 20, 21, 26, 27, 28, 30,  
Mueller 31, 42, 43, 47, 49, 50, 52, 54, 55, 56, 58,  
60, 63, 64, 69, 71, 73, 76, 81, 88, 110, 112,  
115, 118, 121, 124.  
2b, 5b, 7, 9, 12, 19, 21, 26, 28, 30, 31, 42,  
Blake 18153 43, 47, 49, 50, 51, 52, 54, 55, 56, 58, 60,  
63, 64, 69, 110, 112, 114, 115, 118, 121, 124.

Culm surface

Hairs; multicellular, each with 1-3 short stalk cells with slightly thickened walls, and 2-3 radiating unicellular branches, each branch cell with very thin walls, and 10-25 times longer than wide, end rounded or tapering; see fig. 35 D. Epidermal cells; 4-6-sided, as long as wide to  $1\frac{1}{2}$ (2) times longer than wide, smaller cells in clusters of 8-30 (corresponding to mounds formed by elongated cells as seen in T.S.). Walls moderately thickened, sometimes wavy. Stomata; subsidiary cells variable, mainly of types (xi), (xii), (xiii), (xv) and (xviii); guard cells of type (ix); apertures of type (ii). Tannin; none seen. Cuticular marks; granular, with longitudinal striations.

Culm T.S.

## Fig. 35A

Outline; round, with irregularly scattered mounds formed by small areas of elongated epidermal cells. Cuticle; moderately thickened. Hairs; see above. Epidermal cells; smallest between mounds, mainly as high as or up to  $1\frac{1}{2}$  times higher than tallest, in centre of mounds, up to 5 or 6 times higher than wide; about 5 cells make up width of average mound, those on flanks grading rapidly to smallest size, with steeply inclined outer walls (fig. 35 A ), cells surrounding stomata extending about  $\frac{1}{5}$  -  $\frac{1}{2}$  of way into chlorenchyma. Outer walls very thick, outer surface irregular, granular; anticlinal walls wavy, thick at outer ends, thickening tapering rapidly, and most of wall slightly to moderately thickened; inner walls slightly thickened. Stomata; superficial, normally amongst shorter cells; subsidiary cells of types (h) or (m); guard cells with pronounced lips at outer apertures (5b) and slight lips at inner apertures (8); lumina wide lenticular, of types (1) or (4b). Chlorenchyma; composed of 1 layer of palisade peg-cells, mostly between 6-9 (11) times higher than wide, those opposite to elongated epidermal cells surrounding stomata shorter; pegs small or medium-sized, short, numerous. Protective cells absent. Parenchyma sheath; 1-layered, cells wide, rounded-hexagonal, about as high as wide or slightly wider than high, with slightly thickened walls. Layer interrupted at places by stegmata. Sclerenchyma sheath; 3-6-layered, outline rounded; fibres narrow to medium-

sized, with very thick walls. Vascular bundles: (i) peripheral; 4-7 narrow tracheids arranged in 1-layered arc partially enclosing rounded phloem pole; (ii) medullary; outer bundles small, inner bundles larger, all with 1 mx. vessel on either flank; flanking mx. vessels of inner bundles narrow or medium-sized, rounded, with slightly or moderately thickened walls, separated by 2-4 rows of narrow cells with slightly thickened walls; phloem pole rounded - tangentially oval, ensheathed; px. present in all but smallest bundles; some or most bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous; fibres mostly narrow, thick or very thick-walled, in 1-2 layers at poles, and in 1 layer on flanks. Central ground tissue; parenchymatous; cells surrounding vascular bundles with moderately thickened walls, central cells thin-walled, breaking down to form cavity. Silica; spheroidal-nodular bodies present in stigmata in parenchyma sheath.

Leaf T.S.; see generic description.

L. fasciculata Benth. Culm diameter: 0.7 by 0.5, 1.2 by 1.0,  
1.1 mm.

Card characters: 2b, 5b, 7, 9, 14, 19, 20, 21, 22, 25, 26, 28,  
Koch 31, 42, 43, 44, 47, 49, 50, 51, 52, 54, 55, 56.  
60, 63, 64, 69, 110, 112, 114, 115, 118, 121,  
124.

Carter 2b, 5b, 5c, 7, 9, 14, 20, 22, 26, 27, 28, 31,  
42, 44, 47, 49, 50, 51, 52, 54, 55, 56, 60,  
63, 64, 69, 110, 112, 114, 115, 121, 124.

