THE ANATOMICAL STRUCTURE OF SOME XEROPHYTIC NATIVE GRASSES.

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(Thirteen Text-figures.)

The grasses examined were :—*Spinifex hirsutus* Labill., (male plant), *Panicum flavidum* Retz., *Themeda avenacea* Hackel, *Astrebla pectinata* F.v.M., *Neurachne Mitchelliana* Nees, *Panicum decompositum* R.Br., *Chloris acicularis* Lindl., *Panicum leucophæum* H.B.K., *P. Benthami* Domin, *Eragrostis lacunaria* F.v.M., and *E. curvula* var. *valida* Stapf. These grasses, with the exception of the first, were obtained from the Nyngan district.

Spinifex hirsutus Labill., (male).

Hab.—On the sea-shores throughout Australia, New Caledonia, and New Zealand.

Growth-form.—Grows in the form of tufts. Stems creeping at the base. Leaves intensely hairy, felted in appearance, and soft. The ventral surface is much more hairy than the dorsal. The latter surface is thrown into depressions.

Leaf-anatomy (Fig.1).—A transverse section of a leaf shows a thick cuticle. The epidermal cells on the ventral surface are fairly regular in character, mostly rounded, and small-lumened. The stomata (St.) on this surface are numerous, and, in all cases, sunk in depressions. These depressions are formed by the cells bounding the stomata assuming a cylindrical shape, and being raised above the general level of the epidermal surface. The epidermal cells of the dorsal surface are larger than those of the ventral. The former surface is thrown into ridges of two distinct consecutive sizes, viz., a smaller one to be followed by one twice its depth.

The epidermal cells on the crests of the larger ridges are two-layered, and smaller than those bounding the smaller ridges.

