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A cytological and morphological study in cynodon species

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A CYTOLOGICAL AND MORPHOLOGICAL STUDY IN CYNODON SPECIES

by

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Being a paper presented in fulfilment of the regulations governing the degree of Master of Science in Botany, at the University of the Witwatersrand.

Johannesburg,
February, 1947.

UNIVERSITY OF THE
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WITWATERSRAND

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INTRODUCTION

The increasing interest in turf problems which results from the growing demand for ornamental lawns, sports fields and aerodromes has emphasized the value of Cynodon species as lawn grasses.

Many problems have arisen in connection with the systematics of the genus Cynodon and there is great necessity that these anomalies be cleared up and the genus thoroughly revised. The confused taxonomy is due to the wide range of variability existing within so-called species and also to the large number of intergrading forms that occur between these species.

The study of this genus was undertaken with the object of disclosing definite characteristics which would enable workers to distinguish between species and varieties of Cynodon and to identify isolated plants.

It was decided to commence the work with the study of Cynodon grasses in common use. The five lawn grasses selected are known to gardeners and field-workers as "Coarse kweek" (C. dactylon Pers.), "Florida" (C. transvaalensis Burtt Davy), "Bradley" (C. Bradleyi Stent), "Magennis" and "Hall's Selection". The three first-mentioned are recognised species. The writer found "Magennis" to be a hybrid between C. dactylon and C. transvaalensis. Because this hybrid reproduces vegetatively and so remains true to type, it has been given specific rank and is referred to as Cynodon Magennisii Hurcombe sp. nov.. "Hall's Selection" was found to be a variety of C. dactylon; it is referred to as C. dactylon Pers. var. iensus Hurcombe var. nov. owing to its compact habit of growth.

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In the past, morphological distinction has been considered decisive, or at least of major importance, as a criterion of

species - difference. The rise of other branches of biology has exerted a profound effect on the outlook of taxonomists, with the result that the artificiality of the purely morphological species-concept has become apparent. It is now recognised that all aspects of biological research must be utilised for taxonomic purposes, and that the final judgement must be based on the maximum correlation of all the available data.

In accordance with this outlook of "The New Systematics", it was decided to base the classification of the Cynodon genus on a study of external morphology, leaf anatomy and chromosomes.

PLATE 1



Cynodon dactylon Pers.

Moss Herbarium 21713

HISTORY OF THE SPECIES.

Cynodon dactylon Pers.

This cosmopolitan grass is widely distributed throughout the warmer regions of both hemispheres. It is known in South Africa as "Kweek gras" or "Couch grass", in America as "Bermuda grass", in Australia as "Couch grass", as "Bahama grass" in the West Indies, and as "Doub" in India. Bews (1929) writes: "It is probably a native of the Mediterranean region, though it may be indigenous in South Africa, and elsewhere in the Southern Hemisphere as well."

Although fairly constant in its essential characters, the grass varies in habit according to the locality and to the conditions under which it is grown. The species was first described by Dr. C.H. Persoon in "Synopsis Plantarum", vol. 1, 1805. This original description is very brief and subsequent workers have enlarged it considerably, with the result that these later descriptions vary within fairly wide limits.

C. dactylon is essentially a pioneer grass; it is occasional to abundant in all disturbed and exhausted areas, including old roads, burned veld, overgrazed land, river banks, termite's nests, abandoned kraals, and cultivated lands. Because of its capacity for binding soil and because of the rapidity with which it covers bare ground, it has been used, both in this country and in America, to prevent erosion. Throughout the war it was found suitable as a turf grass for aerodromes owing to the fact that it rapidly produced a good cover and was hard-wearing and drought-resistant.

In parts of India, Australia, and in the Southern States of America, C. dactylon is valued as a pasture grass. According to Hitchcock (1935): "Bermuda grass is the most important pasture grass of the Southern States....On alluvial ground it may grow sufficiently rank to be cut for hay."

In South Africa this grass seldom attains any height and is generally regarded as a troublesome weed which is difficult to eradicate. Meredith (1944) concluded that C. dactylon was more hardy and usually more nutritious than many other veld grasses and that it responded well to fertiliser treatment. He suggests that more attention should be given to this grass which could be one of the more valuable South African pasture grasses.

C. dactylon is extensively cultivated as a lawn grass in most of the warm countries where it occurs. Stent (1927a) writes: "...it makes a smooth, compact, but rather coarse lawn, and withstands drought well..."

Cynodon transvaalensis Burtt Davy

Stent (1927b) gives the following account of the history of this grass: "The grass was first noticed on the Germiston Town lands and a florist in Johannesburg dug up roots and planted it in his nursery and thence distributed it as Germiston grass. Subsequently another nurseryman discovered the same grass growing at Florida, another suburb of Johannesburg, and distributed roots of this under the name of Florida grass." According to Meredith (1937) C. transvaalensis was used for one of the first grass greens put down in the Transvaal in 1908.

Burtt Davy in his original description of C. transvaalensis in the "Kew Bulletin", 1921, refers to it as a "strikingly distinct species". He says: "I have had C. transvaalensis under cultivation for many years, under precisely similar conditions of soil, moisture, exposure, etc., and alongside of both C. dactylon Pers., and C. incompletus Nees; it retains its characters without showing any tendency in the direction of either species. Transplanted from the damp sandy soil of a dam margin to a harder and drier soil, it also retains its characters."

Stent (1927a) considers C. transvaalensis to be a natural

hybrid between C. dactylon and C. hirsutus.

C. transvaalensis is one of the most popular lawn grasses of South Africa; it makes a fine, level, compact, springy turf of a vivid yellow-green. It is fairly hardy and if provided with a certain amount of moisture will keep green throughout the hottest summer.

Cynodon Bradleyi Stent

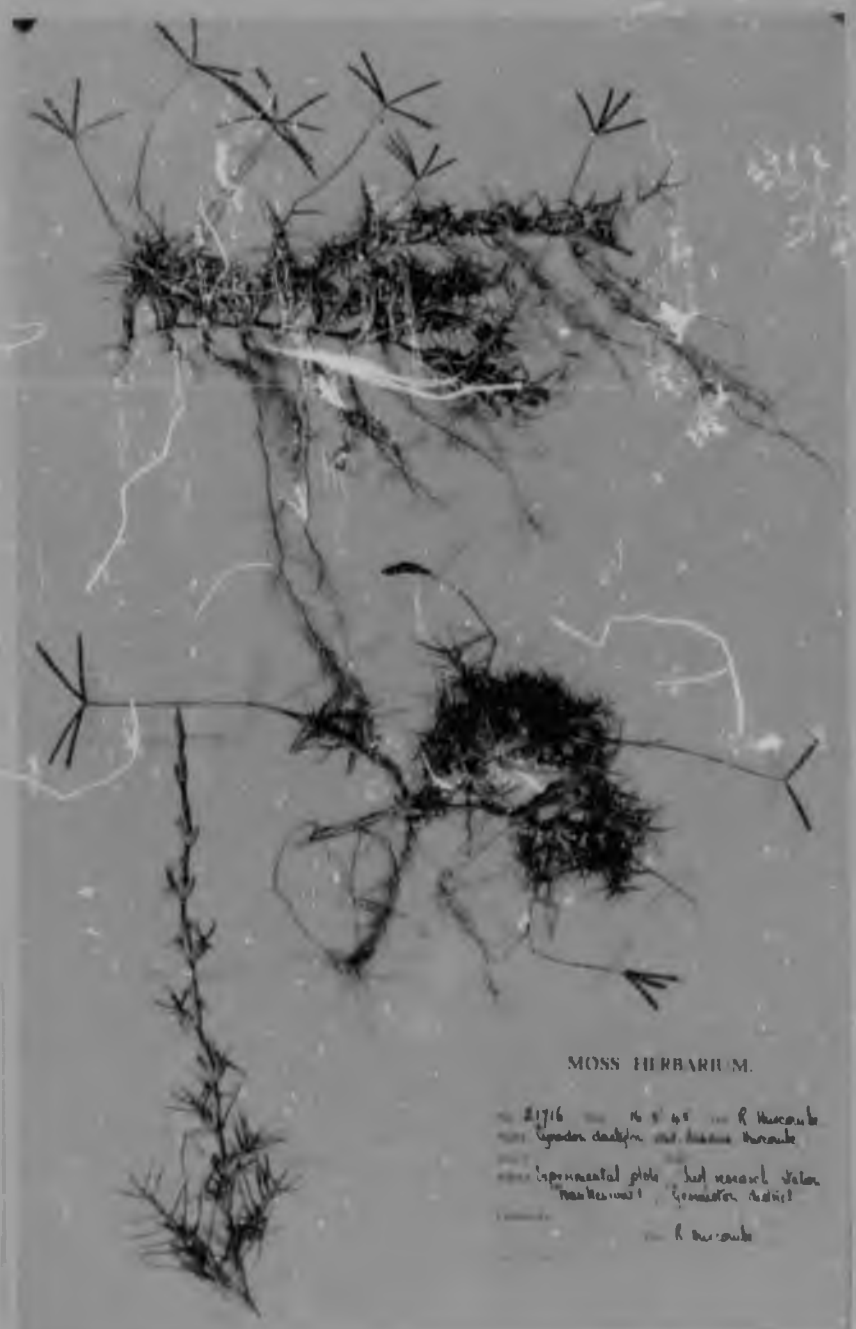
Cynodon Bradleyi Stent

To quote Stent (1927b): "The grass is named after Mr. William Bradley who first observed it growing on the veld just outside Johannesburg, and thinking it had possibilities as a lawn grass, cultivated a plot of it and eventually put it on the market. It became very popular simply because it was new." According to Meredith (1937), Mr. Bradley made the first lawn of this grass prior to 1910.

The original description of C. Bradleyi was made by Stent in "Bothalia", vol. II, 1927. In Stent's opinion the grass in a natural hybrid between C. dactylon and C. hirsutus, resembling the latter more than the former. (C. hirsutus Stent - "Red kweek" or "Transvaal kweek" - is a coarse grass indigenous to the Transvaal and Southern Rhodesia.) She did not consider "Bradley" to be a true species, but conferred specific rank on the grass for the sake of convenience; "Bradley grass" was being widely cultivated, and as it did not set seed and was being propagated vegetatively, it remained true to type.

In recent years C. Bradleyi has become a very popular lawn grass. It has one advantage over C. transvaalensis in that it grows very rapidly: "....planted in rows 9 in. to 2 ft. apart it will under favourable conditions completely cover the ground in 2 months..." (Stent, 1927b). However, it is not as hardy as C. transvaalensis; being a "surface grass" it does not readily withstand drought or rough usage. It is also susceptible to fungous diseases and to the attack of a nematode (Anguillulina tumefaciens). This endemic parasite produces galls on the leaves and stem and may in time destroy a whole lawn.

PLATE



Cynodon dactylon Pers. var. densus Hurcombe var. nov.

Moss Herbarium 21716

Cynodon Magennisii Hurcombe sp. nov.

Matthews (1935), in an article entitled "Lawn grasses on trial at Kirstenbosch", has included the following note supplied by Mr. W.D. Magennis on the origin of "Magennis grass".
"In August, 1920, when Magistrate of East London, I planted a fairly large section of Florida grass from the Transvaal in the Residency garden at East London. The Florida was allowed to grow naturally and seeded - not having been cut. In the fence adjoining the Florida, and along the sides of the road outside, the East London Kweek grass grew profusely and seeded. Pollination of the Florida by the East London Kweek must have taken place for in 1922 a seedling appeared amongst the Florida. This seedling grew rapidly and soon a small lawn was planted with it. This grass has the fineness of the Florida with the vigour of the Kweek. In 1923 I took a few rootlets to Kimberley. It thrived, and Mr. Sharwood of the Kimberley Bowling Club became interested in its possibilities for Bowling Greens and called it the Magennis grass. A green was in course of construction at Wolselton and half of this green was planted with it. Its success was phenomenal. Since then many greens have been planted with this grass. It seems particularly adapted to the Northern Provinces."

Unfortunately this grass is frequently attacked by the red mite (Tetranychus sp.) which may cause considerable damage.

Cynodon dactylon Pers. var. densus var. nov.

Dr. T.D. Hall, when on a visit to the Germiston Golf Course in December, 1933, found that patches of a "coarse kweek" were being removed from the 15th green. He transplanted a sod of this grass to the turf experimental plots at Frankenwald where it was referred to as "Hall's Selection."

This variety of C. dactylon forms a compact, dense cover and has been found to be hardy and drought resistant. For these reasons it is particularly suitable for sportsgrounds which will be subjected to frequent hard usage.

MATERIAL AND METHODS

The Cynodon species selected for study were grown in the experimental plots at Frankenwald, the Botanical Research Station of the University of the Witwatersrand, 14 miles north of Johannesburg. C. dactylon was grown from seed harvested at the end of 1943 on the Nigel aerodrome. (The grass is indigenous to this area). C. dactylon var. densus was grown from a sod taken from the Germiston Golf Course in December, 1933, and C. Magennisii from rhizomes obtained from a lawn at the University in 1936. Both C. transvaalensis and C. Bradleyi were originally planted at Frankenwald in December, 1933, but their source is unknown. Before the commencement of this study, therefore, the five grasses had been growing in a common testing ground for at least three years and had throughout this time retained their original distinguishing features.

On September 25th., 1945, three sods of each of these five grasses were planted at random on a clean area of soil at Frankenwald. The sods were watered once a week and the grass was allowed to grow rank. On Plates 6 to 8 are photographs of a sod of each grass taken three months after planting.

Material for both the morphological and the cytological study was taken from these sods, as also were the specimens of each grass which were placed in the University herbarium. These pressed specimens were numbered as follows:-

C. dactylon	Moss Herbarium		21713
C. transvaalensis	"	"	21712
C. Bradleyi	"	"	21714
C. Magennisii	"	"	21717
C. dactylon var. densus	"	"	21716

Photographs of these herbarium sheets will be found on Plates 1 to 5.

A careful description of the methods used in the cytological and in the morphological study will be found in these respective sections. Although the writer is aware that a detailed

description of routine techniques is not usually included in an M.Sc. thesis, yet it was felt that such detail would be appreciated by students working for the first time on the anatomy or cytology of similar grasses.

PLATE 3



Cynodon transvaalensis Burtt Davy

Moss Herbarium 21712

EXTERNAL MORPHOLOGY

METHODS

Previous workers have found difficulty in separating the various Cynodon species and varieties on a morphological basis. Although certain of these grasses appear to be quite distinctive as regards their general appearance, yet closer study reveals the fact that they are very similar in all essential characters. The writer, therefore, decided to study the morphology of the Cynodon species selected in great detail, in order to detect possible minute differences which might prove constant or specific.

In order to determine the vernation of the leaves, sections of the shoot were cut from a region as far as possible from the shoot apex where the young leaves were surrounded by at least two leaf sheaths.

A general description of the external morphology of the Cynodon genus is included, in order to introduce the terminology which has been used throughout the descriptions of the species.

DESCRIPTION OF EXTERNAL MORPHOLOGY

External Morphology of Cynodon Rich.

Perennial grasses with creeping stolons and rhizomes, rooting at the nodes and emitting from them fascicles of barren shoots and flowering culms; several slender spikes arranged digitately at the summit of the culm; spikelets 1-flowered, solitary, sessile, imbricate, unilateral in 2 rows on the slender keeled rachis, awnless, laterally compressed; rachilla disarticulating above the glumes and prolonged or not beyond the lemma as a slender naked bristle sometimes bearing a rudimentary floret; floret hermaphrodite; glumes 2, about equal, keeled, 1-nerved, shorter than the floret, membranous; lemma 1, exceeding the glumes, 3-nerved, firmly membranous, subtending a pale and a bisexual flower; pale about

as long as the lemma, 2-keeled, membranous; lodicules 2; stamens 3; ovary glabrous; styles distinct, about as long as the plumose stigmas; grain oblong, subterete.

External Morphology of Cynodon dactylon Pers. (Plates 1-6)

Vegetative characters.

Habit. Ascending and creeping perennial sending out long surface runners and underground rhizomes that root and shoot from the nodes; rhizomes penetrate to a depth of 45 cm.

Stem.

Underground stem. Branched; node glabrous; internode glabrous, hollow, 2 to 4 mm. in diameter, 1 to 5 cm. long, exserted.

Prostrate aerial stem. Node glabrous; internode glabrous, hollow, green or brown, 2 to 3 mm. in diameter, 3 to 10 cm. long, exserted.

Flowering culm. Erect or sub-ascending; many-noded; up to 40 cm. long (excluding inflorescence); node glabrous; internode glabrous, hollow, the lower internodes very short and inserted, the upper much longer and more or less exserted, sulcate, uppermost internode 0.5 to 1 mm. in diameter.

Shoot. Circular or elliptical in t.s.

Leaf. Leaves conspicuously distichous.

Sheath. 1.5 to 6 cm. long; split throughout its length; glabrous or sparsely hairy, bearded at the mouth with tubercle-based hairs 1 to 3 mm. long; finely striate; distinctly keeled.

Ligule. Reduced to a short, densely ciliate and fimbriate rim about 0.3 mm. long.

Blade. Folded or more usually flat when mature, folded in the bud and on drying; keeled; linear or lanceolate; apex obtuse to acutely acuminate; length varies from 2 to 16 cm; 3 to 4 mm. wide near the base; 2 primary nerves and 5 to 11 secondary nerves on either side of the midrib; nerves fine,

distinct, prominent on the abaxial surface; margin scabrid, keel smooth or slightly scabrid; usually glaucous green; rigid; abaxial surface glabrous or very sparsely hairy, adaxial surface sparsely or very hairy, hairs 1.5 mm. long and tubercle-based; adaxial surface distinctly scabrid, abaxial surface smooth.

Floral characters.

Spikes. Digitate, arising from one level, occasionally sub-digitate; usually 4 or 5, often 3, rarely 2 or 6; 1.5 to 6.5 cm. long; purplish; not reflexed.