### Culm surface

Hairs; multicellular, each composed of several basal cells with slightly to moderately thickened walls (frequently elongated epidermal cells) and a uniseriate outer portion composed of 4 or 5 cells, each cell several or many times longer than wide, often curved, with oblique end walls showing conspicuous pitting; walls slightly to moderately thickened (see fig. 354). Epidermal cells mostly 4-sided, of 2 types: (i) as long as or slightly longer than wide, frequently grouped round stoma (elongated as seen in T.S.), and (ii) 2-6 times longer than

wide, normally between stomata (shorter cells as seen in T.S.); walls moderately thickened, wavy. Stomata; often raised on taller cells; subsidiary cells mainly of types (xviii) and (xii); guard cells of types (x) and (viii b); aperture narrow, of type (ii). Tannin; none seen. Cuticular marks; fine, longitudinal striations.

Culm T.S.

Outline; round, with pronounced mounds and short club-shaped emergences (possibly hair bases?). Cuticle; slightly thickened. Hairs; see above. Epidermal cells; of 2 main types: (i) elongated, 3-4 times higher than wide, sometimes associated with stomata, when also extending slightly into chlorenchyma, sometimes producing multicellular emergences (see fig. 35E); (ii) shorter cells, mostly as high as to  $1\frac{1}{2}$  times higher than wide, normally present between stomata, but occasionally associated with them (cells mostly of this type in Koch specimen). Outer walls very thick, convex or irregular; anticlinal and inner walls slightly or moderately thickened; anticlinal walls frequently slightly wavy. Stomata; superficial; subsidiary cells of types (c), (g), (l) or (o); guard cells with slight lips at outer and inner apertures (5a), (3); lumina of type (1), wide. Chlorenchyma; composed of 1 or 2 layers of palisade peg-cells; cells of outer layer  $1\frac{1}{2}$ -2(3) times higher than wide, those of inner layer as high as to  $1\frac{1}{2}$  times higher than wide; pegs wide, frequent. Protective cells absent. Parenchyma sheath; 1-layered, cells slightly to  $1\frac{1}{2}$ (2) times wider than high. Sclerenchyma sheath; 4-5-layered, outline rounded; fibres rounded, moderately thick to thick-walled, with intercellular spaces filled by extracellular substances; fibres of inner layer difficult to distinguish from central ground tissue in some specimens. Vascular bundles: (i) peripheral; tracheids medium-sized, arranged in 1-2-layered arc, flanking tracheids sometimes wider than others; phloem pole rounded, situated in cavity of arc; (ii) medullary; each with 1 angular or rounded-angular, moderately thick-walled mx. vessel on either flank; flanking mx. vessels of outer bundles narrow, those of inner bundles

medium-sized or wide, separated from one another by 2-4 rows of narrow cells with moderately thickened walls; phloem poles rounded or tangentially oval, separated from xylem by 1 layer of narrow cells with slightly to moderately thickened walls; px. present in all but smallest, outer bundles; most bundles free from culm sclerenchyma sheath. Bundle sheaths; weak, sclerenchymatous, composed of 1 or 2 layers of narrow to medium-sized tracheids with moderately thickened walls. Central ground tissue; outer cells narrow, inner cells wider, with moderately thickened walls, central cells wide, thin-walled, breaking down to form central cavity. Silica; spheroidal-nodular bodies present in stegmata in outer layer of culm sclerenchyma sheath. Tannin; none seen.

L. flexuosa Benth. Culm diameter: 1 by 0.5, 1.0, 0.5 mm.  
 Card characters: 2b, 5b, 7, 9, 12, 20, 21, 26, 27, 28, 31,  
 Bennet 5849(type) 42, 43, 44, 47, 49, 50, 51, 52, 54, 55, 56,  
 (near apex) 60, 70b, 112, 114, 115, 121, 124.  
 2b, 5b, 7, 9, 12, 20, 21, 26, 27, 28, 30,  
 Andrews 1110 31, 42, 43, 44, 47, 49, 50, 51, 52, 54, 55,  
 57c, 60, 63, 64, 69, 71, 72, 81, 88, 110,  
 112, 115, 118, 121, 124.  
 2b, 5b, 7, 9, 12, 20, 21, 22, 23, 26, 27,  
 Drummond 96 28, 31, 42, 43, 47, 49, 50, 51, 52, <sup>54</sup>55, 60,  
 69, 112, 114, 115, 118, 121, 124.