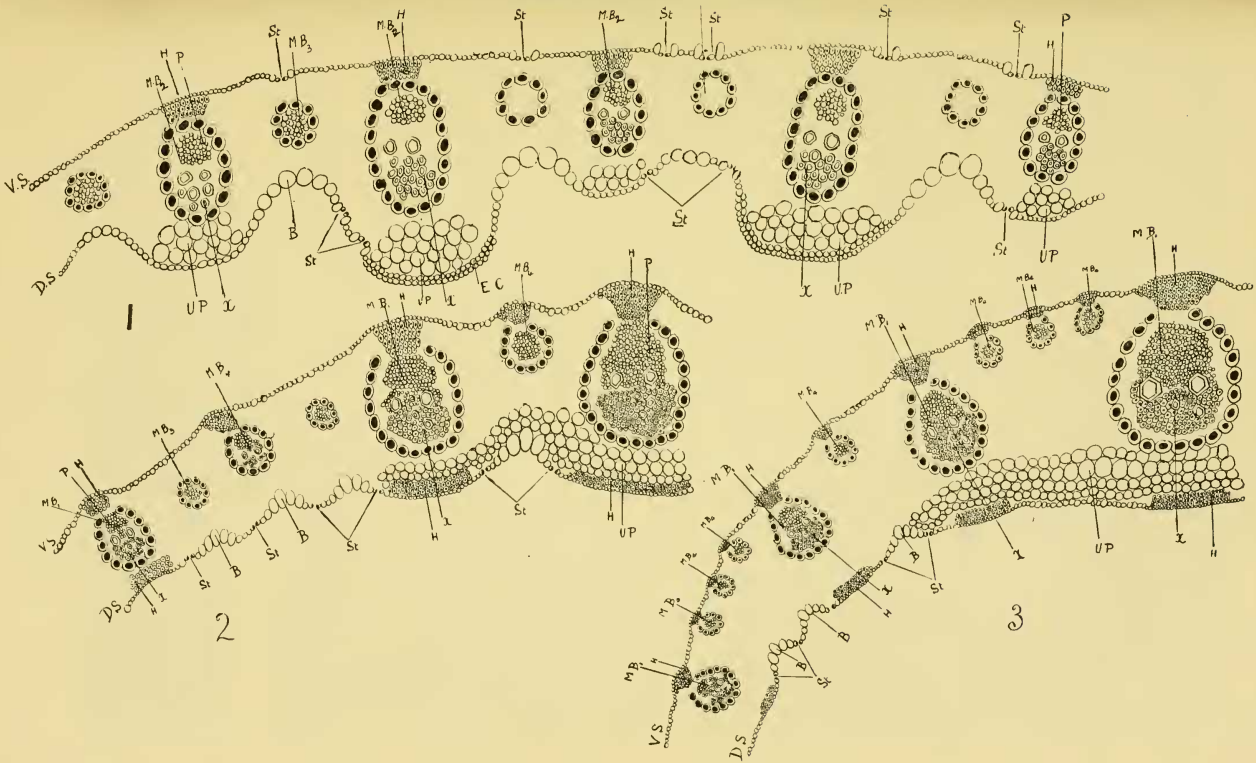


Fig. 1.—*Spinifex hirsutus* Labill. Fig. 2.—*Panicum flavidum* Retz. Fig. 3.—*Themeda avenacea* Hackel, (midrib).

The epidermal cells (B.) in the depressions are very large, and, although not distinctly bulliform in character, by their position and arrangement probably aid in the rolling of the leaf. The stomata are numerous, and invariably occur on the sides of the depressions. They are themselves sunk, being bounded by epidermal cells similar to those on the ventral surface. In the rolled-up position of the leaf, these stomata would be completely concealed.

There are two kinds of bundles, viz., those ($M.B_3$) in the narrow bands, closed, and not bounded by hypoderma; and those ($M.B_2$) in the wider bands, also closed, but bounded on the ventral surface by hypoderma. The smaller bundles ($M.B_3$) are completely surrounded by chlorophyll-bearing parenchyma, and contain no xylem-elements. The larger bundles ($M.B_2$) are similar in character. They are oval-shaped, and completely surrounded by chlorophyll-bearing parenchyma. The phloëm does not present any noteworthy features. The xylem, however, is characteristic in nature. All the vessels are extremely large, much larger than in any other grass examined, more or less uniform in size, and with very narrow lumens.

Between the epidermis of the dorsal face and the larger bundles are three to four rows of large, uncoloured parenchyma-cells, probably functioning as water-storage cells.

Conclusion.—The large, uncoloured parenchyma-cells, the extremely large xylem-elements, the depressed stomata, the narrow-lumened epidermal cells, the intensely hairy surfaces, all aid in the storage of water; to this purpose, the development of hypoderma (stereome) seems to be sacrificed.

Note.—The presence of hairs, which are extremely numerous, is not indicated in the diagram.

Explanation of References.

H., Hypoderma—P., Phloëm—X., Xylem—C.P., Chlorophyll-bearing parenchyma—B., Bulliform cells—M.S., Mestome-sheath—St., Stoma—U.P., Uncoloured parenchyma—$M.B_1$, Primary bundle—$M.B_2$, Special form of secondary bundle—$M.B_3$, Secondary bundle—$M.B_4$, Intermediate type of bundle—S.p.P., Sub-papillose protuberance—T., Trichome—V.S., Ventral surface—D.S., Dorsal surface.

Panicum flavidum Retz.

Hab.—New South Wales, Queensland, and tropical Asia. In this State, it is most common on the better class of soils.

Growth-form.—Tufted, bases of stems knotted but not bulbous; adventitious roots strong, long, and not typically fibrous. Leaves rigid, and often broad and scabrous.

Leaf-anatomy (Fig. 2).—The stomata (St.) are confined to the dorsal surface, while the bulliform cells are arranged in groups of six or seven, and occur in depressions.

The bundles are of three kinds ($M.B_1$), open below, but bounded on the dorsal and ventral surfaces by hypoderma. The secondary bundles ($M.B_3$) are completely enclosed by chlorophyll-bearing cells, and not bounded by hypodermal fibre. The bundles ($M.B_4$) are open on the ventral surface, but bounded by hypoderma only on that surface. The bundles of this series contain xylem as well as phloëm. The xylem of the bundles is better developed than in any of the other Panicums examined.