Rachis. Rounded straight keel; keel and margin minutely scabrid; glabrous except at the microscopically pubescent base; bearing loosely imbricating spikelets, lowest spikelet borne near the base to 4 mm. above the base; deeply and bluntly notched on the margin at the insertion of the spikelets; striate; about 0.4 mm. wide; flattened.

Spikelet. Oval and unequal-sided; acute; 2 to 2.5 mm. long, purplish; rachilla produced into a bristle 1 to 1.5 mm. long, usually bearing a reduced purplish floret.

Glumes. Usually subequal; upper glume straight, about 1.6 mm. long; lower glume curved, about 1.8 mm. long; more than half the length of the spikelet, sometimes almost as long; 1-nerved; smooth except for the scabrid green keel; acuminate apex.

Lemma. Not winged; broadly ovate; 2 to 2.5 mm. long, 0.8 mm. wide (folded); 3-nerved, side-nerves run from the base to within 0.7 mm. of the apex, mid-nerve distinctly excurrent below the apex forming a scabrid projection which usually projects above the apex; prominent appressedly ciliate keel, cilia 0.2 mm. long; apex obtuse and hyaline; purplish.

Pale. Narrowly elliptic; equalling the lemma in length; 0.5 mm. wide (folded); deeply canaliculate between the 2 dark green firm minutely scaberulous keels; apex rounded or narrowly truncate; purplish.

Lodicules. Minute, fleshy, cuneate, 0.3 mm. long.

PLATE 4



Dynodon Mugennisii Hurcombe sp. nov.

Moss Herbarium 21717

Stigmas. Exserted at the top of the ovary, plumose from below the middle, purple.

Ovary. Broadly ovate.

Grain. Oblong; 1.5 mm. long, 0.6 mm. wide.

(This grass seeds fairly freely).

The original description of C. dactylon by Persoon (1805) in "Synopsis Plantarum" agrees in all respects with that given above. Subsequent workers, however, have enlarged this original description and these later descriptions are found to vary considerably.

As regards the length of the leaf and of the spike, the writer's observations are supported by the description of C. dactylon in "Flora Capensis" (1900); both Fisher (1940) and Stent (1927), however, find that the leaf blades are 2 to 10 cm. long, and the spikes 3 to 5.5 cm. long. According to these two workers, the flowering culms are 30 cm. long, while Hews (1929) maintains that they may reach a height of 2 feet (approx. 60 cm.). Stent records 3 to 8 spikes, although most workers find that the number of spikes does not exceed 5 to 6. In no descriptions, other than the writer's, is a clear distinction made between the hairiness of the upper and lower leaf surfaces, the leaf being merely described as glabrous or hairy.

Ek (1942), in an article on varieties of C. dactylon found in Indiana, notes that there may be 6 to 10 spikes (rarely 11 to 14) 5 to 10 cm. long and that leaves 5 to 6 mm. wide and 25 cm. long were observed. Unfortunately this article was obtainable only in abstract and no reference was made to the possible cause of such size and vigour.

External Morphology of Cynodon dactylon Pers. var. densus Harcombe var. nov. (Plates 2 and 6).

A C. dactylone differt habitu repentiore, densiore caespite et auctu tardiore.

Vegetative characters.

Habit. Prostrate, very densely caespitose perennial sending out surface runners and underground rhizomes which root and shoot from the nodes; rhizomes penetrate to a depth of 8 cm.

Stem.

Underground stem. Branched; node glabrous; internode glabrous and hollow, 1.5 to 3 mm. in diameter, 1 to 2.5 cm. long, exserted.

Prostrate aerial stem. Node glabrous; internode glabrous, hollow, green or brown, 1.5 to 2 mm. in diameter, 1.5 to 3 cm. long, exserted.

Flowering culm. Erect; 3 to 5-noded; up to 10 cm. long (excluding inflorescence); node glabrous; internode glabrous, hollow, the lower internodes very short and inserted, the upper much longer and exserted, sulcate, uppermost internode 0.5 to 0.8 mm. in diameter.

Shoot. Circular or elliptical in t.s.

Leaf. Leaves conspicuously distichous.

Sheath. 5 to 15 mm. long; split throughout its length; glabrous, bearded at the mouth with tubercle-based hairs 1 to 2 mm. long; finely striate; distinctly keeled.

Ligule. Reduced to a short densely ciliate and fimbriate rim about 0.4 mm. long.

Blade. Folded or flat when mature, folded in the bud and on drying; keeled; linear or lanceolate; apex rounded or obtuse; 5 to 30 mm. long; 2 to 3 mm. wide near the base; 2 primary nerves and 5 to 9 secondary nerves on either side of the midrib; nerves fine, distinct, prominent on the abaxial surface; margin minutely scabrid; keel smooth or slightly scabrid; dark green; rigid; abaxial surface glabrous, adaxial surface hairy or occasionally glabrous, hairs 0.5 mm. long and

tubercle-based; adaxial surface slightly scabrid, abaxial surface smooth.

Floral characters.

Spikes. Digitate, arising from one level; usually 4, often 2 or 3; 1.5 to 2.5 cm. long; purplish; not reflexed.

Rachis. Sharp straight keel; margin minutely scabrid, keel smooth; glabrous except at the microscopically pubescent base; bearing closely imbricating spikelets inserted in shallow alternate notches on the rachis, lowest spikelet borne near the base to 2 mm. above the base; striate; approximately 0.6 mm. wide; flattened.

Spikelet. Broadly oval and unequal-sided; obtuse; 2 mm. long; purplish; rachilla produced into a slender bristle usually less than 1 mm. long, and often bearing a reduced purplish floret.

Glumes. Usually subequal; upper glume straight, about 1.4 mm. long; lower glume curved, about 1.6 mm. long; more than half the length of the spikelet; 1-nerved; smooth except for the scabrid green keel; acute apex.

Lemma. Not winged; broadly ovate; 2 mm. long, 1 mm. wide (folded); 3-nerved, side-nerves run from the base to within 0.6 mm. of the apex, mid-nerve distinctly excurrent from just below the apex forming a scabrid projection; appressedly ciliate keel, cilia 0.2 mm. long; apex obtuse and hyaline; purplish.

Pale. Narrow elliptic; slightly longer than the lemma; 0.5 mm. wide (folded); deeply canaliculate between the 2 dark green firm minutely scaberulous keels; apex rounded or narrowly truncate; purplish.

Lodicules. Minute, fleshy, cuneate, 0.3 mm. long.

Stigmas. Exserted at the top of the ovary, plumose from below the middle, purplish.

Ovary. Narrowly ovate, usually undeveloped.

Grain. Mature grain occasional; oblong; 1 mm. long, 0.7 mm. broad.

PLATE 5



Cynodon Bradleyi Stent

Moss Herbarium 21714

Although C. dactylon var. densus closely resembles C. dactylon in all essential characters, these two grasses differ markedly as regards their habit and growth form. C. dactylon var. densus is a more prostrate, tufted grass; the rhizomes of C. dactylon penetrate the soil to a depth of 45 cm., whereas those of the variety seldom grow deeper than 5 cm.

Associated with this difference in their habit is the fact that the length of the stem internodes, of the leaf sheath and blade, of the flowering culm and spikes, and of the tubercle-based hairs, is much greater in C. dactylon; for instance, the leaf blade seldom exceeds 3 cm. in length in the variety while in C. dactylon it may be 16 cm. long.

C. dactylon is a vigorous grass which seeds readily; C. dactylon var. densus is slow-growing and only occasionally produces mature grain.

External Morphology of Cynodon transvaalensis Burtt Davy

(Plates 3 and 7).

Vegetative characters.

Habit. Densely caespitose perennial sending out surface runners and underground rhizomes which root and shoot from the nodes; rhizomes penetrate to a depth of 5 to 8 cm.

Stem.

Underground stem. Branched; node glabrous, usually contracted giving the stem a beaded appearance; internode glabrous, hollow, 2 to 3 mm. in diameter, 0.5 to 1 cm. long, exserted.

Prostrate aerial stem. Node glabrous; internode glabrous; hollow, dark purple, 0.5 to 0.9 mm. in diameter, 2 to 4 cm. long, exserted.

Flowering culm. Erect; 2 to 6-noded; 5 to 12 cm. long (excluding inflorescence); node glabrous, slightly contracted; internode glabrous, hollow, usually exserted, sulcate, uppermost internode 0.2 to 0.5 mm. in diameter.

Shoot. Circular or elliptical in t.s.

Leaf. Leaves distichous, but not conspicuously so.

Sheath. About 1 cm. long; split throughout its length; usually glabrous or with a few scattered tubercle-based hairs 0.5 mm. long; bearded at the mouth with tubercle-based hairs 1 to 1.4 mm. long; finely striate; keeled; often purplish.

Ligule. Membranous, 0.3 mm. long, fimbriate; or reduced to a ciliate rim.

Blade. Flat or more usually folded when mature, folded in the bud and on drying; distinctly keeled; narrowly linear, subulate; apex obtuse or rounded; up to 5 cm. long; 1 to 1.5 mm. wide near the base; 1 primary nerve and 5 or 6 (usually 5) secondary nerves on either side of the midrib; nerves fine and slightly prominent on the abaxial surface; margin scabrid; keel slightly scabrid; bright yellow green; flaccid, sparsely hairy with tubercle-based hairs 0.5 mm. long, evenly spread over both surfaces; adaxial surface slightly scabrid, abaxial surface usually smooth.

Floral characters.

Spikes. Digitate, arising from one level; usually 2, rarely 1 or 3; 1 or 2 cm. long; light green; often sharply reflexed.

Rachis. Keel blunt, straight or flexuous, smooth or slightly scabrid; scabrid margin; glabrous except at the microscopically pubescent base; bearing very loosely imbricating spikelets inserted in shallow alternate notches on the rachis, lowest spikelet borne 2 to 4 mm. above the base; striate; 0.2 to 0.4 mm. wide; flattened.

Spikelet. Narrowly elliptic; acute; 2 to 2.5 mm. long; light green; rachilla produced into a bristle 1 mm. long.

Glumes. Subequal, straight upper glume 1 mm. long, curved lower glume 0.8 mm. long; ½ to ⅔ the length of the spikelet; 1-nerved; glabrous or slightly scabrid green keel; acute or subacute apex.

Lemma. Not winged; membranous; elliptical; 2 mm. long, 0.8 mm. wide (folded); 3-nerved, side-nerves run from the base to within 0.4 mm. of the apex, mid-nerve is distinctly excurrent just below the apex forming a scabrid projection; prominent dark green sparsely ciliate keel, cilia 0.3 mm. long; apex subacute; margins and apex hyaline.

Pale. Narrowly elliptic; slightly longer than the valve; 0.5 mm. wide (folded); deeply canaliculate between the 2 minutely scaberulous firm green keels; hyaline tip narrowly truncate or rounded.

Lodicules. Minute, fleshy, cuneate, 0.3 mm. long.

Stigmas. Exserted at the top of the ovary; glabrous from below the middle; purple.

Ovary. Broadly ovate.

Grain. Mature grain rarely seen; oblong; 1.5 mm. long, 0.6 mm. wide.

Most descriptions of C. transvaalensis differ from the above in certain minor aspects. Burtt Davy (1921), in the original description of this grass, notes that:-

(a) the spikes are nude at the base;

(b) the leaves are very acute not pungent;

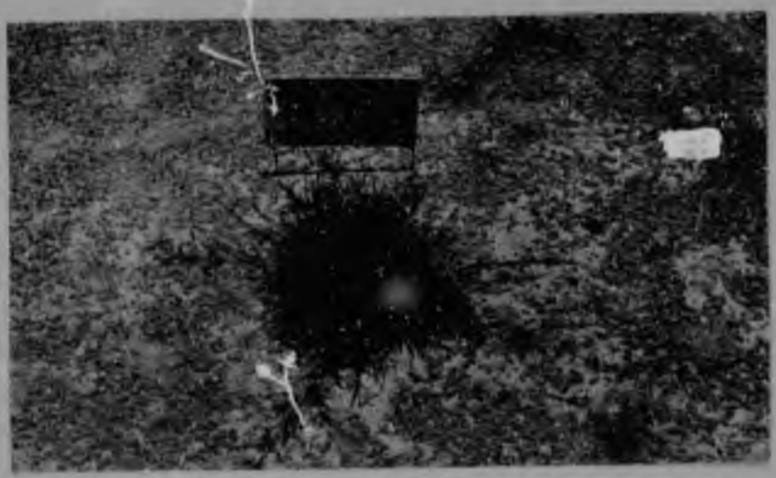
(c) the glumes are more acute than in C. dactylon.

Whereas the writer found that the inflorescence may have 1 to 3 spikes, Burtt Davy records only a distachyous inflorescence which he maintains is a constant character, that is "not attributable to xerophytic conditions".

According to Fisher (1940) and Stent (1927), the culms of C. transvaalensis are only 2 to 3-noded and the leaf apex is sometimes minutely apiculate. Stent notes also that the

PLATE 6

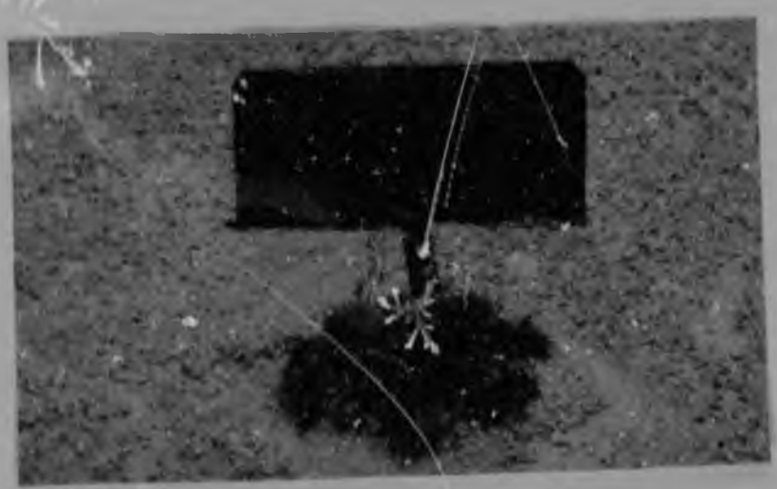
FIG. 1



Cynodon dactylon Pers.

Photographed 3 months after planting.

FIG. 2



Cynodon dactylon Pers. var. denseus Hurcombe var. nov.

Photographed 7 months after planting.

leaves may be glabrous, that the rachilla is not always produced, and that the grass is apparently sterile.

External Morphology of Cynodon Magennisii Hurcombe sp. nov.

(Plates 4 and 7).

C. transvaalensis x C. dactylon; C. transvaalensem magnitudine et habitu revocat.

Perennis; repens, dense caespitosa, stolonifera, et rhizomis subterranneis; culmi tenues, erecti, 3 - 6 cm. alti; folia ab initio plicata deinde angusta linearia, fusca viridia nec glauca; vagina 0.4 - 1.5 cm. longa; lamina 0.5 - 4.5 cm. longa, basim 2 mm. lata, nervibus praecipuis 5, supra subtusque papillis et ciliis sparsis 0.8 mm. longis; ligula 0.2 mm. longa, membranacea vel ad seriem ciliatam reducta; spicae 3 vel 4, digitatae, 1.5 - 2.5 cm. longae; rachilla prolongata, tenuis, 1 mm. longa, saepe flosculo reducto; spicula sterilis, ovata, 2 mm. longa; glumae subaequales et acutae, dimidia spiculae parte longae, uninerves; lemma trinervis, nec carinata, apice subacuto, 2 mm. longa; palea 2 mm. longa.

Vegetative characters.

Habit. Densely caespitose perennial sending out surface runners and underground rhizomes which root and shoot from the nodes; rhizomes penetrate to a depth of 15 cm.

Stem.

Underground stem. Branched; node glabrous; internode glabrous, hollow, 1 to 2 mm. in diameter, 0.5 to 2 cm. long, exserted.

Prostrate aerial stem. Node glabrous; internode glabrous, hollow, green or purple, 0.8 to 1 mm. in diameter, 2 to 4 cm. long, exserted.

Flowering culm. Erect; 4 to 6-noded; 3 to 6 cm. long

(excluding inflorescence); node glabrous; internode glabrous, hollow, lower internodes short and inserted, upper longer and slightly exserted, sulcate, uppermost internode 0.4 mm. in diameter.

Shoot. Circular or elliptical in t.s.

Leaf. Leaves distichous, but not conspicuously so.

Sheath. 0.4 to 1.5 cm. long; split throughout its length; sometimes glabrous, usually hairy with tubercle-based hairs about 1 mm. long; bearded at the mouth with tubercle-based hairs up to 2 mm. long; finely striate; keeled.

Ligule. A fimbriate membrane 0.2 mm. long; or reduced to a ciliate rim.

Blade. Folded or more usually flat when mature, folded in the bud and on drying; keeled; linear or lanceolate; apex obtuse or rounded; length varies from 0.5 to 4.5 cm; 2 mm. wide near the base; 2 primary nerves and 5 to 7 secondary nerves on either side of the midrib; nerves fine and slightly prominent on the abaxial surface; margin scabrid; keel slightly scabrid; dark green; flaccid; both surfaces equally hairy, with hairs up to 0.8 mm. long and tubercle-based; adaxial surface minutely scabrid, abaxial surface usually smooth.

Floral characters.

Spikes. Digitate, arising from one level; usually 3, often 4; 1.5 to 2.5 cm. long; light green; often sharply reflexed.

Rachis. Rounded, straight, slightly scabrid keel; minutely scabrid margin; glabrous except at the base which is hairy, with hairs up to 1 mm. long; bearing closely imbricating spikelets inserted in shallow alternate notches on the rachis, lowest spikelet borne near the base to 3 mm. above the base; striate; about 0.4 mm. wide; flattened.

Spikelet. Oval and unequal-sided; acute; 2 mm. long; light green; rachilla produced into a bristle 1 mm. long, often bearing a reduced purplish floret.

Glumes. Subequal; upper glume straight, 1.3 mm. long; lower glume curved, 1 mm. long; about half the length of the spikelet; 1-nerved; scabrid green keel; acute apex.