#### Culm surface

Hairs; basal cells only, seen in 1110 and 96. Epidermal cells; mostly 4-sided, as long as wide and up to 3 or 4 times longer than wide; groups of smaller, short cells present in 1110 and 96 (forming mounds as seen in T.S.); walls moderately thickened, wavy. Stomata; subsidiary cells of types (xviii) and (xii), long anticlinal walls sometimes slightly wavy; guard cells of types (viii) or (x); apertures narrow, of type (ii). Tannin; none seen. Cuticular marks; granular, with longitudinal striations.

#### Culm T.S.

Outline; round with emergences or type 70b. Cuticle;

slightly thickened. Hairs; see above. Epidermal cells; mostly slightly to  $1\frac{1}{2}$  times higher than wide in 5849 and 96, those next to stomata 2-4 times higher than wide, extending into chlorenchyma, forming substomatal tube; some elongated, 3-4 times higher than wide, in 1110, forming emergences. Outer walls very thick, outer surface irregular, other walls slightly to moderately thickened; anticlinal walls of elongated cells wavy, those lining substomatal tube moderately thickened. Stomata; superficial; subsidiary cells of types (m) or (o); guard cells with lips at outer (7) and inner (8) apertures; lumina of type (1). Chlorenchyma; composed of palisade peg-cells in 1 or 2 layers, individual cells mostly 5-6 times higher than wide or 3-10 (12) times higher than wide; those opposite to substomatal cavities shortest; pegs numerous, medium-sized. Parenchyma sheath; 1-layered, cells as high as wide or slightly to  $1\frac{1}{2}$  times wider than high. Sclerenchyma sheath; 5-6 (8)-layered; fibres narrow to medium-sized, very thick-walled. Vascular bundles: (i) peripheral; with arc of narrow to medium-sized tracheids partially enclosing tangentially oval phloem pole; (ii) medullary; outer bundles small, inner bundles large, all with 1 mx. vessel on either flank; flanking mx. vessels narrow or narrow to medium-sized, rounded, with moderately thickened walls, separated from one another by 3-4 rows of narrow, moderately thick-walled cells; phloem poles tangentially oval, separated from xylem by 1 layer of cells with slightly to moderately thickened walls; px. present in all but smallest, outer bundles; some bundles free from culm

sclerenchyma sheath in 1110. Bundle sheaths; sclerenchymatous; fibres narrow and narrow to medium-sized, thick-walled, in 1 or 2 layers. Central ground tissue; outer cells round vascular bundles thick- or moderately thick-walled, central cells thin-walled, breaking down to form central cavity. Silica; spheroidal-nodular bodies, present in stigmata in outer layer of sclerenchyma sheath. Tannin; none seen.

Leaf T.S.; see generic description.

L. pubescens Benth.

Culm diameter: 1.1, 1.1, 0.5 mm.

Card characters: 3,5c,7,9,14,20,21,25,26,27,28,31,42,45,47,48,

Bennet 5852 49,50,51,52,54,55,56,60,63,64,68,110,112,114,  
(type) 115,121,124.

3,5c,7,9,14,20,21,22,26,27,31,42,45,47,48,49,  
50,52,54,55,56,60,63,64,68,110,112,114,115,

Pries ♂ 117,121,124.

3,5c,7,9,14,18,19,21,25,26,31,35,42,45,47,  
48,49,50,51,52,54,55,56,58,63,64,66,68,112,

Koch 1880 ♀ 114,115,<sup>117</sup>121,124.

Culm surface

Hairs; multicellular, each composed of uni- or bi-seriate stalk of 3-6 cells, with moderately thickened walls, and flattened branching free part, composed of many elongated, moderately thick-walled, loosely associated cells.

Epidermal cells; mostly 4-sided, sometimes 5-6-sided, as long as to 4-5 times longer than wide, but mostly  $1\frac{1}{2}$ -2 times longer than wide; walls slightly to moderately or moderately thickened; wavy, except in 1880, where irregular in outline and mostly short; cells over pillar cells usually