The midrib is well developed, and contains three primary bundles ($M.B_1$), and two bundles ($M.B_4$) of an intermediate type. The uncoloured parenchyma-cells are in two or three bands.

The hypodermal development of the leaf is large, and raises the surface at these points above the general level of the epidermis.

Conclusion.—The dorsal position of the stomata, the bulliform cells, the well developed hypoderma, the large and numerous xylem-elements, are the principal xerophytic features of this grass.

Themeda avenacea Hackel.

Hab.—Throughout Australia (except Tasmania). In this State, it grows principally on the black soils of the northern tablelands and north-western interior.

Growth-form.—Very tussocky, with well developed root-system. Bases of stems not bulbous. Leaves extremely coarse and rigid, mostly confined to the base of the plant.

Leaf-anatomy (Fig. 3).—The epidermal cells are small. The stomata are confined to the dorsal surface. Groups of bulliform cells, in series of five or six, occur.

The grass has a very distinct midrib. The mid-primary bundle is very large, contains well developed xylem-elements, and is bounded dorsally and ventrally by a large development of hypoderma. There are three primary bundles in the midrib, and the development of uncoloured parenchyma-cells on the dorsal surface is large.

The bundles are confined mostly to the primary ($M.B_1$) or the intermediate ($M.B_4$) types. The latter are characteristic, being close to the ventral surface, open, and bounded by hypoderma. There is, thus, a large development of palisade-tissue towards the dorsal surface.

Conclusion.—This grass presents some characteristic features. The harsh, rigid character of the leaves in the field is due to the extreme development of hypodermal fibre, greater, perhaps, in this grass than in any other examined.

On this development of hard tissue, and on the bulliform cells, the grass evidently depends for its xerophytic characteristics.

Astrebla pectinata F.v.M.

Hab.—New South Wales, Queensland, Northern Territory, Western and South Australia. In this State, it is found both on the red and black soils in the northern and western interior.

Growth-form.—Tufted, bases of stems bulbous. It is particularly characterised by the rapidity with which leaf-growth takes place at the joints under moist conditions.

Leaf-anatomy (Figs.4-5).—The epidermal cells of the ventral surface are much larger than those of the dorsal. The cuticle is moderately thick, but not so thick as in *Spinifex hirsutus* Labill.

The stomata (St.) are confined solely to the dorsal surface, and are on the sides of groups of bulliform cells. The latter (B.) are in groups of five. The middle bulliform cell is the largest, and the two on each side of decreasing dimensions. There appears to be no doubt, from the shape and arrangement of these cells, that they aid in closing the leaf, in which case the stomata would be hidden.

The bundles are of three kinds, viz., primary ($M.B_1$), secondary ($M.B_3$), and a special form of secondary ($M.B_2$). The primary