Lemma. Not winged; membranous; narrowly ovate; about 2 mm. long, 0.6 mm. wide (folded); 3-nerved, side-nerves run from the base to within 0.4 mm. of the apex, mid-nerve is excurrent just below the apex forming a scabrid projection; prominent dark green ciliate keel, cilia 0.3 mm. long; sparsely ciliate towards the apex; apex sub-acute; margins and apex hyaline.

Palea. Narrowly elliptic; equalling the lemma in length; 0.4 mm. wide (folded); deeply canaliculate between the 2 minutely scaberulous firm green keels; hyaline tip broadly truncate.

Lodicules. Minute, fleshy, cuneate, 0.2 mm. long.

Stigmas. Exserted at the top of the ovary; plumose from below the middle; purple.

Ovary. Narrowly ovate, often undeveloped.

Grain. No mature grain discovered.

External morphology of Cynodon Dactylon Stent.

(Plates 5 and 8).

Vegetative characters.

Habit. Perennial; long surface runners producing roots and short upright barren and flowering shoots at the nodes; no underground rhizomes present.

Stem.

Prostrate aerial stem. Node glabrous; internode glabrous, hollow, light green to pink, 0.7 to 1 mm. in diameter, 5 to 7 cm. long, exserted.

Flowering culm. Erect; 3 to 6-noded; 10 to 20 cm. long (excluding inflorescence); node glabrous; internode glabrous, hollow, enclosed or shortly exserted, finely striate,

Glumes. Subequal; upper glume straight, 1.3 mm. long; lower glume curved, 1 mm. long; about half the length of the spikelet; 1-nerved; scabrid green keel; acute apex.

Lemma. Not winged; membranous; narrowly ovate; about 2 mm. long, 0.6 mm. wide (folded); 3-nerved, side-nerves run from the base to within 0.4 mm. of the apex, mid-nerve is excurrent just below the apex forming a scabrid projection; prominent dark green ciliate keel, cilia 0.3 mm. long; sparsely ciliate towards the apex; apex sub-acute; margins and apex hyaline.

Pale. Narrowly elliptic; equalling the lemma in length; 0.4 mm. wide (folded); deeply canaliculate between the 2 minutely scaberulous firm green keels; hyaline tip broadly truncate.

Lodicules. Minute, fleshy, cuneate, 0.2 mm. long.

Stigmas. Exserted at the top of the ovary; plumose from below the middle; purple.

Ovary. Narrowly ovate, often undeveloped.

Grain. No mature grain discovered.

External Morphology of Cynsion Bradleyi Stent.

(Plates 5 and 8).

Vegetative characters.

Habit. Perennial; long surface runners producing roots and short upright barren and flowering shoots at the nodes; no underground rhizomes present.

Stem.

Prostrate aerial stem. Node glabrous; internode glabrous, hollow, light green to pink, 0.7 to 1 mm. in diameter, 3 to 7 cm. long, exserted.

Flowering culm. Erect; 3 to 6-noded; 10 to 20 cm. long (excluding inflorescence); node glabrous; internode glabrous, hollow, enclosed or shortly exserted, finely striate,

PLATE 7

FIG. 1



Cynodon transvaalensis Burtt Davy

Photographed 3 months after planting.

FIG. 2



Cynodon Magennisii Hurcombe sp. nov.

Photographed 3 months after planting.

uppermost internode 0.5 to 0.8 mm. in diameter.

Shoot. Circular or elliptical in t.s.

Leaf. Leaves distichous, but not conspicuously so.

Sheath. Average length 1.6 cm.; split throughout its length; sparsely hairy with tubercle-based hairs 1.5 to 2 mm. long; bearded at the mouth with hairs 2 mm. long; striate; keeled.

Ligule. Distinctly membranous; 0.5 to 1 mm. long; ciliate with cilia up to 0.5 mm. long; seldom reduced to a ciliate rim.

Blade. Flat or folded when mature, rolled in the bud and on drying; keeled; linear or lanceolate; apex obtuse or sub-obtuse; length varies from 1.2 to 5 cm., average 3.2 cm; about 2.5 mm. wide at the base; 2 primary nerves and 7 to 9 secondary nerves on either side of the midrib; nerves fine but distinct and prominent on the abaxial surface; margin scabrid; keel scabrid; light grey-green; flaccid; blades very hairy on both surfaces but hairs more numerous on the abaxial surface, hairs up to 1.5 mm. long and tubercle-based; both surfaces scabrid.

Floral characters.

Spikes. Digitate, arising from one level; sometimes 4, usually 3, rarely 2; 2 to 3 cm. long; light green; often sharply reflexed.

Rachis. Distinctly keeled; keel sharp, straight or flexuous, scabrid; margin scabrid; long-hairy at the base, otherwise glabrous; bearing closely imbricating spikelets, the lowest spikelet borne near the base to 2 mm. above the base; deeply and bluntly notched on the margins at the insertion of the spikelets; striate; 0.6 mm. wide; flattened.

Spikelet. Oval and unequal-sided; acute; 2.4 mm. long; light green; rachilla produced, in some spikelets only, into a very slender bristle less than 1 mm. long.

Glumes. Subequal; straight upper glume 1.4 mm. long, curved lower glume 1.6 mm. long; equal to half the length of the

uppermost internode 0.5 to 0.8 mm. in diameter.

Sheet. Circular or elliptical in t.s.

Leaf. Leaves distichous, but not conspicuously so.

Sheath. Average length 1.6 cm.; split throughout its length; sparsely hairy with tubercle-based hairs 1.5 to 2 mm. long; bearded at the mouth with hairs 2 mm. long; striate; keeled.

Ligule. Distinctly membranous; 0.5 to 1 mm. long; ciliate with cilia up to 0.5 mm. long; seldom reduced to a ciliate rim.

Blade. Flat or folded when mature, rolled in the bud and on drying; keeled; linear or lanceolate; apex obtuse or sub-obtuse; length varies from 1.2 to 5 cm., average 3.2 cm; about 2.5 mm. wide at the base; 2 primary nerves and 7 to 9 secondary nerves on either side of the midrib; nerves fine but distinct and prominent on the abaxial surface; margin scabrid; keel scabrid; light grey-green; flaccid; blades very hairy on both surfaces but hairs more numerous on the abaxial surface, hairs up to 1.5 mm. long and tubercle-based; both surfaces scabrid.

Floral characters.

Spikes. Digitate, arising from one level; sometimes 4, usually 3, rarely 2; 2 to 3 cm. long; light green; often sharply reflexed.

Rachis. Distinctly keeled; keel sharp, straight or flexuous, scabrid; margin scabrid; long-hairy at the base, otherwise glabrous; bearing closely imbricating spikelets, the lowest spikelet borne near the base to 2 mm. above the base; deeply and bluntly notched on the margins at the insertion of the spikelets; striate; 0.6 mm. wide; flattened.

Spikelet. Oval and unequal-sided; acute; 2.4 mm. long; light green; rachilla produced, in some spikelets only, into a very slender bristle less than 1 mm. long.

Glumes. Subequal; straight upper glume 1.4 mm. long, curved lower glume 1.6 mm. long; equal to half the length of the

spikelet; 1-nerved; distinct green scabrid keel; apex subacute.

Lemma. Not winged; broadly ovate; 2 mm. long, 0.8 mm. wide (folded); 3-nerved; side-nerves run from the base to within 0.6 mm. of the apex, mid-nerve is very rarely excurrent below the apex; prominent dark green appressedly ciliate keel, cilia up to 0.5 mm. long; apex subacute; margins and apex hyaline.

Pale. Narrowly elliptic; equalling the lemma in length; 0.5 mm. wide (folded); 2 dark green firm scabrid keels; apex rounded or obtuse.

Lodicules. Minute, cuneate, fleshy, 0.3 mm. long.

Stigmas. Exserted at the top of the ovary; plumose from below the middle; purple.

Ovary. Broadly ovate.

Grain. No mature grain discovered.

The original description of C. Bradleyi (see Stent, 1927a) differs from the above on four minor points. Stent noted that:-

(a) the flowering culms were 1 to 2-noded.

(b) the leaf sheath was sometimes glabrous.

(c) the leaf blades were "0.5 - 2 cm. long and about 1.5 mm. wide at the base".

(d) the glumes had a smooth keel.

Neither Stent (1927b) nor Fisher (1940) make any definite mention of the fact that C. Bradleyi has no underground rhizomes. Stent (1927b), however, does refer to C. Bradleyi as a "surface grass", and Bews (1929) observes that it "does not withstand drought well, being a surface rooter".

DISCUSSION.

As previously stated on page 7, the Cynodon material used for this study was allowed to grow rank. This fact should be borne in mind when the morphological characters are studied, and particularly when the key on page 46 is used for classifying grasses which have been rolled, mown, or subjected to considerable wear and tear.

After a critical and detailed examination of the external morphology of the Cynodon species studied, the writer concluded that these species do not differ greatly, and that the only reliable and constant characters are the vernation of the leaves, the presence or absence of rhizomes, the nature of the produced rachilla, the number of primary nerves, and the length of the glumes in relation to that of the spikelet. In addition, the length and width of the leaf and the hairiness of the leaf are characters which are useful diagnostically when they are considered not individually but in conjunction with other characters. Goossens (1938) maintains that much stress should not be laid on length and width which are variable characters, and Lewton-Brain (1904) notes that the hairiness of grass leaves varies considerably and can rarely be relied on as distinctive.

The writer's descriptions of C. dactylon, C. transvaalensis and C. Bradleyi differ in certain respects from those of other writers. The descriptions, however, do not differ in essential characters, but chiefly as regards size, number of spikes, and number of nodes in the flowering culm. These writers do not give the habitat of the material they describe, and it is possible that in certain cases the material had been taken from lawns or from turf used for sporting purposes, in which case the size and habit of the grass would be greatly modified.

In the writer's opinion C. Bradleyi is a distinct species which differs from the other Cynodon species studied in the following respects:-

PLATE 5



Cynodon Bradleyi Stent

Photo reached 7 months after planting.

(a) no underground rhizomes are present.

(b) the leaves are rolled in the bud.

(c) the leaves are very hairy on both surfaces, with hairs up to 1.5 mm. long. (The hairiness of the leaves appears to be a constant character in this species.)

(d) the ligule is usually distinctly membranous and up to 1 mm. long.

(e) the rachilla when produced is a short bristle less than 1 mm. long, which never bears a reduced floret.

C. transvaalensis differs from the other Cynodon species studied in that there are only 3 primary nerves in the leaf blade. In addition, this species is characterised by leaves less than 1.5 mm. wide, 1 to 3 (usually 2) spikes, glumes ¼ to 1/3 the length of the spikelet, and a produced rachilla which never bears a reduced floret.

C. dactylon is distinctive in that the glumes may be almost as long as the spikelet. This grass is vigorous and has a more robust habit than any of the other forms; the spikes may be as many as 6 and 1.5 to 6.5 cm. long, the leaves are 3 to 4 mm. wide and 2 to 16 cm. long, and the flowering culms may grow to a height of 40 cm. A comparison of the descriptions of C. dactylon given by various workers in S. Africa, America, and in other countries, shows that this grass is extremely variable. As Stent (1927a) describes it; C. dactylon is a species "fairly constant in its essential characters, but varying in height, texture, breadth of leaf etc., according to the locality and conditions under which it is grown."

A careful study of the external morphology of C. dactylon var. densus ("Hall's Selection") shows that this grass is closely similar to C. dactylon in all essential features. Since these two grasses differ only in size and habit, it would appear that "Hall's Selection" is merely a prostrate, slow-growing variety of C. dactylon.

C. Magennisii closely resembles both C. dactylon and

C. transvaalensis in external morphology, and appears to be intermediate between these two species. In general appearance C. Magennisii is very similar to C. transvaalensis; the two grasses are both fine lawn grasses, with the same growth form, and fairly short narrow leaves sparsely hairy on both surfaces. However, as regards the number of primary nerves in the leaf blade, and the presence of a reduced floret borne on the produced rachilla, C. Magennisii is closely related to C. dactylon.

A diagnostic key to the species studied, which is based on characters of external morphology in conjunction with anatomical characters, is given on page 46 .

LEAF ANATOMY

METHODS.

Previous workers have found that grass leaf anatomy varies considerably according to the age and position of the leaves selected, and according to the region of the leaf studied. Burr & Turner (1933) maintain that "for the purposes of identification the vegetative lower leaves should be used, never those from the flowering culm." Throughout this study of Cynodon leaf anatomy, leaf sections were cut from the upper portion of the basal third of mature vegetative leaves. Sections of the shoot were cut from a region where the young leaves were surrounded by at least two leaf sheaths.

Permanent prepar[illegible] of mic.otomed sections were made according to the method [illegible] by Johansen (1940). The following schedule [illegible] sed:-

(1) Fixation in [illegible] in - aceto - alcohol (Johansen, p. [illegible]	24 hrs.
(2) Dehydration (Johansen, p. 130)	
(a) 50% normal butyl alcohol mixture	2 hrs.
(b) 70% " " " "	overnight
(c) 85% " " " "	1 hr.
(d) 95% " " " "	1 hr.
(e) 100% " " " "	1 hr.
(f) 100% pure normal butyl alcohol (2 changes)	1 hr. each
(g) 100% pure normal butyl alcohol	overnight
(3) Infiltration (Johansen, p. 131-134)	
(a) mixture of equal parts of paraffin oil and normal butyl alcohol	2 hrs.
(b) mixture of ¾ parowax and ¼ normal butyl alcohol - paraffin oil	overnight
(c) Parowax	3 changes over 6 hrs.
(d) Paraffin wax	overnight.

The material was embedded in paraffin wax (M.P. 52° - 54°C.);

sections were cut at 10 microns and then double-stained with safranin and fast green as follows:-

(a) xylol	1 hr.
(b) xylol - absolute alcohol mixture (equal parts)	5 mins.
(c) 95% alcohol	5 mins.
(d) 70% alcohol	5 mins.
(e) safranin (alcoholic solution prepared according to Johansen, p. 62)	2½ hrs.
(f) differentiation under the microscope in 95% alcohol.	
(g) fast green (2% soln. in clove oil)	1 min.
(h) differentiation under the microscope in a mixture of 50 parts clove oil, 25 parts xylol and 25 parts absolute alcohol	—
(i) xylol (2 changes)	5 mins. each
(j) mount in xylol - balsam.	

Hand sections were made from fresh green material, or from material which had been stored in 50% alcohol. Sections cut from fresh material were immediately fixed in 50% alcohol for about 15 mins. Double-stained preparations were made as follows:-

(a) Eau de Javelle (prepared according to Cavers, 1925, p. 407, (b))	10 to 15 mins.
(b) Acetic water (0.1%)	5 mins.
(c) Iodine green (1% aqueous soln.)	10 secs.
(d) Differentiation in 90% alcohol under the microscope.	
(e) Distilled water	2 mins.
(f) Carmine - alum (prepared according to Bop and Gautié, 1928, p. 94)	10 mins.
(g) Distilled water	5 mins.
(h) Differentiation in 70% alcohol under the microscope.	
(i) 95% alcohol	1 min.
(j) Absolute alcohol	5 mins.
(k) Xylol (2 changes)	5 mins. each
(l) Mount in xylol - balsam.	

This staining procedure could be used only for hand sections. It gave very satisfactory results with Cynodon material; the iodine-green proved to be more specific for lignin than did safranin, and the silicified cells showed up very clearly in the final preparations owing to their refractive index.

Rapid permanent mounts were made by placing freshly cut hand sections in 20% glycerine for 5 mins., and then mounting the sections in glycerine jelly containing safranin. After 24 hours the lignified tissue was stained red.

Adaxial and abaxial strips of the epidermis were also taken from the basal third of mature vegetative leaves. Various methods which might facilitate the stripping of the epidermis were tried, but the only method which proved successful was a modification of Schulze's maceration process. Leaves were placed in a test tube containing 2 volumes of official nitric acid diluted with 1 volume of water. To this were added a few crystals of potassium chlorate, and the test tube was warmed gently until a gas evolved, when the material was immediately transferred to a beaker of water. After this treatment the epidermis was readily removed from the leaf. Epidermal strips were stained with iodine-green.

The following microchemical tests were applied to hand sections or to epidermal strips of fresh green leaves in order to reveal the nature of the cell walls and cell contents.

(a) Test for cellulose. After treatment with iodine and sulphuric acid (Lee, 1937, p. 645), cellulose walls turned bright blue, lignified and suberised walls, brown.

(b) Test for lignin. Lignified walls were stained red-purple when placed in a 1% solution of phlorogluoin for 2 minutes and then mounted in concentrated hydrochloric acid.

(c) Test for suberin. Suberised epidermal cells turned reddish when placed in a saturated solution of Sudan III in absolute alcohol according to the method described by Dop and Gautié (1928) p. 113.

(d) Test for silica. Pieces of the leaves were boiled in water for some time and then placed in a concentrated solution of carbolic acid for 2 to 3 days. All silicified structures viz. silicified cells, tubercle-based hairs, and asperities, were, owing to their refractive power, revealed with great precision after this treatment.

GENERAL DESCRIPTION OF CYNODON LEAF ANATOMY.

Fisher (1940), in her work on the Chlorideae, includes a general description of the leaf anatomy of this group. The following general outline of the anatomy of Cynodon leaves may therefore appear redundant, but it is included in this paper for the sake of convenience and in order that no significant point should suffer from lack of explanation. This outline is largely based on Fisher's description and the anatomical terms she uses have been adopted in order to avoid confusion.

As seen in transverse section, Cynodon leaves are thin and possess a distinct midrib with a prominent abaxial keel. The leaf surface may be flat, undulated, or ridged, the margin acute, obtuse, or rounded.

Epidermis

The epidermis is complex and highly differentiated. It is composed of cells arranged in regular rows extending lengthwise of the leaf. Two distinct, alternating, longitudinal bands of cells are visible - the one band lying in the region opposite the nerves, the other in the region between the nerves. In the abaxial epidermis, the region between the vascular strands consists of long ripple-walled cells interrupted at intervals by 1 or 2 short cells or by stomata; this same region in the adaxial epidermis consists of motor cells flanked on either side by a row of ripple-walled cells interrupted by stomata. The region opposite the vascular

bundles in both epidermises consists of 1 or more files of short cells alternating with files of ripple-walled cells.