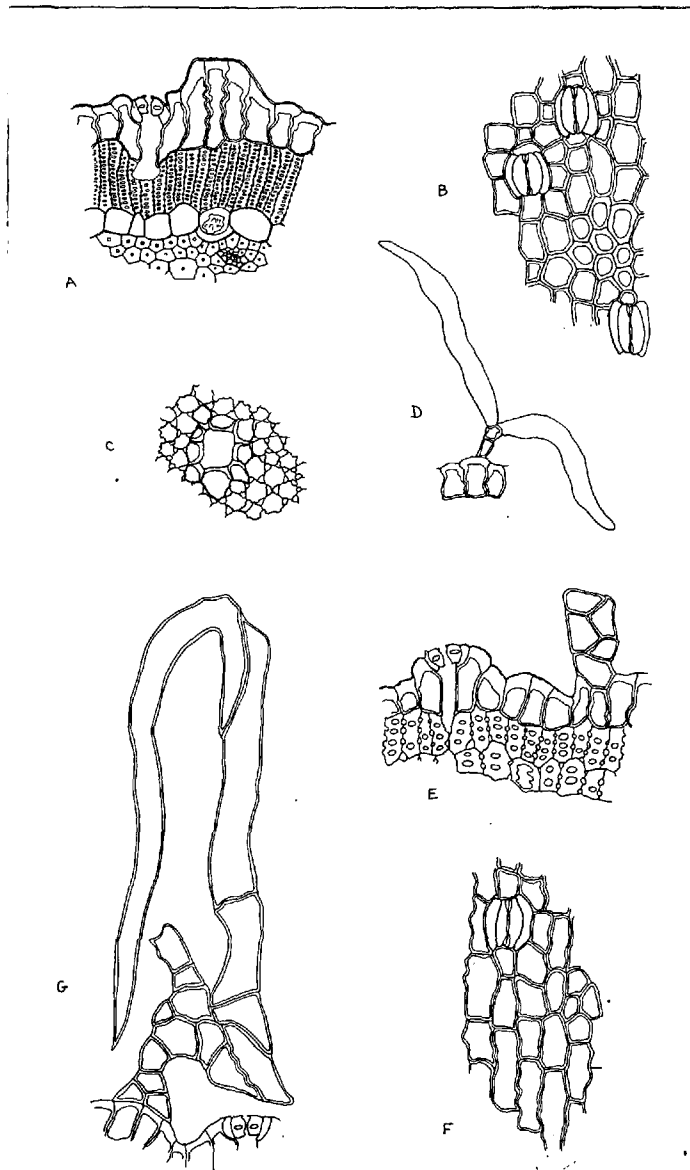


Fig. 35. Loxocarya. A-D cinerea, E-G fastigiata.  
 A, E, part of culm T.S.; B, F, culm surface; D, G, hairs;  
 C, T.L.S. culm in region of chlorenchyma, note substomatal  
 tube lined by epidermal cells. All except C x185, C x290.

longest. Stomata; subsidiary cells of types (xi), (xii) and (xiii); guard cells of types (vii) and (ix); apertures of type (ii). Tannin; present in many epidermal cells.

Cuticular marks; longitudinal striations.

Culm T.S.

Outline; round, or rounded with emergences. Cuticle; slightly or moderately thickened. Hairs; see above.

Epidermal cells; all about as high as wide except in 1880, where as high as, or up to  $1\frac{1}{2}$  times higher than wide next to stomata, and reaching  $2\frac{1}{2}$ - $3\frac{1}{2}$  times higher than wide between stomata. Outer walls thick or very thick, other walls slightly or moderately thickened. Stomata; superficial; subsidiary cells of type (m); guard cells with lips at outer (7) and inner (8) apertures; lumina of type (1). Chlorenchyma; mostly 3-(4)-layered, divided into longitudinal channels by ridges from sclerenchyma sheath and their associated pillar cells. Chlorenchyma cells mostly slightly to 2 times higher than wide, with few pegs (up to 3 times higher than wide, pegs numerous, small, in 1880). Parenchyma sheath; composed of 2 types of cell: (i) rounded, more or less as high as wide, with slightly thickened walls, on flanks of ridges from sclerenchyma sheaths, and occasionally completely covering them; (ii) pillar cells, 2-4 (5) times higher than wide, with slightly to moderately thickened walls, radiating from most ridges from sclerenchyma sheath to epidermis. Sclerenchyma sheath; 3-4 or 6-7-layered, outline rounded with conspicuous ridges, 1 opposite to and enclosing each p.v.b.; fibres narrow, very thick-walled.