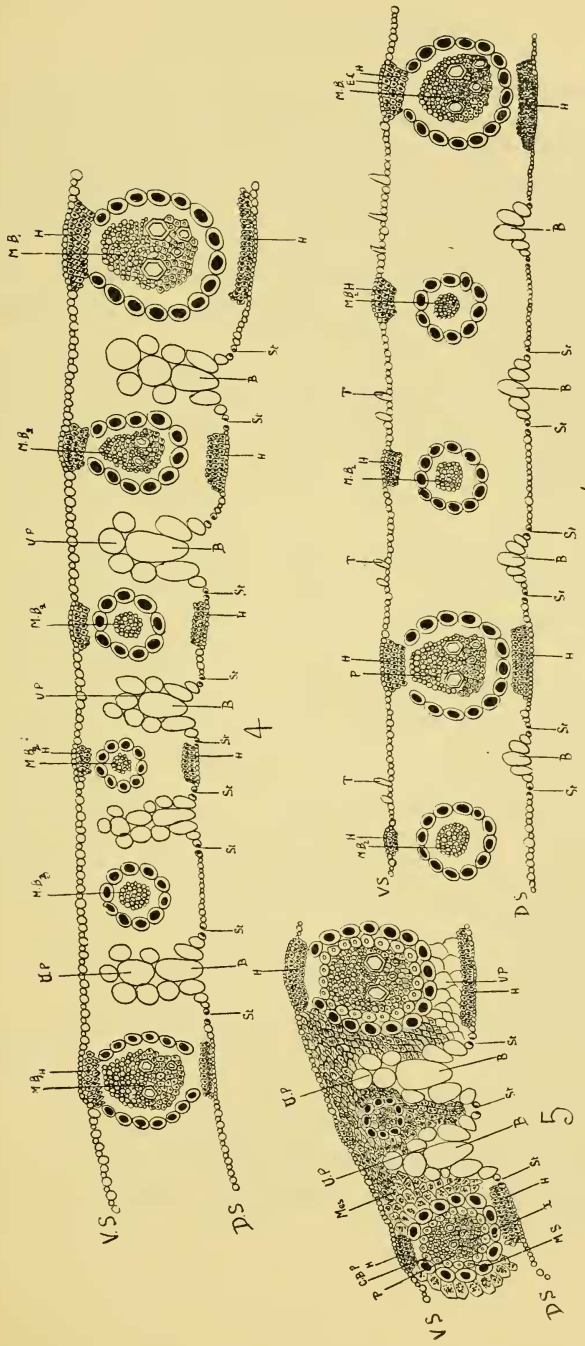


Fig. 4.—*Astrebla pectinata* F. v. M. Fig. 5.—*A. pectinata* F. v. M., (midrib). Fig. 6.—*Neurachne Mitcheliana* Nees.

bundles are open above and below, and bounded by hypoderma. The special forms of secondary bundles contain phloëm only, and are bounded, both on the dorsal and ventral surfaces, by hypoderma. These are the most numerous in the leaf. The secondary bundles are completely enclosed, contain phloëm only, and have no hypoderma either on the dorsal or ventral surfaces. As will be seen from Fig. 4, the arrangement of the bundles is irregular; two primary bundles may occur consecutively, the only difference being in the larger size of one of them.

Between each pair of bundles, colourless parenchyma-cells extend for almost the whole distance between the two surfaces. These cells are large, irregular in size, and separated in all cases from the chlorophyll-bearing parenchyma by palisade-tissue.

Conclusion.—A comparison of the structure of the leaf of this grass with that of *Spinifex hirsutus* presents some interesting features. The development of hypoderma in *Astrebla pectinata* is much greater than in *S. hirsutus*. This hypoderma (stereome), besides aiding in the mechanical strengthening of the leaf, also helps to repress transpiration The characteristic bands of colourless parenchyma-cells, present in this grass, are absent in *S. hirsutus*. It is probable that these bands of cells are utilised for the assimilation of the palisade-tissue. In the field, a noteworthy feature of the grass is the rapid development of new leaves from every node of the stem. The arrangement and distribution of the colourless parenchyma would allow light to penetrate readily into the palisade-tissue, even in the rolled-up position of the leaf-bud, and thus materially aid in the development of the leaf.

Another feature distinguishing it from *S. hirsutus* is the undepressed nature of the stomata.

The means adapted for rigidity, assimilation, and xerophytism in *A. pectinata* are thus different from those of the halophytic Spinifex, previously under review.

Neurachne Mitchelliana Nees.

Hab.—Interior of all the States, except Tasmania and Western Australia. In this State, it seems to be more common on the red than on the black soils.

Growth-form.—Tufted, bases of stems extremely bulbous and hairy. Leaves rigid, pungent, and very hairy.

Leaf-anatomy (Fig.6).—In this grass, the stomata are confined to the dorsal surface. Groups of bulliform cells occur between the bundles.

There are only two kinds of bundles, viz., primary ($M.B_1$), and a special form of secondary ($M.B_2$). The hypoderma is thus well developed under all the bundles. The primary bundles are more numerous than in any of the other grasses examined. Trichomes are very numerous.

Conclusion.—The trichomes, the position of the stomata, the bulliform cells, the large number of primary bundles, and the well developed hypoderma, are the principal xerophytic characteristics of this grass.