In transverse section, epidermal cells are square or rectangular and closely similar in appearance. The walls of the cells - particularly the outer wall - may be considerably thickened. This wall is usually arched outwards and is covered by a thin cuticle; the arching of the outer wall may be exaggerated to form a papilla. The papillae of cells surrounding a stoma arch over the stoma so that it is often obscured by surface view. Opposite the vascular strands, the epidermal cells are smaller and have thicker walls than the remaining cells, thus closely resembling the sclerenchyma cells which they adjoin.

Emerging from the epidermis are three types of hairs - long tubercle-based hairs, shorter bulbous-based hairs or asperities, and small club-shaped hairs. All three emergences may be found on either surface of the leaf.

Ripple-walled cells. These elements form the greater part of the epidermal tissue. In surface view, the cells are rectangular and greatly elongated, the long axis of each cell being parallel to the long axis of the leaf. The cells are often conspicuously papillose and have strongly undulated lateral walls. Ripple-walled cells are longer than other epidermal cells and attain their greatest length in the region opposite the vascular strands.

Short cells. In a single file of short elements found opposite the vascular strand, suberised cells alternate with silicified cells.

A silicified cell appears colourless and devoid of contents, is almost circular in surface view, and, in transverse section, has a concave outer wall. The writer's observation that the silicified cell is completely filled by a block of silica which contains granular inclusions is confirmed by Prat (1932b).

Fisher (1940) was unable to determine whether the cells with concave outer walls visible in a transverse section were silicified or suberised cells. The writer found that sections treated with carbolic acid showed quite clearly that these were silicified cells.

A suberised cell is thin-walled with dense contents and gives a positive test for suberin. In a transverse section, the outer wall is conspicuously arched, while in surface view, the cell is rectangular and slightly longer than broad, with undulated lateral walls.

Ripple-walled cells are often interrupted by 1 or 2 short cells. If 1 only is present, the cell is suberised, but if 2 are present, the one nearest the leaf base is suberised, the other silicified. Silicified cells may be modified to form bulbous-based hairs, while club-shaped hairs sometimes replace suberised cells.

Motor cells. These cells form groups of 3 to 7 of which the central cell is conspicuously the largest, the lateral cells decreasing in size towards the side. The central cell is pear-shaped, with the broad end in contact with the mesophyll, and it occupies at least half the leaf thickness. In surface view, the motor cells are more or less rectangular, with no undulations of the walls. They may be papillose and are usually thin-walled, although the outer tangential wall is often slightly thickened. An entire group may be modified to form the "cushion" of a tubercle-based hair.

Stomata. The stomata are of the typical grass type and are very uniform in structure. Four cells contribute to the function of the stoma - 2 guard cells, and adjacent to these, 2 accessory cells. In surface view, the guard cells are dumb-bell-shaped and the accessory cells triangular. A large intercellular space subtends the stoma and projects into the mesophyll.

In both the abaxial and the adaxial epidermis, 2 longitudinal

rows of stomata are found between adjacent vascular strands.

Emergences.

Tubercle-based hairs. These macroscopic hairs are very characteristic of all Cynodon species. The hair is unicellular, long-tapering, and silicified, and is surrounded at its base by slightly thickened cells which are deeper than broad and project above the general tissue of the epidermis. The hairs, when present, are restricted to the region lying between the vascular strands and may also occur along the margin. In the abaxial epidermis, these hairs are modifications of ripple-walled cells, while in the adaxial epidermis, they arise from motor cells.

Bulbous-based hairs. These short hairs form asperities which are visible only microscopically and which since their walls are extensively silicified, are responsible for the scabrid surface and margin of the leaves. The hair has a swollen base but tapers rapidly to an acute apex; it is seldom twice as long as broad. Asperities are usually found opposite the vascular strands and are directed towards the apex of the leaf.

Club-shaped hairs. These microscopic emergences are two-celled, the smaller of the two cells forming the blunt apex, and are generally twice as long as broad. They occur in the regions between the nerves. It is probable that these hairs are modified suberised cells, since they have thin walls and dense contents, and often appear to replace suberised cells.

Vascular tissue.

The vascular strands are embedded at regular intervals in the mesophyll and run parallel from the base to the apex of the blade. Minute cross-anastomoses between the veins are not infrequent.

Pee-Laby (1 98) recognises five orders of vascular bundles

distinguished by their degree of development. The vascular bundles in Cynodon leaves are found to be characteristic of the first three of these orders.

First order bundles (primary nerves). 3 or 5 first order bundles may be present; these occur in the midrib and at regular intervals in the lateral part of the blade.

Typically, there are 2 metaxylem vessels in the equatorial region of each bundle, and 1 or 2 protoxylem elements present towards the adaxial surface; the latter may break down to form a lysigenous space. The phloem, which occupies the abaxial region of the bundle, is seldom clearly differentiated into sieve tubes and companion cells.

The first order bundle is surrounded by a double sheath. The inner sheath is continuous, thick-walled, and strongly lignified; as the cells are more strongly thickened along the inner and lateral walls, this sheath closely resembles the typical monocotyledonous endodermis. The outer parenchymatous sheath consists of large, thin-walled cells which contain larger chloroplasts than the mesophyll cells, and are isodiametric in transverse section. This sheath may be continuous or may be interrupted abaxially or adaxially by groups of colourless parenchyma or sclerenchyma cells; the bundles, however, are rarely girdered. (It appears that Fisher (1948) uses the term "girdered bundles" in cases where the lignified sheath abuts directly on the fibrous strands, and the outer sheath is therefore arranged laterally in the form of two arcs. Fisher's usage has been adopted in this paper.)

Second order bundles (secondary nerves). These are similar to first order bundles except that the protoxylem is absent. They may occasionally be seen near the margin in a transverse section of the blade, in which case they replace first order bundles.

Third order bundles (tertiary nerves). 1 to 4 third order bundles occur between every two bundles of the first order.

They are smaller than those of the first or second order, and are characterised by the absence of an inner bundle sheath and of definite protoxylem or metaxylem vessels. A number of lignified elements may be present together with several phloem cells. The chlorophyllose sheath is similar to that found in first and second order bundles; it forms a circular layer around the bundles, but may occasionally be interrupted by 1 or 2 large colourless parenchyma cells.

The structure of the bundles in the various species is so uniform that it is not used as a means of identification: however, the number of bundles of the different orders and the ratio of first to third order bundles is of importance.

phyll.

chlorophyll is comprised of regular, compact, thin-walled chlorenchyma cells with few intercellular spaces. The cells are arranged in 2 layers about the vascular bundles, with their long axes at right angles to the bundles. These sheathing girdles of chlorophyllose tissue are separated by larger thin-walled cells, isodiametric in transverse section, which extend in 1 or more rows from the motor cells to the abaxial epidermis. In certain species, some or all of these cells may be clear and devoid of chlorophyll.

Colourless parenchyma.

Colourless parenchyma may be found in the midrib region separating the outer bundle sheath from the adaxial fibrous strand. This character proved to be variable in any one species. Fisher (1940), however, found the absence or presence of these colourless parenchyma cells in the midrib to be a feature of some value in separating Cynodon species.

1 or 2 colourless cells are often found adjacent to first or third order bundles, separating the chlorophyllose sheath from the abaxial or adaxial fibrous strands.

PLATE 9

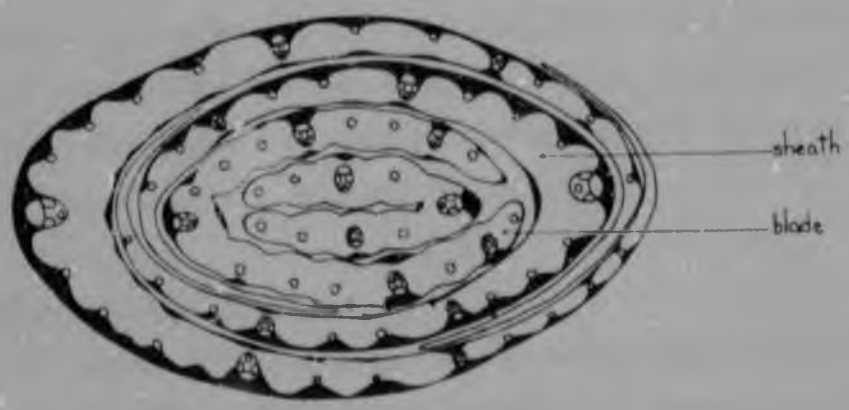
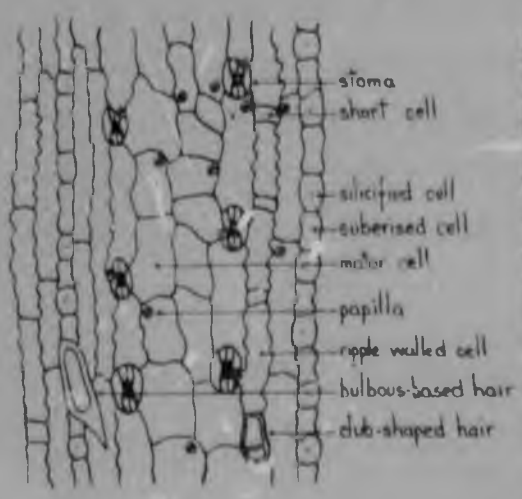
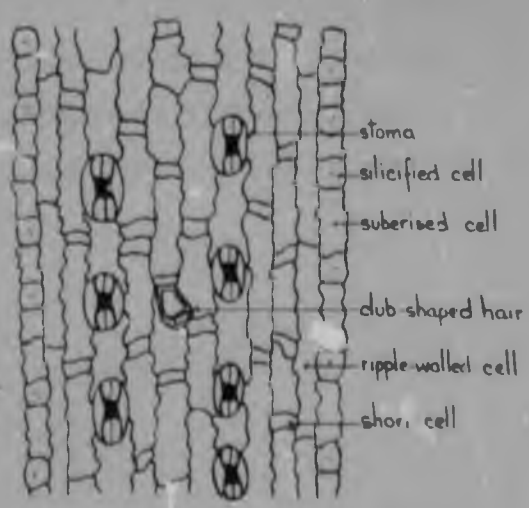


Diagram of t.s. of shoot of Cynodon dactylon Pers. 80 X



adaxial epidermis



abaxial epidermis

Portions of epidermis of Cynodon dactylon Pers. 340 X

Mention has already been made of colourless cells situated between the vascular bundles. In some species, 1 or 2 rows of these cells may extend from the central motor cell to or almost to the abaxial epidermis. Stent (1927) in her monograph on Cynodon, considers the absence or presence of colourless parenchyma between the bundles to be a diagnostic feature of importance. The writer, however, found that the degree of development of this parenchyma is not constant but varies considerably within any one species.

Mechanical tissue.

The degree of development of the mechanical tissue in the blade is variable. This tissue consists of groups of fibres situated above and below the vascular bundles, forming abaxial and adaxial strands. According to most workers, these strands, when they link the bundles to the epidermis - as is often the case in Cynodon leaves - are said to form girders. Fisher (1940), however, uses the term "girdered bundles" in a more specialised sense. In the midrib, the adaxial fibrous strand is a constant feature and the abaxial strand is developed to such an extent that it may partly encircle the midvein.

A small strand of thick-walled elements extends along the margin of the blade immediately within the epidermis.

The fibres making up the mechanical tissue are much elongated, empty cells with pointed ends. Their walls are thick and often distinctly pitted.

Leaf anatomy of Cynodon dactylon Pers.

(Plates 9 to 11).

Shape in transverse section.

Both surfaces flat or undulating; rounded keel; margin acute, obtuse or rounded.

Epidermis .

Motor cells in groups of 3 or 5 cells, the central cell

PLATE 10

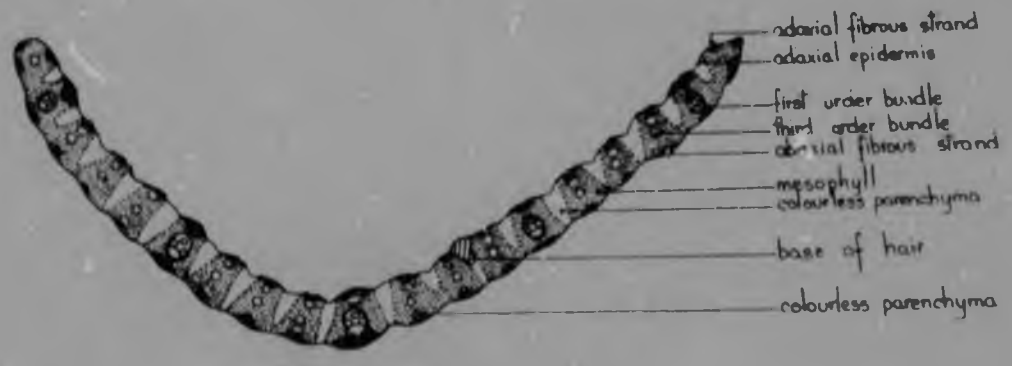
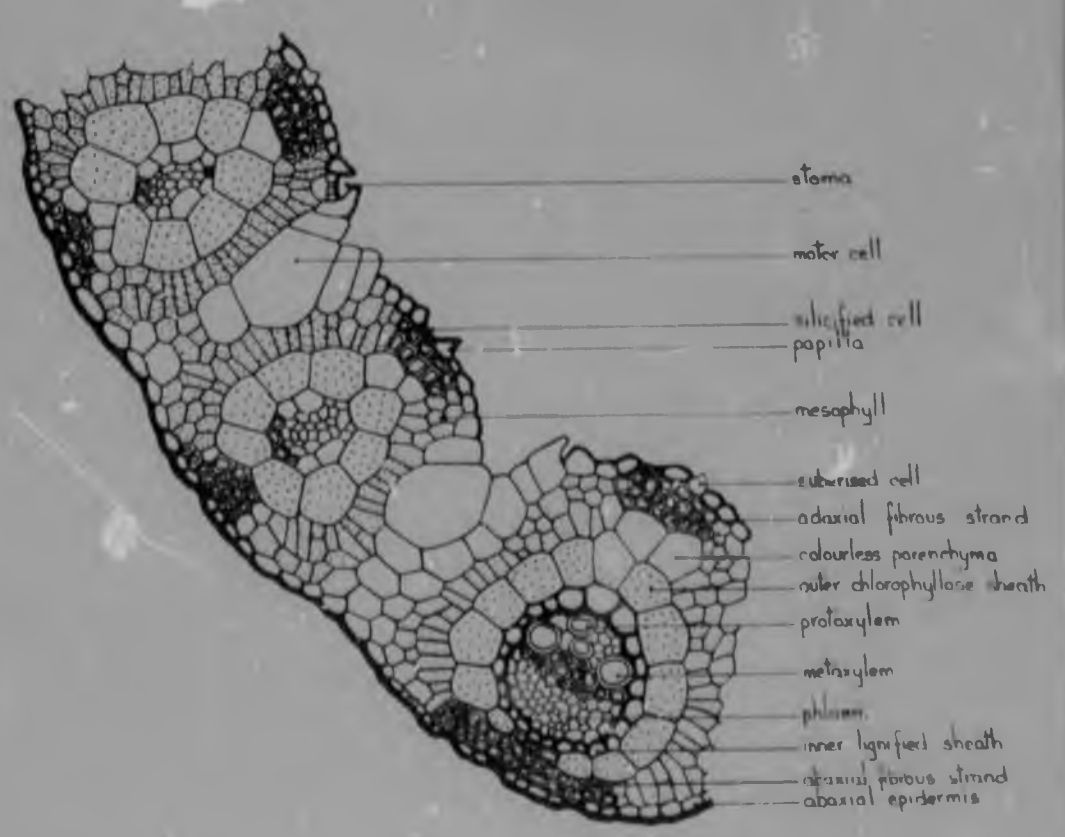
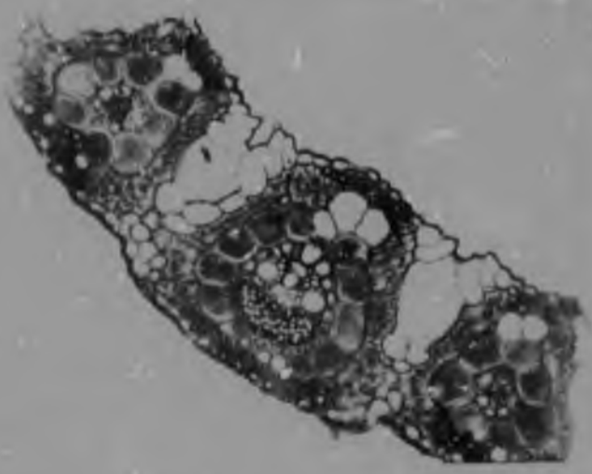


Diagram of T.s. of leaf of Cynodon dactylon Pers. 60X



Portion of T.s. of leaf of Cynodon dactylon Pers. 340 X

PLATE II



Photomicrograph of t.s. of leaf
of Cynodon dactylon Pers.

250x

of each group deeper than broad and occupying at least half the leaf thickness; 1 or 2 files of short elements opposite third order bundles, 3 to 5 files opposite first order bundles (6 to 10 files opposite the midvein in the abaxial epidermis); occasional club-shaped hairs found in both epidermises; asperities occur in the adaxial epidermis but not in the abaxial epidermis; tubercle-based hairs present in the adaxial epidermis but absent or occasional in the abaxial epidermis; papillae conspicuous in the adaxial epidermis where 2 or 3 often surround a stoma but absent or very minute in the abaxial epidermis; epidermal cells slightly smaller adjacent to the vascular bundles; ripple-walled cells interrupted by 1 or 2 short cells; the outer wall of the abaxial epidermal cells almost twice as thick as that of the adaxial epidermal cells.

Vascular bundles.