Vascular bundles: (i) peripheral; each with 1 medium-sized tracheid on either flank of arc of narrow tracheids; phloem pole small, rounded; (ii) medullary; mostly tangentially oval in outline (radially oval in 1880), each with 1 mx. vessel on either flank; flanking mx. vessels angular, with slightly thickened walls, narrow in outer bundles, medium-sized in inner, larger bundles (narrow in 1880), separated from one another by 1-6 rows of narrow cells with slightly thickened walls; phloem poles tangentially oval, separated from xylem by 1 layer of narrow cells with slightly thickened walls; many smaller, outer bundles without px.; some bundles free from culm sclerenchyma sheath, except in 1880. Bundle sheaths; sclerenchymatous; fibres in 1 or 2 layers, narrow, with thick or moderately thickened walls. Central ground tissue; parenchymatous, most outer cells with thick or moderately thickened walls; central cells, free from mvbs., thin-walled, breaking down to form central cavity, except in 1880, where moderately thick-walled. Silica; spheroidal-nodular bodies present in stigmata in outer layer of sclerenchyma sheath. Tannin; present in some epidermal cells.

L. vestita

Culm diameter: 0.75 by 0.5 mm.

Card characters: 2b, 5c, 7, 9, 12, 19, 21, 26, 27, 28, 31, 42, 44, 47, 49, 50, 51, 52, 54, 55, 60, 63, 64, 69, 71b, 112, 114, 115, 121, 124.

Culm surface

Hairs; similar to those in L. fastigiata. Epidermal cells; 4-sided,  $1\frac{1}{2}$ -4 times longer than wide, walls

moderately thickened, wavy. Stomata; subsidiary cells of type (xvii); guard cells of type (x); lumina of type (ii). Tannin; none seen. Cuticular marks; granular.

Culm T.S.

Outline; kidney-shaped, with low mounds. Hairs; see above. Epidermal cells; 4-sided, mostly as high as or slightly higher than wide, some up to twice as high as wide, forming low, rounded mounds; those next to stomata extending a short distance into chlorenchyma and lining substomatal cavity. Outer walls very thick, outer surface irregular; other walls slightly to moderately thickened. Stomata; superficial; subsidiary cells elongated, of type (i), with pronounced ridge on outer wall; guard cells with lips at outer and inner apertures (5a) (8); walls to pore (12); lumina wide lenticular, of type (1). Chlorenchyma; composed of 2 layers of palisade peg-cells; cells of outer layer 3-5 times higher than wide, those of inner layer 2-3 times higher than wide, slightly wider than outer cells; pegs medium-sized to large. Parenchyma sheath; 1-layered, cells slightly to  $1\frac{1}{2}$  times wider than high with slightly to moderately thickened walls; interrupted in places by large stegmata. Sclerenchyma sheath; 3-6-layered, outline following that of culm, sheath in contact with epidermis along concave face of culm; fibres very thick-walled, those of outer layers narrow, those of inner layers wider. Vascular bundles: (i) peripheral; each with 1 medium-sized tracheid on either flank of arc of narrow or narrow to medium-sized tracheids; phloem poles wide, tangentially oval; (ii) medullary; smaller, outer

bundles with 1 central or 2 flanking, medium-sized, rounded-angular mx. vessels and no px. poles; larger, inner bundles each with 1 medium-sized or wide, rounded-radially oval, mx. vessel on either flank, separated by 2-3 rows of narrow cells with slightly thickened walls; phloem poles tangentially oval, separated from xylem by 1 layer of narrow to medium-sized cells with thin walls next to phloem and slightly to moderately thickened walls next to xylem; px. present in most inner bundles; no bundles free from culm sclerenchyma sheath.

Bundle sheaths: sclerenchymatous, 1-2-layered; fibres thick-to very thick-walled, narrow and medium-sized. Central ground tissue: parenchymatous, cells wide, with moderately thickened walls. Silica: large, spheroidal-nodular bodies present in stigmata in parenchyma sheath. Tannin: none seen.

L. virgata R.Br.

Culm diameter: 1 mm.

Card characters: 2b,5b,7,9,12,19,20,21,22,26,27,28,30,31,42,43,47,49,50,51,52,54,55,56,60,63,64,69,110,112,114,115,118,121,124.

Culm surface

Hairs; multicellular, each composed of a 2-3-celled, uniseriate stalk and 1 or 2-5 branch cells; stalk cells mostly as high as wide, with slightly thickened walls; branch cells thin-walled, mostly between 6 and 10 times longer than wide (see fig.35D). Epidermal cells; mostly 4-sided, as long as wide near stomata and in groups (corresponding to mounds as seen in T.S.), and slightly to  $1\frac{1}{2}$  (2) times longer than wide between stomata; walls moderately thickened to thick, slightly wavy at surface, straight at lower focus.

Stomata; subsidiary cells with irregular outlines, most like type (xviii); guard cells of type (x); apertures of type (ii). Tannin; none seen. Cuticular marks; coarsely granular.