PANICUM DECOMPOSITUM (R.Br.).

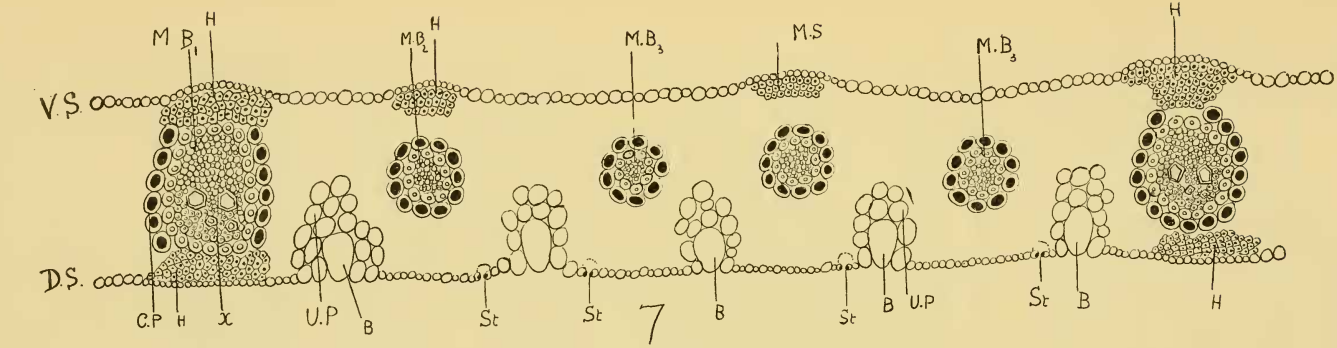
Hab.—Throughout Australia. It reaches its best development, in this State, on the red and black soils of the interior.

Growth-form.—Tufted. Stems very large and succulent. Base of stems bulbous. Leaves large, wide, and rather flaccid.

Leaf-anatomy (Fig.7).—The epidermal cells on the ventral surface are large, round, and fairly regular in size. Those developed over the hypoderma, however, are smaller and have thicker walls. Bulliform cells (B.), in groups of three, occur between the bundles. The stomata (St.) are, for the most part, arranged on the sides of the bulliform cells. Three kinds of bundles are present, viz., primary ($M.B_1$), secondary ($M.B_3$), and a special form of secondary ($M.B_2$). The secondary and the special form of secondary are about equal in numbers.

The hypodermal tissue (H.) is not as well developed as in *P. flavidum*. Groups of colourless parenchyma-cells (U.P.) extend between the bundles from the dorsal surface, about half the distance to the ventral surface.

Conclusion.—This is the only Panic-grass examined, in which the bands of colourless parenchyma occur, evidently adapted to aid assimilation. The grass, according to its leaf-anatomy, is not as xerophytic as *P. flavidum*, and this is also borne out by its behaviour in the field.