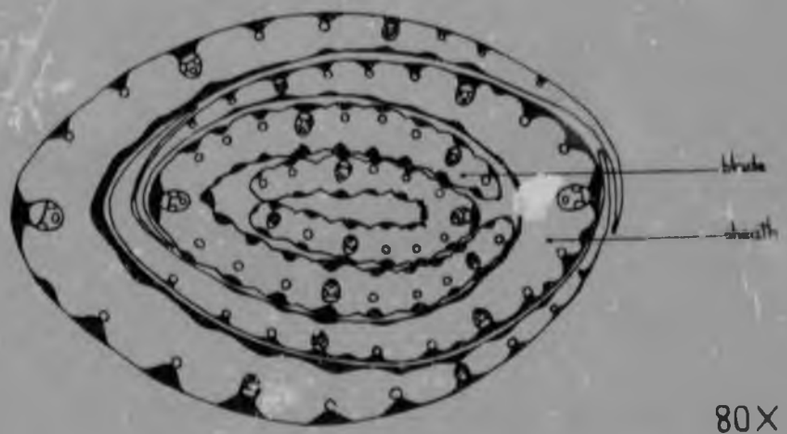
First order bundles. 5 first order bundles - the penultimate bundle sometimes of the second order; outer bundle sheath arranged in a circle or "horse-shoe" of 7 to 13 chlorenchyma cells, the sheath around the midvein continuous adaxially and interrupted abaxially by sclerenchyma, the sheath around other first order bundles usually continuous adaxially or interrupted by 1 or 2 parenchyma or sclerenchyma cells and either continuous abaxially or interrupted by the abaxial fibrous strand.

Third order bundles. 3 or 4 third order bundles between every two bundles of the first order; circular bundle sheath of 6 to 9 chlorenchyma cells uninterrupted adaxially or abaxially.

Colourless parenchyma.

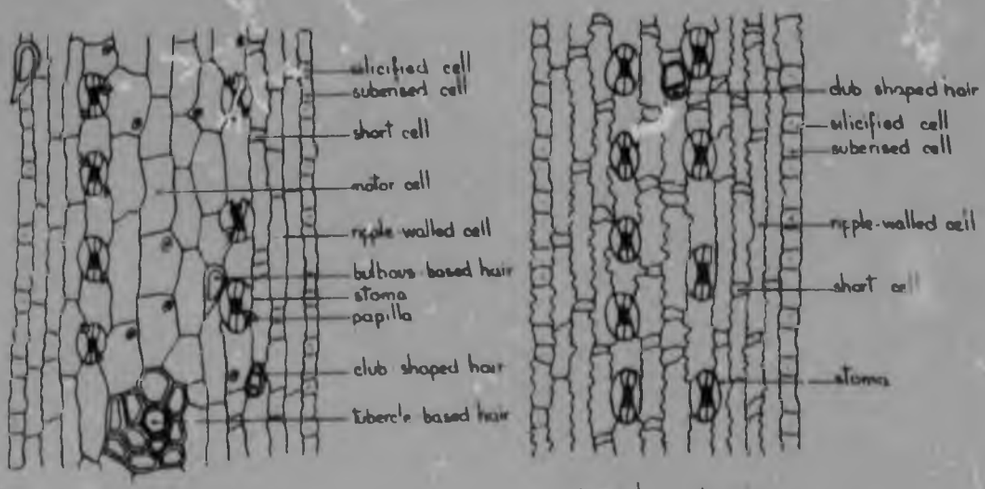
Found in the midrib as a group of 2 to 5 large cells separating the outer bundle sheath from the adaxial fibrous strand; usually found between the outer bundle sheath and the adaxial or abaxial fibrous strands of third order bundles;

PLATE 12



80X

Diagram of t.s. of shoot of
Cynodon dactylon Pers. var densus Hurcombe var. nov.



adaxial epidermis

abaxial epidermis

340 X

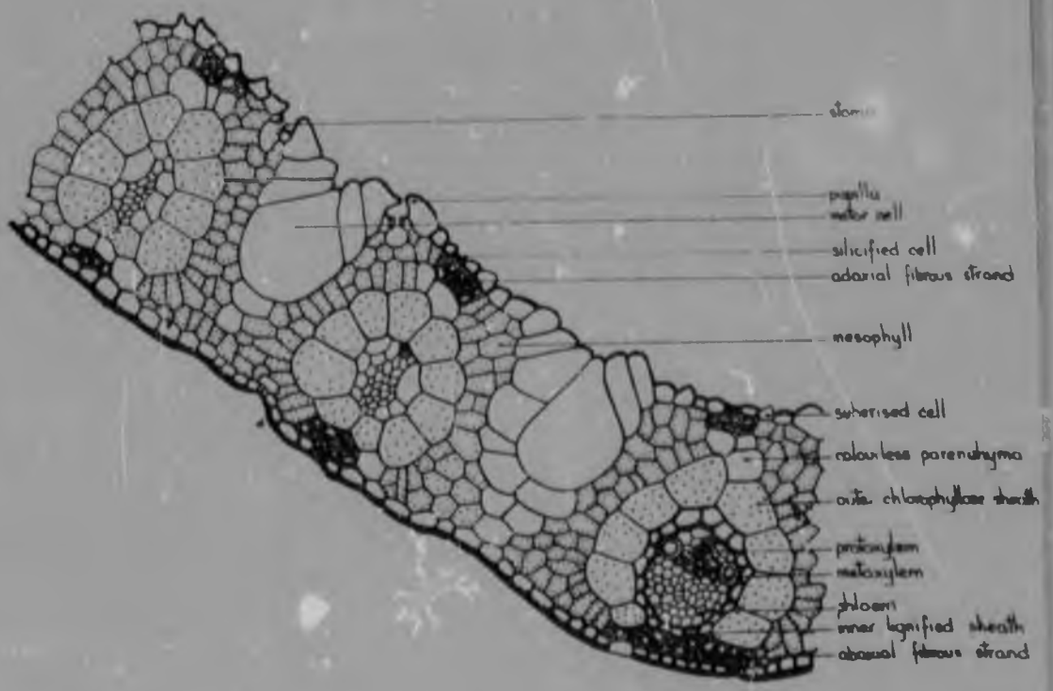
Portions of epidermis of
Cynodon dactylon Pers. var. densus Hurcombe var. nov.

PLATE 13



60x

Diagram of T.s. of leaf of
Cynodon dactylon Pers var densus Hurcombe var nov.

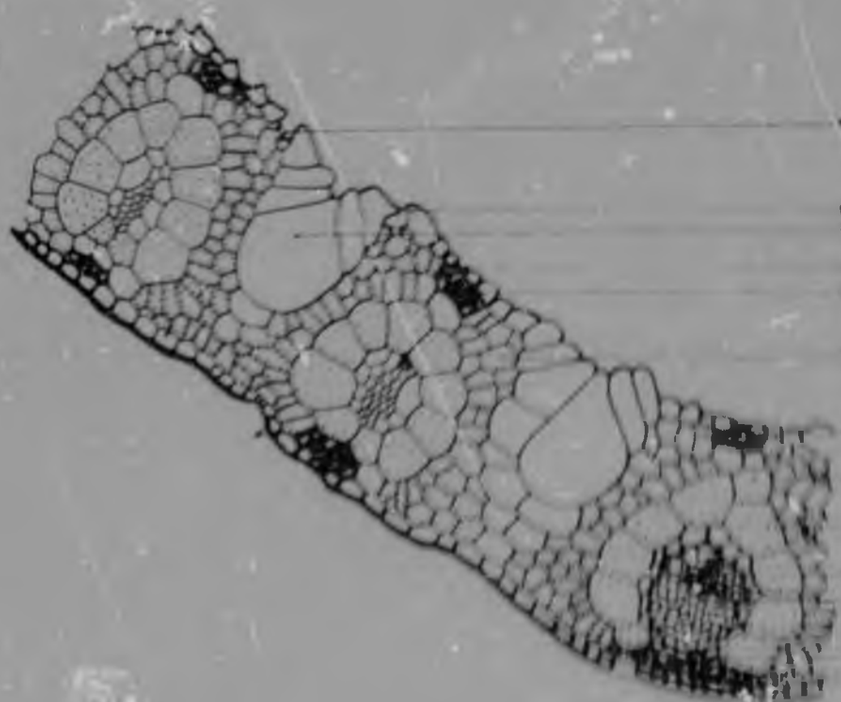


Portion of T.s. of leaf of
Cynodon dactylon Pers. var densus Hurcombe var nov.

PLATE 15



Diagram of T s of leaf of
Cynodon dactylon Pers var densus Horcombe var nov



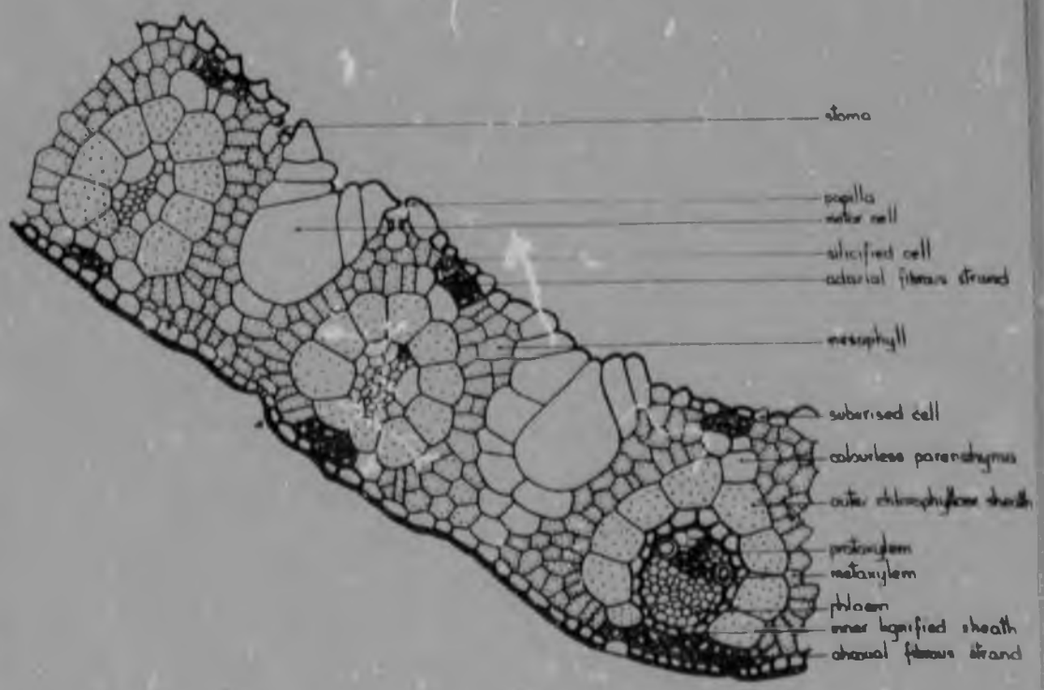
Portion of T s of leaf of
Cynodon dactylon Pers var densus Horcombe var nov

PLATE 13



60x

Diagram of T.s. of leaf of
Cynodon dactylon Pers var densus Hurcombe var. nov.



Portion of T.s. of leaf of
Cynodon dactylon Pers. var densus Hurcombe var nov.

PLATE 14



Photomicrograph of t.s. of leaf of

Cynodon dactylon Pers. var. densus Harcombe var. nov.

250x

present as 1 or 2 rows of cells extending from the motor cells to or almost to the abaxial epidermis.

Mesophyll.

Confined to 1 or 2 rows of radiating cells round the bundles and usually separated by a band of colourless parenchyma.

Mechanical tissue.

Fairly well developed; abaxial and adaxial fibrous strands found adjacent to all the bundles, the abaxial strands being more strongly developed; first order bundles very rarely girdered.

Fisher's description of the leaf anatomy of C. dactylon differs from the above in the following respects:-

(a) 5 to 7 motor cells occur in a group.

(b) The outer bundle sheath around first order bundles consists of 6 to 10 cells.

(c) 1 to 4 (rarely 5) third order bundles are found between those of the first order.

(d) The midrib is without colourless parenchyma.

(e) First order bundles are usually girdered.

Leaf anatomy of C. dactylon Pers. var. densus Hurcombe

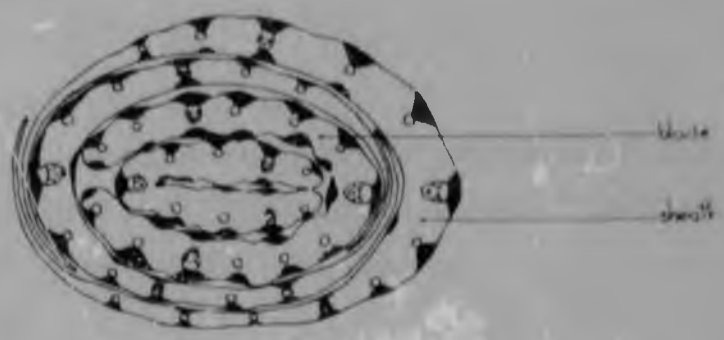
(Plates 12 to 14)

The leaf anatomy of this grass is almost identical with that of C. dactylon. Minor differences in structure are listed below.

(1) There are seldom more than 4 to 7 files of short elements opposite the midvein in the abaxial epidermis.

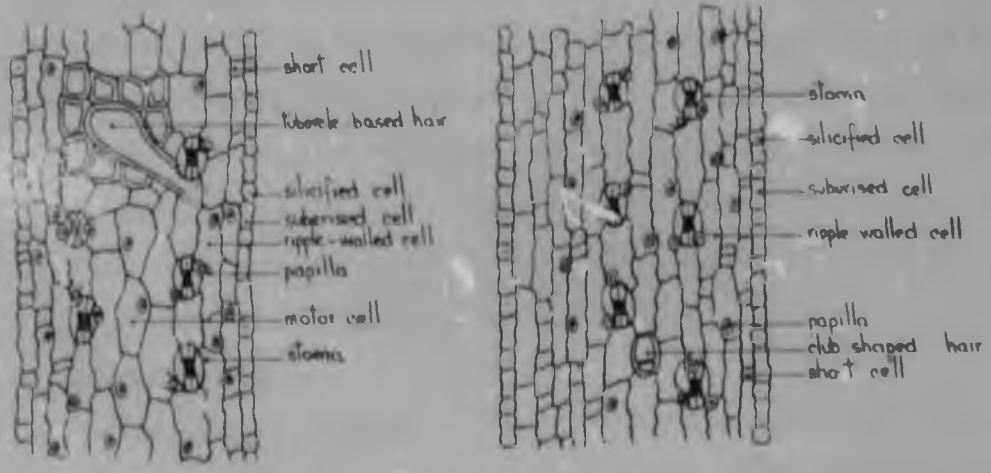
(2) The chlorophyllose sheath around the bundles other than the midvein is not interrupted adaxially; the cells making up this sheath are usually smaller and more numerous than those found in C. dactylon.

PLATE 15



80X

Diagram of T.S. of shoot of Cynodon transvaalensis Burtt Davy



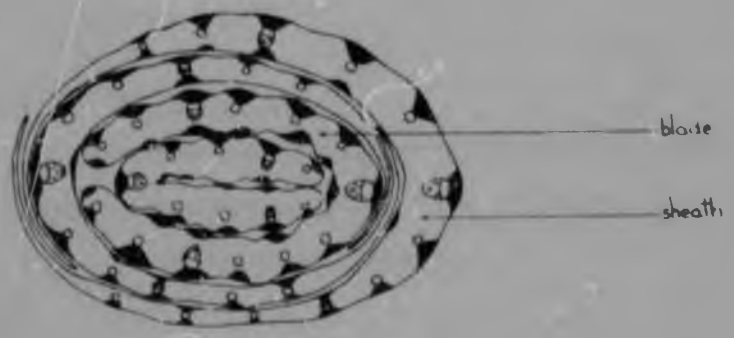
adaxial epidermis

abaxial epidermis

340 X

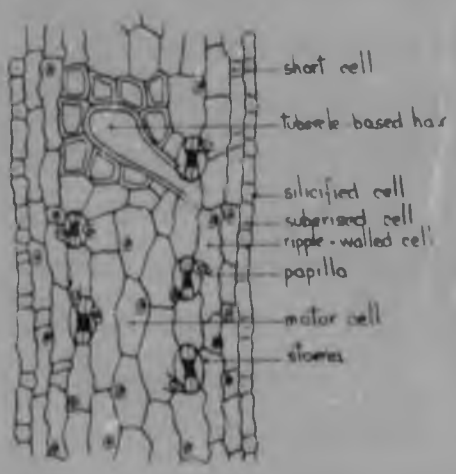
Portions of epidermis of Cynodon transvaalensis Burtt Davy

PLATE 15

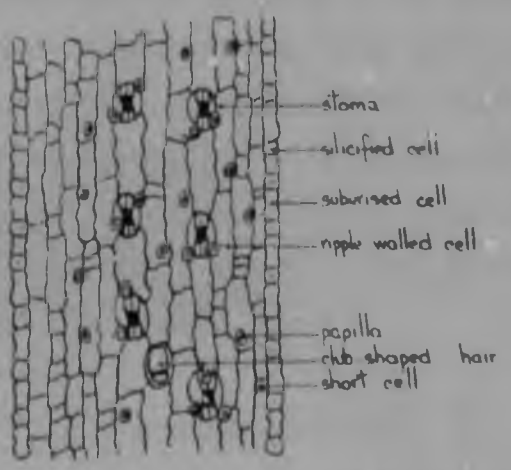


80X

Diagram of T.s. of shoot of Cynodon transvaalensis Burtt Davy



adaxial epidermis



abaxial epidermis

340 X

Portions of epidermis of Cynodon transvaalensis Burtt Davy

(3) The band of colourless [illegible]enchyma between the vascular bundles seldom extends to the abaxial epidermis.

(4) The mechanical tissue is not as well developed as in C. dactylon; first order bundles are not girdered.

Leaf anatomy of Cynodon transvaalensis Burtt Davy

(Plates 15 to 17)

Shape in transverse section.