Culm T.S.

Outline; rounded, with irregular mounds. Cuticle; thick, Hairs; see above. Epidermal cells; 4-sided, mostly slightly to  $1\frac{1}{2}$  times higher than wide, some elongated, forming mounds, largest of these about 5 times higher than wide, those on flanks of mounds of intermediate size, with sloping outer walls; cells surrounding stomata elongated inwards, being about 4 times higher than wide, anticlinal walls lining cavity about twice as long as others, inner walls sharply inclined (see fig. <sup>as in L. cinerea</sup> 35A, <sub>1</sub>). Outer walls very thick; anticlinal walls wavy, thick at outer ends, slightly thickened at inner ends, thickening tapering; inner walls slightly thickened. Stomata; superficial; subsidiary cells of type (m); guard cells with conspicuous outer lips (5b) and lips at inner aperture (8); lumina of type (1), wide. Chlorenchyma; 1-layered, peg-cells mostly about 10 times longer than wide, those opposite stomata 5-7 times longer than wide, pegs numerous, medium-sized. Parenchyma sheath; 1-layered, cells as high as to slightly higher than wide, some slightly wider than high; walls slightly thickened; stegmata present. Sclerenchyma sheath; 4-6-layered; outer fibres narrow, inner ones wider, walls very thick or thick; outline rounded, with very slight ridges opposite to pvbs. Vascular bundles: (i) peripheral, tracheids narrow to

medium-sized, arranged in 1-layered arc partially enclosing tangentially oval phloem pole; (ii) medullary; all bundles with 1 rounded mx. vessel with moderately thickened walls on either flank, those of outer bundles narrow, those of inner bundles medium-sized, separated by 1-3 rows of narrow cells; phloem ensheathed, poles tangentially oval; px. present in all but smallest, outer bundles; most bundles free from culm sclerenchyma sheath. Bundle sheaths; sclerenchymatous, 1-(2-)layered; fibres narrow, those at phloem pole thick-walled, others with moderately or slightly thickened walls. Central ground tissue; parenchymatous, outer cells round vascular bundles with slightly thickened walls, central cells thin-walled, breaking down. Silica; spheroidal-nodular bodies present in stigmata in parenchyma sheath. Tannin; none seen.

Lyginia R.Br.Generic description

Culm surface: (L. tenax (Labill.) C.A. Gardner only).

Hairs; none seen. Epidermal cells; consisting of 2 main types: (i) not associated with stomata, 4-sided, mostly 2-4 times longer than wide, walls thick, wavy; (ii) surrounding stomata, mostly 2-4 times longer than wide, but with wall bordering stoma produced into an overarching papilla; papillae from adjacent cells frequently fused at their inner ends, but free at their outer ends (see fig.36E). Stomata; paracytic; sunken and overarched by papillae (see above); subsidiary cells irregular in outline, but mostly dome shaped, with rounded or perpendicular ends (see fig. 36D); guard cells narrower than normal for the family (see fig.36D). Silica; none seen. Tannin; present in many epidermal and some subsidiary cells. Crystals; none seen. Cuticular marks; none seen.

Culm T.S.

Figs. 36A-C

Outline; terete, or terete and with irregularly distributed, low, dome shaped emergences. Cuticle; moderately thickened. Epidermal cells; present in 1 layer, all more or less level at culm surface, except for raised papillate cells next to stomata, but extending inwards to differing degrees, the tallest being up to 7 times as high as wide, the shortest about twice as high as wide, with a graded series between the extremes. As seen in L.S., all cells inclined at angle of c.15° from perpendicular. Outer walls very



thick, anticlinal walls very wavy, thick at outer end, but thickening tapering gradually to thin inner end, inner walls thin. Stomata; sunken, attached to inner end of anticlinal walls of epidermal cells; (as seen in L.S., stomata attached to short cells at one end and long cells at other, and thus inclined at about  $45^{\circ}$  to culm surface, all stomata inclined in same direction;) subsidiary cells of type (a); guard cells without lips or ridges. Chlorenchyma; composed of palisade cells arranged in 2 layers; cells of 2 types, each without pegs: (i) opposite stomata, thin-walled; (ii) not opposite stomata, with moderately thickened walls (as seen in T.L.S., cells of type (ii) forming irregular reticulum with cells of type (i) in the lacunae, the thinner-walled cells joined to one another at adjacent angles, thus alternating with air spaces and looking like a chequerboard (see fig. 36F)). Parenchyma sheath; cells in 1 layer, individual cells 1.5-2 times as high as wide, with slightly thickened walls; outline of parenchyma sheath following that of sclerenchyma sheath. Sclerenchyma sheath; 4-7-layered, outline round, with low, dome-shaped ridges each accommodating 1 pvb.; fibres of outer layers thick-walled, with medium-sized lumina, those occurring in the 1 layer to outside of each pvb. and in the inner sheath layers with moderately thickened walls. Vascular bundles: (i) peripheral; with 4-6 narrow, angular, thin-walled tracheids arranged in an arc partially enclosing a small phloem pole; (ii) medullary; (a) outer, smaller embedded in culm sclerenchyma sheath, each having <sup>1</sup>/narrow or