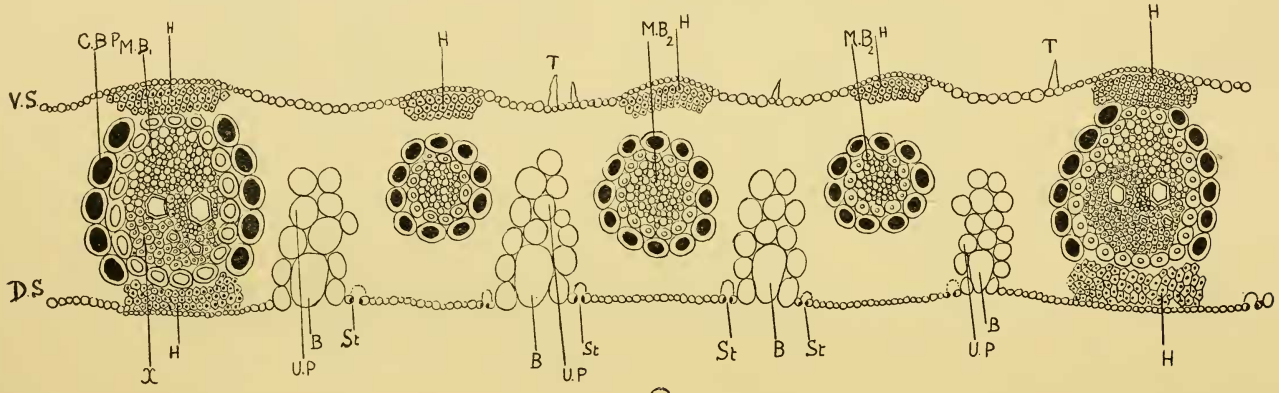


Fig.7.—*Panicum decompositum* R.Br.

Fig.8.—*Chloris acicularis* Lindl.

Chloris acicularis Lindl.

Hab.—Throughout Australia, except Tasmania. Very cosmopolitan, as regards its situation in this State.

Growth-form.—Tufted, somewhat rosette-shaped, bases of stems not bulbous, adventitious roots strongly developed, leaves fairly rigid and pungent.

Leaf-anatomy (Fig.8).—The stomata (St.) are confined to the dorsal surface, and are arranged on the edges of groups of three well developed bulliform cells (B.). The bundles are either primary ($M.B_1$), or a special form of secondary ($M.B_2$). They are large, with well developed xylem-elements. The hypoderma is very well developed. Bands of colourless parenchyma-cells extend between the bundles for about three-quarters of the distance between the two surfaces.

Conclusion.—This grass presents typical xerophytic features in the development of hypoderma, in the bands of colourless parenchyma-cells, in the position of the stomata, and in the bulliform cells.

Panicum leucophæum H.B.K.

Hab.—Throughout Australia, particularly in the interior. Also in tropical Africa and America. It is very partial to shady situations.

Growth-form.—Tufted, bases of stems bulbous and hairy. Leaves narrow and rather flaccid.

Leaf-anatomy (Fig 9).—The epidermal cells on the ventral surface are interrupted by stomata, and trichomes (T.) are numerous. On the dorsal surface, bulliform cells, in groups of five, occur between the bundles; and stomata, as a rule, occur on one side of these groups of cells. Trichomes are numerous on this surface also.

The bundles are of three types, viz., primary ($M.B_1$), secondary ($M.B_3$), and a special form of secondary ($M.B_2$). The secondary bundles, with no hypoderma, are most numerous.

Conclusion.—This is the least xerophytic of all the Panic-grasses examined. The hypoderma is comparatively weakly developed, the bundles are small, and the bulliform cells are not