Adaxial surface undulating or with shallow ridges and furrows, abaxial surface usually flat or slightly undulating; obtuse keel; margin acute or obtuse.

Epidermis.

Motor cells in groups of 3 or 5 cells, the central cell as deep as broad and occupying about half the leaf thickness; 1 file of short elements opposite third order bundles (occasionally 2 files in the abaxial epidermis), 1 to 3 files opposite first order bundles (up to 5 files opposite the mid-vein in the abaxial epidermis); epidermis of both surfaces with tubercle-based hairs and occasional club-shaped hairs; asperities few in the adaxial epidermis and rarely present in the abaxial epidermis; ripple-walled cells of both surfaces with very conspicuous large papillae (in the case of the stoma 2 or 3 large beak-like papillae of neighbouring cells partially obscure the stoma when seen in surface view); epidermis cells scarcely smaller opposite the vascular bundles; ripple-walled cells interrupted by 1 or 2 short cells; the outer wall of the abaxial epidermal cells only slightly thicker than that of the adaxial epidermal cells.

Vascular bundles.

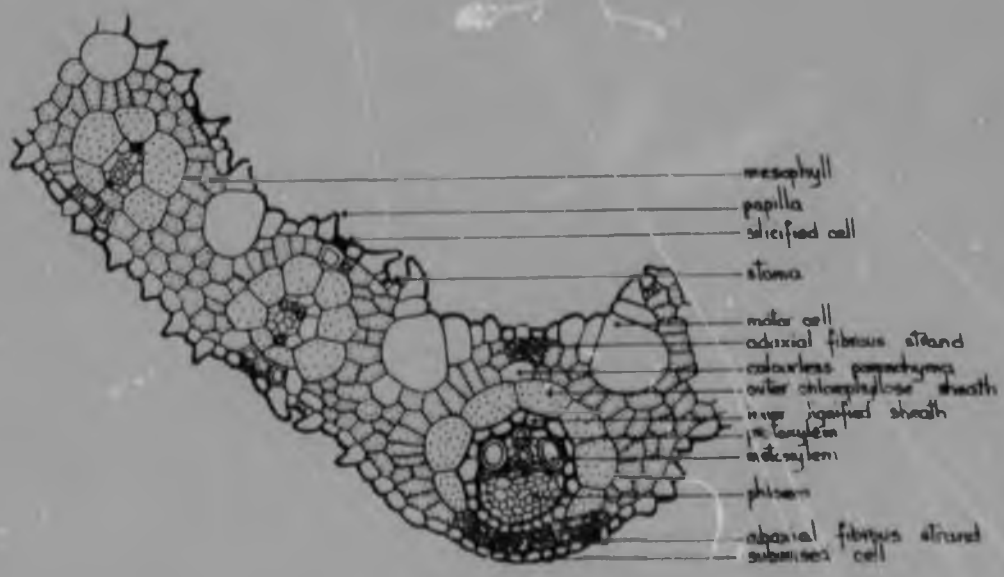
First order bundles. 3 first order bundles - the penultimate bundle often of the second order; outer bundle sheath arranged in a wide "horse-shoe" of 7 to 10 chlorenchyma cells, interrupted abaxially by the abaxial fibrous strand, continuous adaxially or occasionally interrupted by 1 or 2 colourless parenchyma cells.

PLATE 16



60 X

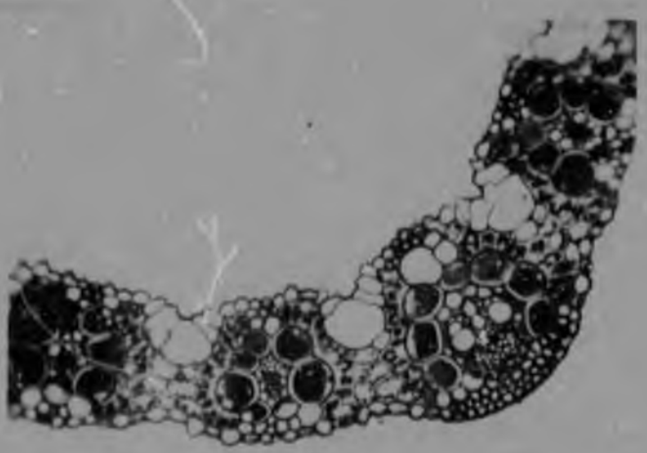
Diagram of T s. of leaf of Cynodon transvaalensis Burtt Davy



Portion of T.s. of leaf of Cynodon transvaalensis Burtt Davy

340 X

PLATE 17



Photomicrograph of t.s. of leaf of

Cynodon transvaalensis Burtt Davy

×60x

Third order bundles. 3 third order bundles between every two bundles of the first order; bundle sheath of 6 to 8 chlorenchyma cells, usually continuous or occasionally interrupted adaxially (rarely abaxially) by 1 or 2 colourless parenchyma cells.

Colourless parenchyma.

Occasionally found in the midrib as 1 or 2 cells separating the outer bundle sheath from the adaxial fibrous strand; sometimes found as 1 or 2 cells adjacent to the abaxial fibrous strands of third order bundles; often present as 1 or 2 cells situated between the vascular bundles abaxial to the motor cells.

Mesophyll.

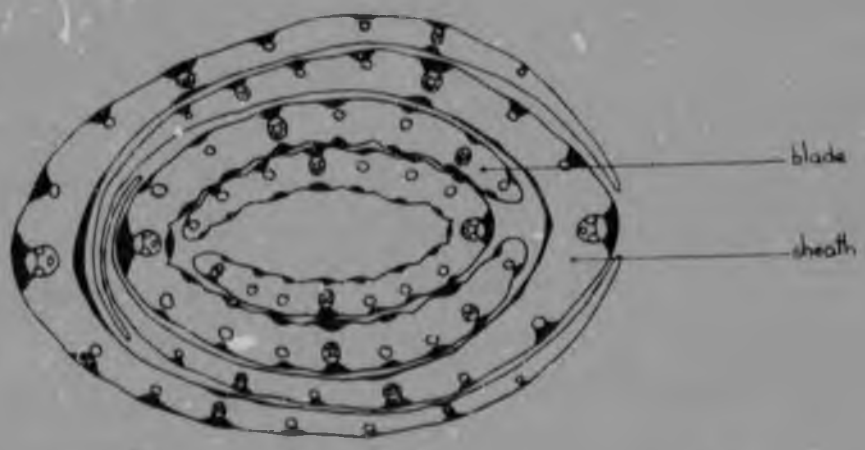
Not restricted to arcs of radiating cells surrounding the vascular bundles, and not separated by a band of colourless parenchyma between the bundles.

Mechanical tissue.

Poorly developed; abaxial fibrous strands present adjacent to all vascular bundles, adaxial strands not as well developed as the former and occasionally absent in the case of the midrib and third order bundles; first order bundles very rarely girdered.

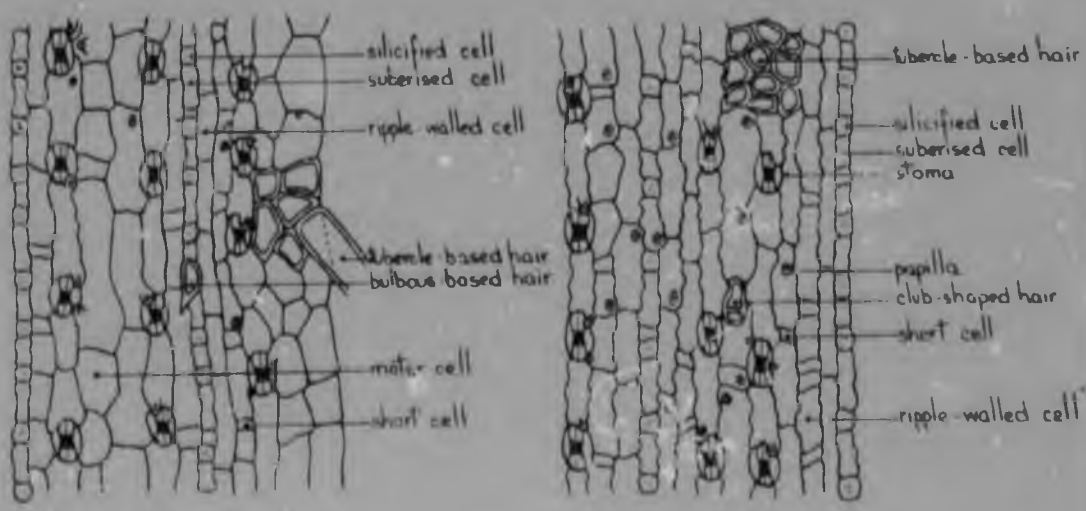
Fisher (1940), in her description of the leaf anatomy of C. transvaalensis, noted that the midrib did not include colourless parenchyma and that first order bundles were usually girdered. Stent (1927a) maintains that the epidermal cells of C. transvaalensis are "not or scarcely papillate", but her sketch of this leaf does not appear to support her statement. Fisher found conspicuous papillae in all the specimens which Stent examined with the exception of one; this specimen Fisher classifies as a variety of C. transvaalensis in which the epidermis has a thick cuticle and no papillae.

PLATE 18



80 X

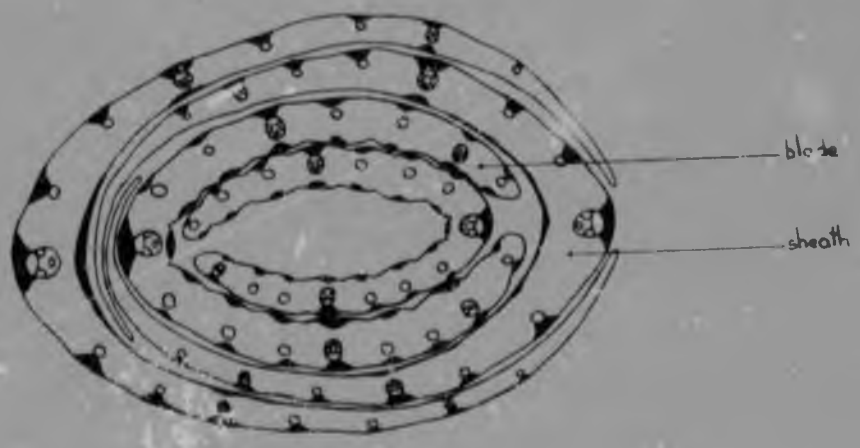
Diagram of T.s. of shoot of Cynodon Magennisii Hurcombe sp. nov.



340 X

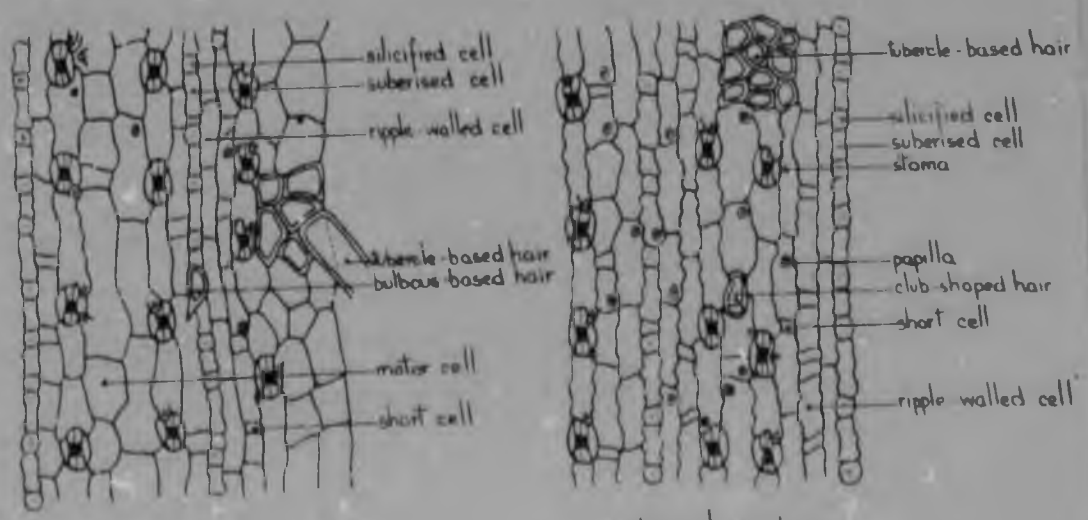
Portions of epidermis of Cynodon Magennisii Hurcombe sp. nov.

PLATE 18



80 X

Diagram of T.s. of shoot of Cynodon Magennisii Hurcombe sp.nov.



340 X

Portions of epidermis of Cynodon Magennisii Hurcombe sp.nov.

Leaf anatomy of Cynodon Nlemfuensis Harcombe

(Plates 18 to 20)

Shape in transverse section.

Adaxial surface undulating or with shallow ridges and furrows, abaxial surface undulating; obtuse or rounded keel; margin acute, obtuse or rounded.

Epidermis.

Motor cells in groups of 3 or 5 cells, the central cell as deep as broad and occupying about half the leaf thickness; 1 file of short elements opposite third order bundles, 2 or 3 files opposite first order bundles (4 or 5 files opposite the midvein in the abaxial epidermis); tubercle-based hairs and club-shaped hairs found in both epidermises; asperities absent or very occasional in the abaxial epidermis and occasional in the adaxial epidermis; papillae conspicuous in both epidermises, 2 or 3 often surrounding a stoma; epidermal cells scarcely smaller opposite the vascular bundles; ripple-walled cells interrupted by 1 (rarely 2) short cells; the outer wall of the abaxial epidermal cells slightly thicker than that of the adaxial epidermal cells.

Vascular bundles.

First order bundles. 5 first order bundles - the penultimate bundle sometimes of the second order; outer bundle sheath arranged in a circle or narrow "horse-shoe" of 6 to 9 chlorenchyma cells, continuous adaxially, interrupted abaxially by sclerenchyma or colourless parenchyma (or in the case of the penultimate bundle often continuous abaxially).

Third order bundles. 1, 2 or 3 third order bundles between every two bundles of the first order; circular bundle sheath of 6 to 8 chlorenchyma cells uninterrupted adaxially or abaxially.

Colourless parenchyma.

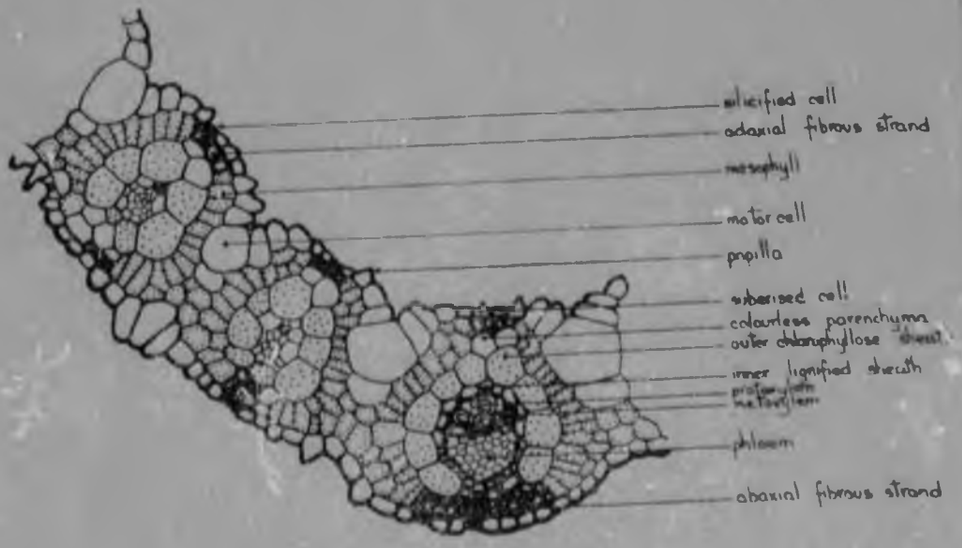
Found in the midrib as 1 or 2 cells separating the outer

PLATE 19



60X

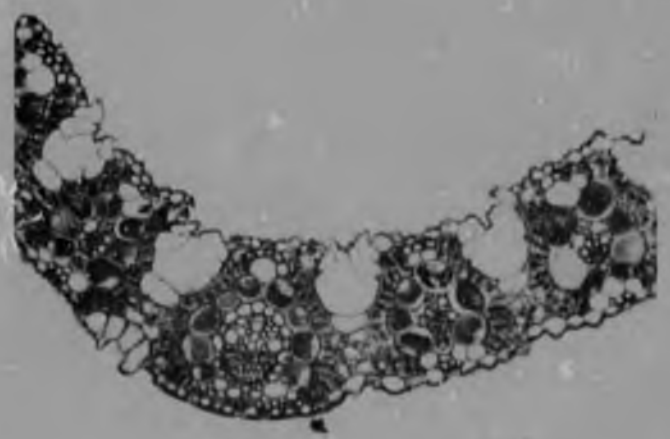
Diagram of t.s. of leaf of Cynodon Magennisii Hurcombe sp.nov.



340X

Portion of t.s. of leaf of Cynodon Magennisii Hurcombe sp.nov.

PLATE 20



Photomicrograph of t.s. of leaf of

Cynodon hagennisii Hurcombe sp. nov.

250x

bundle sheath from the adaxial fibrous strand; often found between the outer bundle sheath and the adaxial or abaxial fibrous strands of other first order bundles; usually found between the outer sheath and the abaxial or adaxial fibrous strands of third order bundles; often present as 1 or 2 cells situated between the vascular bundles abaxial to the motor cells.

Mesophyll.

Not restricted to arcs of radiating cells surrounding the vascular bundles, and not separated by a band of colourless parenchyma between the bundles.

Mechanical tissue.

Not strongly developed; abaxial and adaxial fibrous strands found adjacent to all vascular bundles, the abaxial strands more strongly developed than the adaxial strands except in the case of some third order bundles; first order bundles not girdered.

Leaf anatomy of Cynodon Bradleyi Stent.

(Plates 21 to 23)

Shape in transverse section.

Adaxial surface undulating or with shallow ridges and furrows, abaxial surface flat or slightly undulating; obtuse keel; margin acute.

Epidermis.