medium-sized, many-sided mx. vessel with slightly thickened walls on either flank; mx. vessels separated by narrow parenchymatous cells arranged in 2-3 rows; px. poles present in some bundles; (b) inner, larger, free from culm sclerenchyma sheath, each with 1 (occasionally 2) medium-sized, many-sided mx. vessel on either flank separated by narrow parenchymatous cells arranged in 2-3 rows; vessel wall pitting scalariform, perforation plates scalariform or reticulate-scalariform; phloem pole rounded, separated from xylem by 1 layer of narrow cells with thin walls facing the phloem and slightly thickened walls facing the xylem; px. poles well developed, separated from bundle sheath on either side by 1-2 layers of thin-walled parenchymatous cells.

Bundle sheaths; sclerenchymatous; fibres with moderately thickened walls present in 3-4 layers at xylem and phloem poles and in 1, frequently discontinuous, layer on bundle flanks. Central ground tissue; parenchymatous, most cells rounded, with slightly thickened walls, some with thin walls; intercellular spaces frequent; no central cavity formed.

Silica; none seen. Tannin; present in many epidermal cells, some subsidiary cells and some cells of parenchyma sheath. Crystals; square, slab-shaped, occurring in some specimens in cells of central ground tissue.

Leaf surface only, seen in L. tenax.

Epidermal cells; hexagonal, 4-5 times wider than long, each with long transverse walls and 2 short walls on either side; all walls thick. Cells next to stomata produced into overarching papillae (see culm surface). Stomata;

subsidiary cells of type (xvi); guard cells of type (x).

Rhizome T.S. Seen in L. tenax only.

Epidermal cells; as wide as high, or up to twice as wide as high; outer walls slightly thickened, anticlinal and inner walls thin. Stomata; superficial, subsidiary cells of type (c); guard cells without lips or ridges, walls slightly thickened; lumina wide, triangular, with apex of triangle directed towards subsidiary cell. Hypodermis; composed of 2-5-layered groups of 4-6-sided cells with slightly thickened walls dispersed among parenchymatous, thin-walled cells. Cortex; parenchymatous, thin-walled, rounded cells present in 8-10 layers, interspersed with occasional strands of 6-8 narrow, thick-walled fibres. Endodermoid sheath; not apparent. Vascular bundles; collateral, scattered, outermost with 1-2, innermost with 8-10 angular, thick-walled vessels at xylem pole; vessel wall pitting scalariform, perforation plates simple, oblique; phloem poles oval. Central ground tissue; with several layers of sclerenchymatous, thick-walled cells surrounding individual vascular bundles, the sclerenchyma from adjacent sheaths frequently confluent, and lacunae of parenchymatous, thin-walled, lobed, more or less isodiametric cells. Silica; none seen. Tannin; none seen. Crystals; none seen.

Root T.S. Seen in L. tenax only.

Cortex, not seen. Endodermis; 1-layered, cells small, as wide as high or slightly wider than high; outer walls thin, other walls heavily thickened, lumina narrow.

Pericycle; 2-3 layered, cells more or less hexagonal, thick-walled, as high as wide. Vascular tissue; phloem strands restricted to 1 ring immediately to inside of pericycle, approximately 3 times as numerous as mx. vessels; mx. vessels wide, radially oval-angular, thick-walled, many arranged in single ring just inside that formed by phloem strands. Central ground tissue; outer 6-7 layers thick-or very thick-walled, inner cells thin-walled, breaking down. Silica, Tannin and Crystals; none seen.

Material examined:

<i>L. barbata</i> R.Br.	♀. Narrogin, W. Aust. An. 1913	14 (K)
" "	♀ Grimwade Expd. Pallings Creek W. Aust. An. 1947	15 (K)
" "	Pritzel 101, Avon W. Aust.	16 (K)
<i>L. tenax</i> (Labill.)	C.A. Gardner Cheadle, V.I. CA73, Perth W. Aust.	(S)

Specific descriptions

*L. barbata* R.Br. Culm diameter: 0.8, 1 and 1 mm.