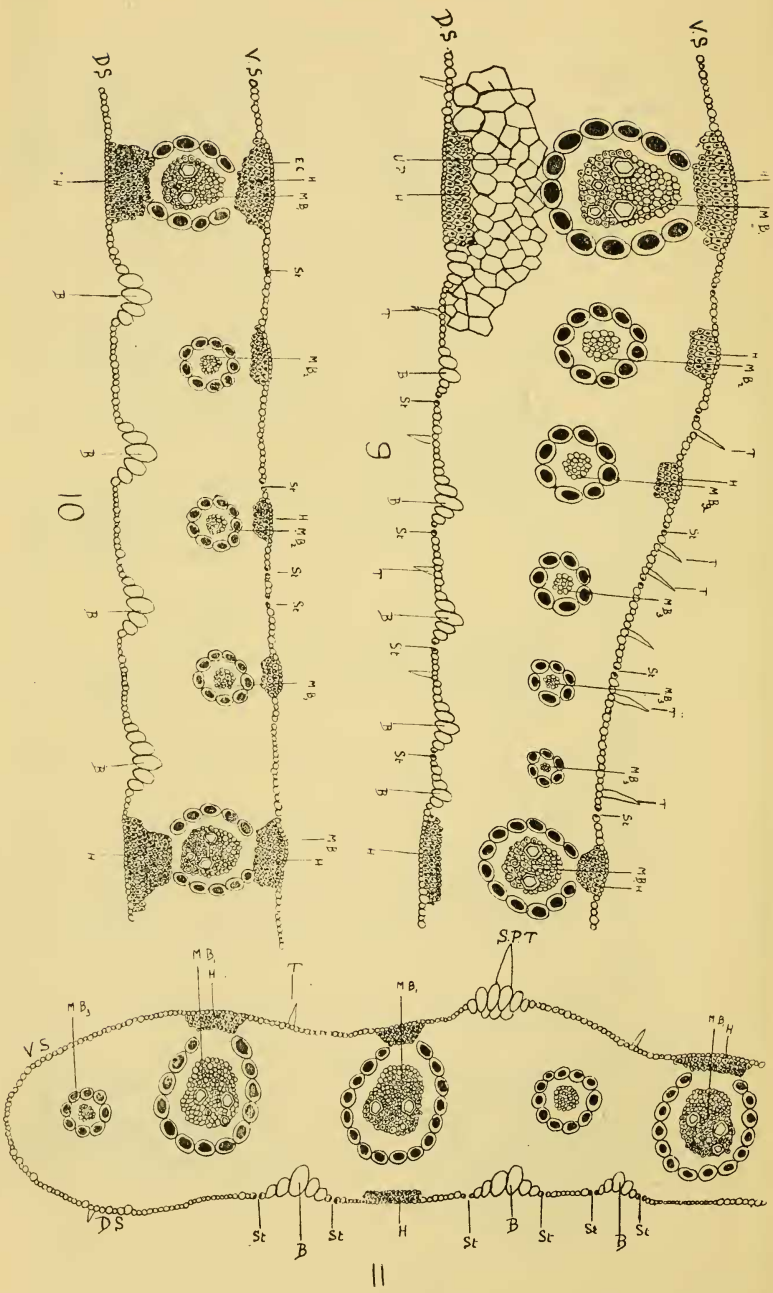


Fig. 9.—*Panicum leucophæum* H.B.K. Fig. 10.—*P. Benthami* Domin. Fig. 11.—*Eragrostis lacunaria* F. v. M.

so distinctly fan-shaped as in the others. My experience of the grass in the field is that, while its rootstock is extremely permanent and drought-resisting, the foliage quickly withers under drought-conditions.

Panicum Benthami Domin.

Hab.—Interior and northern tablelands of the State. The grass occurs principally on the black or alluvial soils.

Growth-form.—Tufted, extreme stem-development, bases of stems hairy but not bulbous, leaves fairly coarse and rigid.

Leaf-anatomy (Fig. 10).—Stomata were seen only on the ventral surface. On the dorsal surface, the bulliform cells (B.), arranged in groups of five or six between the bundles, are large, and form slight depressions.

The bundles are of two kinds, viz., primary ($M.B_1$), and a special form of secondary ($M.B_2$). Hypoderma is developed under all the bundles.

Conclusion.—The order of xerophytism of the Panic-grasses according to their leaf-structure, is thus as follows:—(1) *Panicum flavidum*, (2) *P. decompositum*, (3) *P. Benthami*, and (4) *P. leucophæum*. This corresponds, in my experience, to their behaviour in the field.

Eragrostis lacunaria F.v.M.

Hab.—In the interior of all the States, except Tasmania and Western Australia. In the interior of this State, it is very common on the red soils.

Growth-form.—A small, tufted grass, bases of stems not bulbous, leaves rigid and rather coarse.

Leaf-anatomy (Figs. 11-12).—The epidermal cells on the ventral surface are irregular in size. Trichomes are numerous. A striking feature of some of these trichomes is their large size. The latter are arranged on groups of four or five, large, epidermal cells, somewhat fan-shaped in character; the whole structure may be called a sub-papillose protuberance (S.p.P.).

On the dorsal surface, groups of six bulliform cells occur between the bundles; they are situated in depressions, and have stomata (St.) on their edges.