Motor cells in groups of 3 or 5 (rarely 7) cells, the central cell usually deeper than broad and occupying at least half the leaf thickness; 1 file of short elements opposite third order bundles (occasionally 2 files in the adaxial epidermis), 2 or 3 files opposite first order bundles, (4 to 6 opposite the midvein in the abaxial epidermis); epidermis of both surfaces with asperities, occasional club-shaped hairs, and numerous tubercle-based hairs; papillae conspicuous in both epidermises, 2 or 3 often surrounding a stoma; cells not conspicuously smaller opposite the vascular bundles; ripple-

PLATE 21

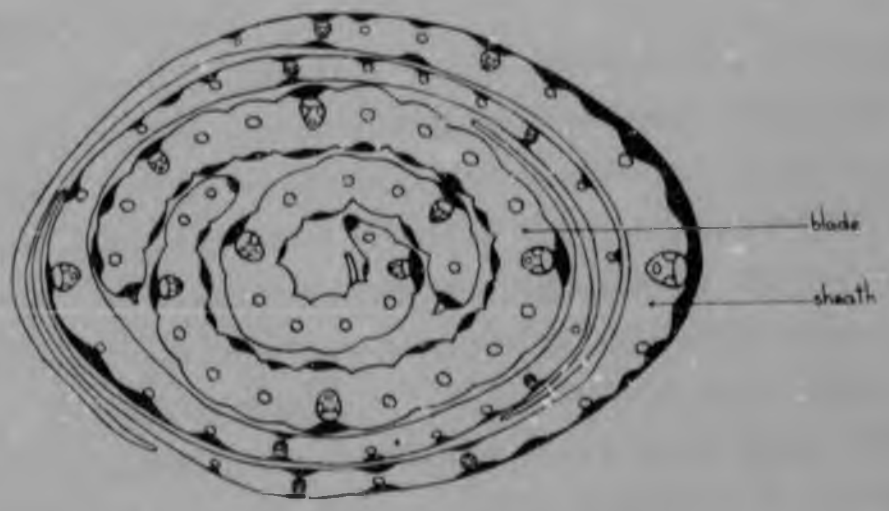
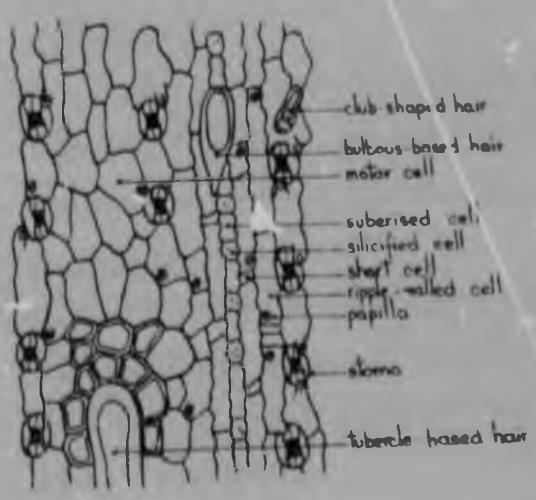
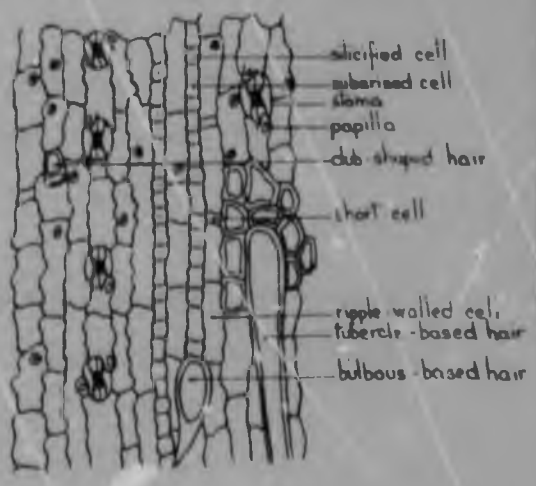


Diagram of t.s of shoot of Cynodon Bradleyi Stent 80 X



adaxial epidermis



abaxial epidermis

Portions of epidermis of Cynodon Bradleyi Stent 340 X

walled cells interrupted by 1 or 2 short cells; the outer wall of the abaxial epidermal cells only slightly thicker than that of the adaxial epidermal cells.

Vascular bundles.

First order bundles. 5 first order bundles - the penultimate bundle sometimes of the second order; outer bundle sheath usually arranged in a "horse-shoe" of 6 to 9 chlorenchyma cells interrupted abaxially by the abaxial fibrous strand, continuous adaxially or interrupted by the adaxial fibrous strand or by 1 or 2 colourless parenchyma cells.

Third order bundles. 3 or 4 (rarely 2) third order bundles between every two bundles of the first order; bundle sheath of 5 to 8 chlorenchyma cells, continuous or occasionally interrupted adaxially (rarely abaxially) by 1 or 2 large colourless parenchyma cells.

Colourless parenchyma.

Usually found in the midrib separating the outer bundle sheath from the adaxial fibrous strand (the number of cells varies from 0 - 10); commonly found between the outer bundle sheath and the adaxial or abaxial fibrous strands of third order bundles; very rarely present as 1 or 2 cells situated between the vascular bundles abaxial to the motor cells.

Mesophyll.

Not restricted to arcs of radiating cells surrounding the vascular bundles, and not separated by a band of colourless parenchyma between the bundles.

Mechanical tissue.

Not strongly developed; abaxial and adaxial fibrous strands found adjacent to all first order bundles and to the majority of third order bundles; first order bundles very rarely girdered.

Fisher (1940), in her description of the leaf anatomy of G. Bradleyi, records that colourless parenchyma cells do not

PLATE 22

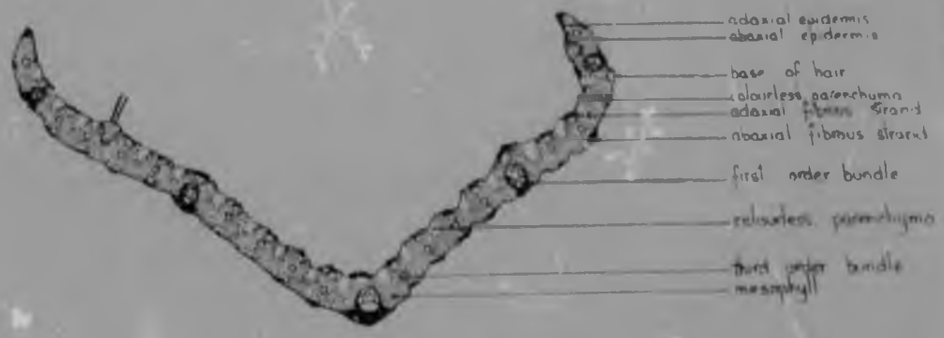
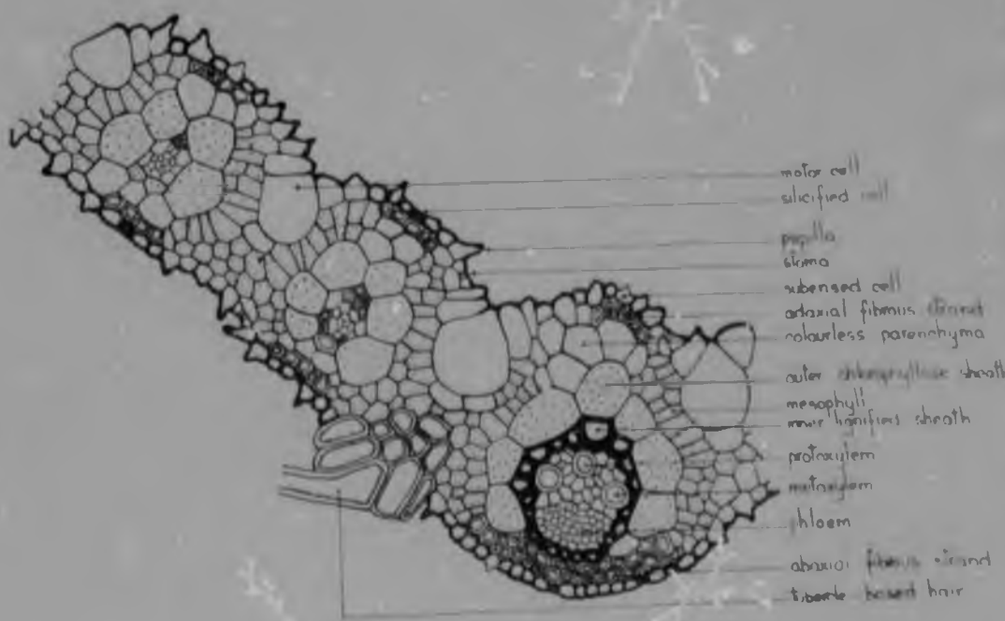
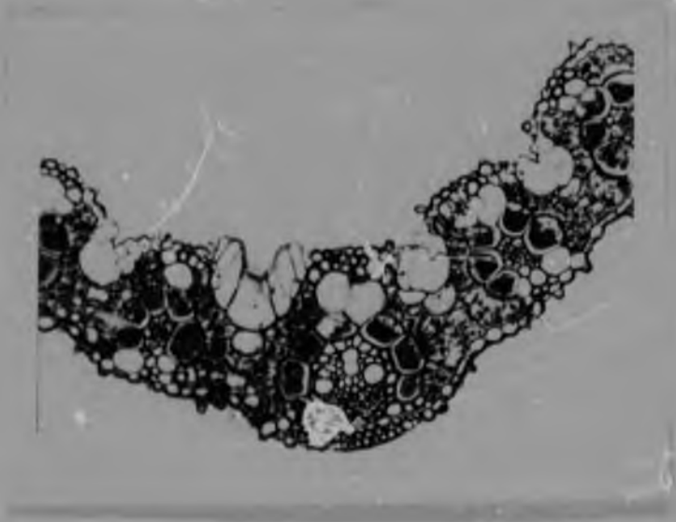


Diagram of T.S. of leaf of Cynodon Bradleyi Stent 60 ×



Portion of T.S. of leaf of Cynodor Bradleyi Stent 340 ×

PLATE 23



Photomicrograph of t.s. of leaf of

Cynodon Bradleyi Stent.

260x

occur in the midrib, and that first order bundles are usually girdered.

DISCUSSION OF THE LEAF ANATOMY

Many workers have recognised the fact that leaf anatomy is a valuable aid in the identification of grasses. Burr & Turner (1933) found that anatomical characters afford a more certain means of diagnosis than do purely vegetative characters, especially in cases where plants are grown in close association and subjected to cutting, rolling, or hard usage. However, these two workers were concerned mainly with a classification of widely differing genera and species. Lewton-Brain (1904) points out that "the anatomical structure of leaves of nearly related species is very similar if not practically identical", particularly when the species in question have a similar habitat. Vickery (1935) found that even widely separated species may strongly resemble each other in leaf anatomy and that to attempt to distinguish such species on minute differences would almost certainly lead to confusion. Prat (1932a), on the other hand, comes to the conclusion that the epidermis of plants supplies sufficient differences to distinguish genera, species, or even varieties, as it reflects very clearly the results of environmental change.

The writer found that a careful and critical examination of the anatomical differences between the leaves of the Cynodon species studied, appears to support Lewton-Brain's observation. In the writer's opinion, the only reliable diagnostic features are the nature of the abaxial epidermis (the presence or absence of tubercle-based hairs and papillae, and the thickness of the outer cell wall), and the number of first order bundles present. Fisher (1940) uses as diagnostic characters not only the nature of the abaxial epidermis and the number of first order bundles, but also the occurrence of parenchyma in the midrib. According to Stent (1927a) the

presence of parenchyma between the bundles is an important specific character. The writer considers the occurrence of parenchyma, both in the midrib and between the bundles, to be variable and unreliable diagnostically.

The similarity in the leaf anatomy of the Cynodon species may be correlated with the fact that they were taken from the same habitat and had been subjected to the same treatment. However, Fisher's and Stent's descriptions of the leaf anatomy of C. dactylon, C. transvaalensis, and C. Bradleyi, differ in minor respects only from those of the writer; these differences are not found in the epidermis or in the number of bundles, but chiefly in the degree of development of sclerenchyma and parenchyma. This fact suggests that the influence of environmental factors upon the leaf tissues is not very great.

C. transvaalensis is characterised by the presence of only three first order bundles, and C. dactylon by the unusual nature of the abaxial epidermis. A comparison of the leaf anatomy appears to support the contention that C. Magennisii is a hybrid - the result of a cross between C. dactylon and C. transvaalensis. On the whole, the internal structure of the leaf of C. Magennisii more closely resembles that of C. transvaalensis, particularly as regards the nature of the abaxial epidermis; however, the presence of five first order bundles establishes its affinity with C. dactylon. The leaf anatomy of C. dactylon var. densus was, for all practical purposes, identical with that of C. dactylon, although these two grasses are very different in habit and growth form. It is of interest that the leaf structure of C. Bradleyi is so similar to that of the other Cynodon species studied, considering that, in respect to the rolling of the leaves in the bud, it is so distinct. The only anatomical feature which separates it from the other species is the excessive hairiness of the leaf. Burt & Turner (1933), however, maintain that too much reliance should not be placed upon hairiness or its

absence as a critical diagnostic feature, owing to the fact that there is a lack of uniformity in this character not only within the species, but often within a given plant.

It may be concluded that Cynodon leaves do not differ so markedly in internal structure that a diagnostic key could be based entirely on anatomic features. However, these features have been used in conjunction with the external morphological characters, to produce a key for the classification of the different species.

ARTIFICIAL KEY TO THE SPECIES.

1) Leaves folded in the bud ..... 3.

2) Leaves rolled in the bud; leaves densely hairy on both surfaces with hairs 1.5 mm. long; rachilla sometimes produced but never bearing a reduced floret; ligule usually distinctly membranous; underground rhizomes absent ..... C. Bradleyi

3) 5 primary nerves in the leaf-balde ..... 5.

4) 3 primary nerves in the leaf-blade; 1 to 3 (usually 2) spikes; rachilla always produced but never bearing a reduced floret; glumes 1/4 to 1/3 the length of the spikelet; leaves not more than 1.5 mm. wide; a fine lawn grass ..... C. transvaalensis

5) Both surfaces of the leaf conspicuously papillate, and sparsely covered with hairs; glumes ½ length of spikelet; leaves less than 2 mm. wide; a fine lawn grass ..... C. Magennisii

6) Abaxial surface of the leaf without distinct papillae and usually glabrous; glumes more than ½ the length of the spikelet; leaves more than 2 mm. wide; coarse grasses ..... 7.

7) Spikes 2 to 6, 1.5 to 6.5 cm. long; leaves 2 to 16 cm. long and 3 to 4 mm. wide; flowering culm up to 40 cm. high; hairs on leaf up to 1.5 mm. long; a vigorous grass ..... C. dactylon

Spikes 2 to 4, 1.5 to 2.5 cm. long; leaves 0.5 to 3 cm. long and 2 to 3 mm. wide; flowering culm up to 10 cm. high; hairs on leaf not more than 0.5 mm. long; a slow-growing prostrate grass ..... C. dactylon var. densus.

CHROMOSOMES

PREVIOUS WORK ON CYNODON CHROMOSOMES

Avdulow (1931) records a diploid chromosome number of 36 for Cynodon dactylon Pers., and maintains that the basic number of the genus is 9. Hunter (1934), on the other hand, found a somatic chromosome number of 30 in Cynodon dactylon Pers., and states that the basic number appears to be 10.

Darlington and Janaki Ammal (1945) consider 9 to be the basic number of the Cynodon genus. They give the following chromosome counts:-

C. ploidum n. sp. (Giant Star grass)	18	Janaki Ammal unpublished count.
C. dactylor (Bermuda grass)	36	Avdulow, 1931.
	36	Janaki Ammal unpublished count.
	30?	Hunter, 1934.

The chromosome numbers given are the somatic or diploid numbers. The question mark is added after Hunter's number, as the writers (Darlington & Janaki Ammal) are uncertain of this number or of its attachment to the botanical name given.

METHODS

In a previous cytological paper (Harcombe 1945), the writer dealt chiefly with the selection of methods suitable for the study of the chromosomes in the root and anther of Cynodon Bradleyi, which methods could later be applied to other Cynodon species. This investigation showed clearly that the temporary aceto-carmine squash technique afforded a fairly effective method of obtaining chromosome counts in pollen mother cells, while the paraffin method proved most successful with root tip material.

Aceto-carmine squash method

The aceto-carmine technique usually affords an easy and rapid method of obtaining clear chromosome counts and should therefore prove of value to field workers. In the case of Cynodon species, however, the method was by no means rapid, as a considerable number of anthers were squashed before one in the desired stage was obtained. (See Hurcombe, 1945, p.3).

The most successful temporary aceto-carmine preparations were made according to the following method:-

(1) Young spikes were removed from the leaf sheaths and immediately plunged into the following fixative:-

3 parts absolute alcohol

1 part saturated soln. of carmine in glacial acetic acid, prepared by boiling the carmine and acid for 1 min., and filtering when cool.

(2) After 2 to 3 days the spikes were removed from the fixative and the spikelets dissected under the microscope.

(3) Anthers were cut into small portions and mounted on a slide in a drop of aceto-carmine stain to which iron had been added. (The aceto-carmine stain used was a 0.5% soln. of carmine (Karlbaum) in 45% acetic acid, boiled for 1 minute, cooled and then filtered. The iron solution mordant was a saturated solution of ferric acetate in 45% acetic acid. A very small drop of this solution was added to the stain on the slide.)

(4) The anthers were squashed by placing blotting paper over the coverslip, and by moving the blunt end of a dissecting needle over the blotting paper and coverslip with a quick clockwise, anti-clockwise movement.

(5) The slide was heated over a flame for a few seconds.