Card characters:

Pritzel	1,2,7,9,14,19,21,26,27,28,30,31,37,44,46,47, 48,50,51,52,69,110,112,114,115,118,121,124.
Grimwade	1,2,7,9,12,14,20,22,25,26,31,37,44,46,47,48, 50,51,52,55,68,111,112,113,114,115,117,118, 121,124.
Narrogin	1,2,7,12,14,20,22,25,26,27,31,37,44,46,47,48, 50,52,68,111,112,113,114,115,117,118,121,124

Culm surface: not seen.

Culm T.S.

Similar to generic description in all but following details: Epidermal cells; those next to stomata produced into larger papillae in Grimwade than in other material.

Vascular bundles; some of larger medullary bundles attached to culm sclerenchyma sheath by fibres at phloem pole. Crystals; present in isolated cells of central ground tissue.

Leaf, Rhizome and Root material not seen.

L. tenax (Labill.) C.A. Gardner Culm diameter: 1.5 mm.

Card characters: 1, 2, 7, 9, 14, 20, 22, 23, 26, 27, 28, 31, 37, 42, 44, 47, 48, 50, 51, 52, 55, 56, 58, 68, 77, 87, 90, 93, 94, 98, 99, 100, 104, 106, 110, 114, 117, 118, 121, 124.

Culm, Leaf, Rhizome and Root as in generic description.

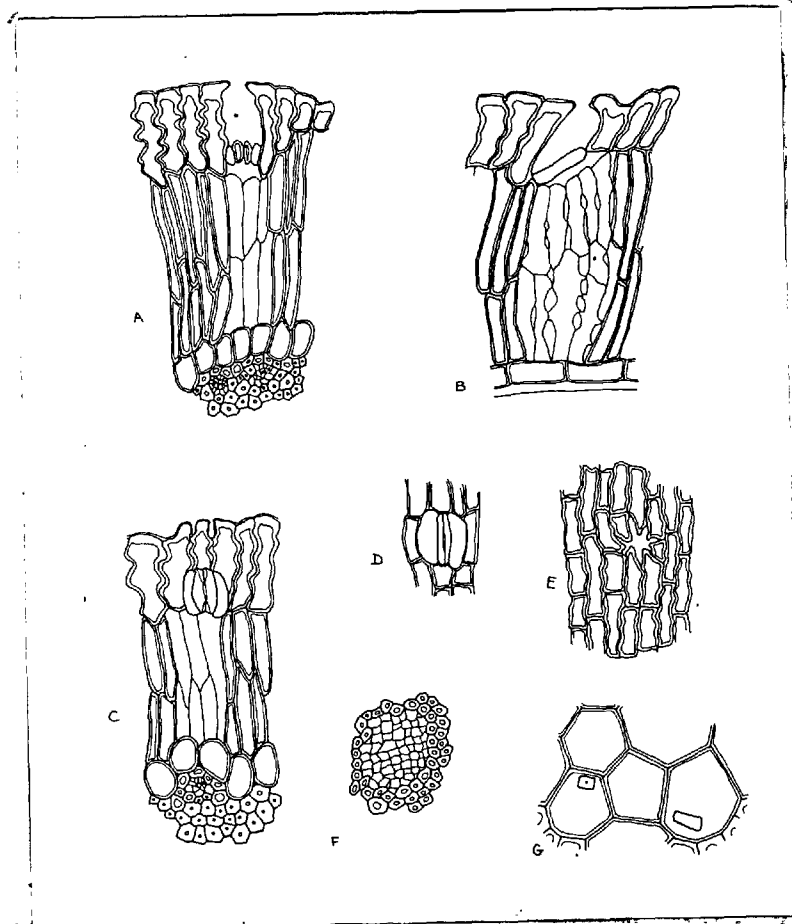


Fig. 36. Lyginia. <sup>D, E</sup> A, B, tenax, C, F, G, barbata.  
 A, C, part of culm T.S.; B, part of culm L.S., note  
 inclined stoma; D, stoma; E, culm epidermis at high  
 level of focus showing papillae extending over  
 region of stoma; F, part of culm T.L.S. at level of  
 chlorenchyma, note protective cells enclosing area  
 of chlorenchyma; G, crystals in cells of ground  
 tissue. (x185).