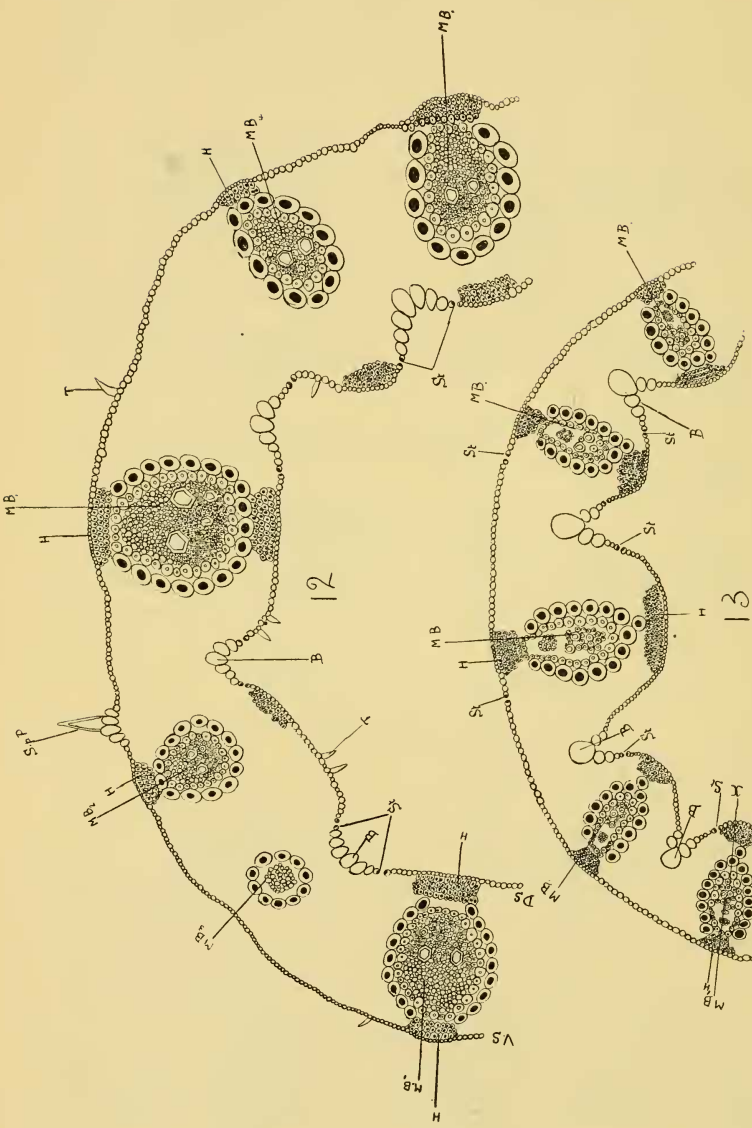


Fig. 12. –*Eragrostis lacunaria* F. v. M., (midrib). Fig. 13.—*E. curvula* var. *valida* (Stapf).

The bundles are of four kinds, viz., primary ($M.B_1$), secondary ($M.B_3$), and a special form of secondary ($M.B_2$), and those of an intermediate type ($M.B_4$). They are about equal in numbers.

The xylem in the bundles consists, for the most part, of small vessels.

Conclusion.—The xerophytism of this grass is shown by its trichomes, bulliform cells, and well developed hypoderma.

ERAGROSTIS CURVULA var. VALIDA Stapf.

Hab.—South Africa, and probably the United States of America. It occurs only under cultivation in this State.

Growth-form.—Tussocky, stems hard and woody, adventitious roots long and tough. Leaves long, coarse, but rather flaccid.

Leaf-anatomy (Fig.13). Stomata occur on both surfaces. Trichomes are absent. The bulliform cells are characteristic; they occur in distinct depressions, and the middle one is very large.

All the bundles ($M.B_1$) are primary, and contain large xylem-elements. Hypoderma is very well developed.

Conclusion.—This grass, an introduced one, is under review for the purpose of comparing it with *E. lacunaria*. Both are growing side by side at Nyngan Demonstration Farm, and both are showing well marked xerophytism. It will be noticed that the leaves of *E. curvula* var. *valida*, which are very long, have much better developed hypoderma and xylem-elements than *E. lacunaria*; this is probably for the purpose of maintaining the rigidity of the leaf.

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