By this method, polar views of the pollen mother cells were frequently obtained, and the chromosomes in the cells were stained deep purple against a background of colourless cytoplasm. It was found that if the material was kept for more

than 3 days in the fixative or in 70% alcohol, the pollen mother cells became too hard, polar views were rarely obtained, and the cytoplasm in the cells absorbed stain readily, resulting in poor definition of the chromosomes. On the other hand, if the material was squashed too soon after fixation, or prior to fixation, the cells were found to be so soft that they were easily destroyed by squashing, and the chromosomes did not readily absorb stain. The addition of iron proved to be essential for successful staining whereas heating the slide after squashing did not appear to intensify the stain, although it was of use in flattening the cells and spreading the chromosomes.

These temporary preparations could be kept for only a few hours because the cytoplasm rapidly absorbed the stain after this period. As there were no facilities for photographing the preparations immediately they were made, the writer had to experiment with methods for making these temporary squash preparations permanent. Several months were spent in unsuccessful attempts. It was found that the pollen mother cells were very delicate and shrank in both alcohol and xylol, and that they did not adhere to the slide and so were lost as the slide and coverslip were passed through the various solutions. The following method suggested by Dr. C. Krupko (Botany Department, University of the Witwatersrand) gave the best results.

A paper clip was fixed over the slide which was then passed through the following solutions:

(1) 25 ml. 45% acetic acid
75 ml. 95% alcohol ..... 10 mins.

(2) 20 ml. 45% acetic acid
80 ml. 95% alcohol ..... 5 mins.

(3) 10 ml. 45% acetic acid
90 ml. 95% alcohol ..... 5 mins.

A.	B.
(4) 95% alcohol ..... 15 mins.	(4) 95% alcohol ..... 5 mins.
(5) absolute alcohol ..... 10 mins.	(5) 95% alcohol and dioxan (equal parts) 5 mins.
(6) absolute alcohol and xylol (equal parts) ...15 mins.	(6) I dioxan ..... 5 mins.
(7) I xylol .....10 mins.	(7) II dioxan ..... 5 mins.
(8) II xylol .....10 mins.	(8) Mount in dioxan-balsam.
(9) Mount in xylol-balsam.	

This method was effective in that there was little loss of material. However, many preparations were completely destroyed when the coverslip was raised in order to introduce the balsam.

The xylol method (A) failed because the pollen mother cells shrank slightly in absolute alcohol and very considerably in xylol and xylol-balsam. An attempt was made to reduce the shrinkage by introducing 5%, followed by 10% xylol-balsam, under the coverslip, before mounting in normal strength xylol-balsam. However, this method proved very laborious and there was no marked lessening in shrinkage.

The dioxan method (B) was preferable to the xylol method in that less shrinkage occurred, but it was found that the cytoplasm absorbed stain during the process and that the chromosomes in the final permanent preparations were poorly defined.

In the writer's opinion, a considerable amount of time should be given to the mastering of a squash technique suitable for the anthers of Cynodon and other similar grasses. However, as several months had already been devoted to the squash method, and as little progress had been made in this time, it was decided to concentrate on the paraffin method, and to make chromosome counts entirely from root tip preparations.

Paraffin method

(a) Preparation of material.

Surface runners or underground rhizomes of the grass were collected. All the adventitious roots were removed and the stems were then soaked in the following solution for 4 hours:

1½ ml. "Hortomone"
569 ml. water (i.e. 1 pint)

This solution was found to stimulate the development of adventitious roots.

The stems were then placed in a dish between sheets of moist blotting [illegible] and kept in an oven at a constant temperature of [illegible]. After 2 to 3 days new adventitious roots had developed. When these roots were ¼ in. to ½ in. long, the stems bearing the roots were placed in water for 6 hours. According to Navashin (1934), germination is closely related to the turgor of the plant tissues; if the roots are placed in water the turgor increases and the chromosomes tend to be more widely spread in the cells.

The root tips were then removed by means of a sharp forceps and immediately plunged into the fixative.

(b) Fixation.

For a description of the fixatives used see p.[illegible]. All fixatives were mixed just before use, as their killing and fixing properties are most effective when the fluid is fresh. The root tips were placed in a phial containing approximately 7 ml. of the fixing solution. The phial was immediately placed under a vacuum pump for 5 minutes in order to remove from the material the air bubbles which might delay penetration. After pumping, the material was left in a fresh solution of the fixative for 24 hours.

(c) Washing.

After 24 hours fixation, the material was removed from the

phial and washed in gently running water for 12 hours, in order to remove all trace of acid from the material.

(d) Dehydration.

The material was dehydrated as follows:

5%	alcohol	15 mins.
10%	"	1 hour.
20%	"	1 "
30%	"	1 "
40%	"	2 hours.
50%	"	2 "
60%	"	2 "
70%	"	2 "
80%	"	2 "
90%	"	2 "
95%	"	2 "
I	absolute alcohol	2 "
II	"	15 mins.

Material was stored for as long as several weeks in 70% alcohol, but was not allowed to remain longer than 12 hours in absolute alcohol. During dehydration the material was placed in a 1% soln. of safranin in 70% alcohol for 1 hour. If the material was not stained in this way, it was very difficult to detect in xylol or wax, and orientation during embedding was unnecessarily difficult.

(e) Infiltration.

The following method of infiltration was used:

(1) Place the material in a small phial and cover with absolute alcohol. Add xylol to the alcohol drop by drop, allowing a 1 to 2 minute interval between each drop, until the phial contains absolute alcohol and xylol in equal proportions.

(2) Place the material in a mixture of ¾ xylol and ¼ absolute alcohol for 15 minutes.

(3) Transfer the material to pure xylol and leave for 1 to 2 hours.

(4) Cover the material with fresh xylol. Add small pieces of wax (M.P. 48°C.), waiting until each dissolves before adding the next. If dissolving is slow place the corked phial on the oven. When the xylol is saturated with wax, uncork the phial and place in the oven. Continue adding wax until the xylol is ¼ of the volume.

(5) Place the material in pure wax (M.P. 48°C.) and leave overnight.

(6) Transfer the material to pure wax (M.P. 54°C.) and leave overnight.

(f) Embedding.

The material was embedded in pure wax (M.P. 54°C.). Care was taken to avoid touching the material with a hot needle during orientation.

N.B. At no stage during the processes of infiltration or embedding, was the material subjected to a temperature higher than 60°C.

(g) Microtoming.

The root tips were cut at 7 microns. Ribbons were fixed to the slide with Haupt's adhesive. (See Johansen, 1940, pp. 20 & 150).

(h) Staining.

Heidenhain's iron haematoxylin stain was used after Lewitsky fixation, and crystal violet stain after Navashin fixation.

The following staining schedules were used:

Heidenhain's iron haematoxylin stain.

(1) xylol ..... 1 hr.

(2) xylol-absolute alcohol (equal parts) ..... 10 mins.

(3) 70% alcohol ..... 5 mins.

(4) 35% alcohol ..... 5 mins.

(5) wash in running water ... . 5 mins.

(6) rinse in distilled water.

(7) mordant in 3% iron alum ..... 6 hrs.

(8) rinse in distilled water.

(9) wash in running water ..... 5 mins.

(10) stain in 0.5% aq. haematoxylin prepared according to Johansen, 1940, p. 50 ..... 12 hrs.

(11) rinse in distilled water.

(12) wash off excess stain in running water.

(13) differentiate with 2% iron alum under the microscope.

(14) distilled water ..... 5 mins.

(15) wash in running water ..... 1 hr.

(16) dehydrate in 50%, 70%, 95% and absolute alcohol ..... 5 mins in each.

(17) absolute alcohol-xylol (equal parts) ..... 5 mins.

(18) xylol (2 changes) ..... 5 mins. each.

(19) mount in xylol-balsam.

Crystal violet stain.

(1) xylol ..... 1 hr.

(2) xylol-absolute alcohol (equal parts) ..... 10 mins.

(3) 70% alcohol ..... 5 mins.

(4) 35% alcohol ..... 5 mins.

(5) distilled water ..... 5 mins.

(6) stain in 1% aq. soln. of crystal violet prepared according to Darlington & la Cour, 1942, p. 111) ..... ½ hr.

(7) after - mordant in 1% iodine, 1% potassium iodide in 80% alcohol ..... 45 secs.

(8) 95% alcohol ..... 2 secs.

(9) absolute alcohol (2 changes) ..... 2 secs. each.

(10) differentiate under the microscope in clove oil.

(11) xylol (2 changes) ..... 5 mins. each.

(12) III xylol ..... ½ hr.

(13) mount in xylol-balsam.

Crystal violet stain was used after Navashin's fixative with excellent results. The cytoplasm was almost colourless, and the chromosomes of a deep violet colour were clearly defined. The stain was preferable to haematoxylin as the chromosomes were thinner and more transparent which made for greater precision in counting.

Fixatives.

The following fixatives were used:

(1) Lewitsky's formula for small chromosomes.

10% formol .... 8 vols.

1% chromic acid ..... 2 vols.

(2) Lewitsky's formula for large chromosomes.

10% formol ..... 5 vols.

1% chromic acid ..... 5 vols.

(3) Navashin's fluid.

1% aq. chromic acid ..... 10 ml.

40% formol (commercial formalin) ..... 4 ml.

Glacial acetic acid .. 1 ml.

Avdulow (1931) recommends the two formulae - one for large, and one for small chromosomes - used by Lewitsky. He appears to have found the latter formula most suitable for Cynodon chromosomes for he includes a figure of the chromosomes of Cynodon Dactylon Pers. (Diag. 56, p. 174) and states clearly that the fixative used for the preparation was Lewitsky's formula for small chromosomes. The figure is poorly reproduced, but it is obvious that the chromosomes are thin and fairly well spread out, and it appears that several of the chromosomes show distinct constrictions.

Because of Avdulow's apparent success the writer decided to use Lewitsky's formula. As it is doubtful whether Lewitsky intended 10% formol to mean 10% or 4% of commercial formalin

(40% formol), the writer used both these percentages in both the formula for large and for small chromosomes. None of these fixatives, however, proved to be suitable for Cynodon root tip material. The chromosomes were thin and well spaced, but were scarcely visible as they were only slightly darker than the cytoplasm. Owing to the absence of acetic acid - which destroys the finer plasma structures - the mitochondria are well preserved by Lewitsky fixation. In preparations of roots rich in plasma, these mitochondria might form a deeply stained background against which the chromosomes are poorly defined. Cynodon root tip cells are particularly rich in plasma and it is probably due to this fact that the Lewitsky formulae gave such poor fixation.

Various methods were tried in order to darken the chromosomes:

(a) The material was left in the fixative for 2 to 3 days instead of for 24 hours.

(b) After fixation and rinsing in water, the material was placed in 1% chromic acid for 2 days and then washed for 12 hours.

(c) Before mordanting the sections were placed in 1% chromic acid for 2 days and then rinsed in water.

(d) Sections were mordanted in 6% iron alum for 6 hours, or alternatively for 12 hours, instead of mordanting in 3% iron alum for 6 hours.

None of these methods met with any success.

In the writer's previous paper on Cynodon Bradleyi (Hurcombe, 1945), several fixatives were used while experimenting with the paraffin method as applied to root tip material. Of all the fixatives tried, only Navashin and 2BK fluids gave good results; but even these two fixatives failed to reveal any details of chromosome morphology. The writer selected Navashin's fluid for use in the present study, as this fixative gave the best results with crystal violet stain.

After Navashin fixation, the chromosomes were fairly well spread out and were clearly outlined against a background of colourless cytoplasm.

Critical observations of chromosomes were made with a Bausch & Lomb 2 mm. (90 x) apochromatic oil immersion objective and a Zeiss 17x ocular, giving a total magnification of 3000x at table level. The diagrams of the metaphase plates were drawn at this magnification with the aid of a Zeiss camera lucida. Photographs of the same metaphase plates were taken at a magnification of 1150x and subsequently enlarged twice.

RESULTS

Because of the tendency for overlapping of the somatic chromosomes, exact determinations of chromosome numbers were obtained only with great difficulty.

The following chromosome counts were made from metaphase plates in root tip cells fixed in Navashin's fluid and stained with crystal violet.

<u>Cynodon Bradleyi</u> Stent .....18. (Plate 28)

<u>Cynodon transvaalensis</u> Burtt Davy....20. (Plate 26)

<u>Cynodon dactylon</u> Pers.....40. (Plate 24)

<u>Cynodon dactylon</u> Pers. <u>var. densus</u> Burcombe.....40. (Plate 25)

<u>Cynodon Magennisii</u> Burcombe.....39. (Plate 27)

DISCUSSION

Recent trends in taxonomy have placed emphasis on the application of the results of investigations in genetics and cytology to problems of classification. Cytological data, if carefully determined and used in conjunction with other evidence, have proved a valuable guide to taxonomic relationships.

PLATE 24

FIG. 1



Camera lucida drawing of root metaphase of Cynodon dactylon Pers. x 3000

FIG. 2



2500 x

FIG. 3



1150 x

Photomicrographs of metaphase plate shown in Fig. 1.

Although in large groups there appears to be little correlation between taxonomic position and the nature and number of the chromosomes, yet it is generally agreed that within restricted circles of affinity the number of chromosomes as well as their size and form may often afford important evidence in the determination of species relationships.

In many genera of flowering plants, the chromosomes are so small and similar in size and shape that no constant morphological difference between them can be observed. In such genera the number of chromosomes has proved a useful criterion. Certainly, species groupings made on the basis of chromosome number frequently correspond strikingly with those arranged by taxonomists on other grounds. Darlington (1940) maintains that in a group where polyploidy and other cytological irregularities have resulted in systematic confusion, chromosome numbers are not merely an indispensable guide in solving the taxonomic problem, but actually provide a rigorous basis of classification which is not to be found in the welter of morphological forms.

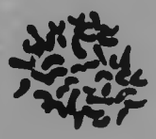
It is possible that the Cynodon genus is such a group, and that a careful cytological study of it would assist greatly in solving the problem of species groupings within the genus.

It is obvious from an examination of the somatic chromosomes of the Cynodon species studied that the chromosomes in each complement, because they are small and remarkably uniform, cannot be distinguished morphologically. Any cytological classification must therefore be based entirely on differences in chromosome number.

With the exception of C. Bradleyi, the somatic chromosome numbers of the Cynodon species studied form a polyploid series with a basic number of 10, in which C. transvaalensis is the diploid form, C. nlemfuensis the triploid, and C. dactylon and C. dactylon var. densus both tetraploid forms.

PLATE 25

FIG. 1



Camera lucida drawing of root metaphase of *Cynodon dactylon* Pers. *var. densus* Hurcombe var. nov.

x 3000

FIG. 2

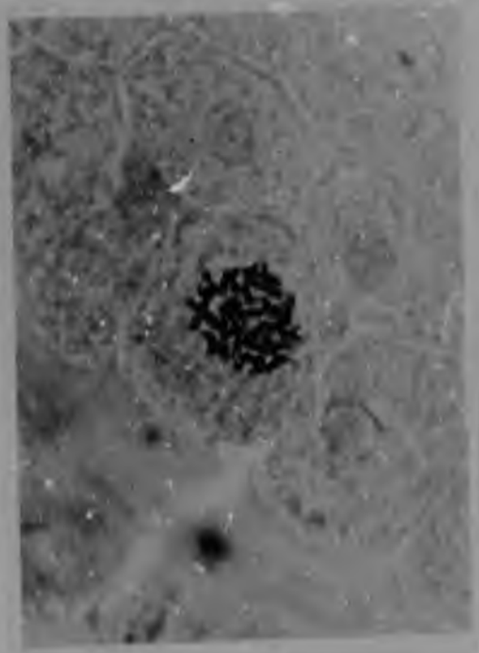


FIG. 3



2300 x

1150 x

Photomicrographs of metaphase plate shown in Fig. 1.

It is difficult to ascertain the cytological relationship of C. Bradleyi to the other species. It is possible that this grass may be an aneuploid; as a result of non-disjunction or unequal distribution of the chromosomes, gametes with one chromosome less than the usual number may arise, and the union of two such n - 1 gametes would result in a form with one pair less than the usual somatic complement. According to Sharp (1926) such aneuploid forms differ more from the normal diploid than do polyploid forms. Church (1929) came across several such examples in his study of grass genera. He found it convenient to use the term "dysploids" for these "irregular deviations from the fundamental haploid base in a polyploid series." He also discovered that many of these "dysploids" had an obvious hybrid origin, and came to the conclusion that hybridity and dysploidy were frequently correlated. The fact that C. Bradleyi is completely sterile suggests that this grass may also be of hybrid origin. Such an origin might certainly account for its unusual chromosome number.

Alternatively, it may be suggested that the Cynodon genus has two basic numbers of 9 and 10, and that the genus has therefore developed along two separate lines. On this assumption, it would be difficult to explain why C. Bradleyi, the diploid form in the 9-series, is completely sterile. If two groups are present in the genus, one would expect to find very distinct morphological and anatomical differences between C. Bradleyi on the one hand, and the other species on the other. Differences do exist; C. Bradleyi is distinct from the other species as regards the leaf vernation and the absence of underground rhizomes. However, these differences would appear too slight to provide the evidence in support of such an assumption.

A careful study of the external morphology and leaf anatomy of C. Hagenniaii suggests that this grass is

intermediate between C. dactylon and C. transvaalensis. In his description of the origin of this grass, Mr. W.B. Magennis definitely considers it to be a hybrid between "Florida" (C. transvaalensis) and "Kweek" (C. dactylon), and the chromosome number supports his contention. Historical, morphological and cytological data, therefore, suggest that this triploid is not an auto-polyploid but a definite allo-polyploid arising from a cross between a diploid and a tetraploid. The fact that C. Magennisii does not set seed supports the observation made by many workers that triploids are nearly always sexually sterile, since they cannot undergo regular reduction owing to the odd number of chromosomes.

That C. dactylon is a tetraploid serves to explain many of the characteristics of this species. As is often typical of tetraploid forms this grass is larger in size, more vigorous in growth, and altogether hardier than the diploid form. C. dactylon has a world-wide distribution and flourishes under a variety of conditions, whereas other Cynodon species are of limited distribution and are often restricted to one particular habitat.

Many systematists have remarked on the width of variation which occurs within this one species. (See p. 12). According to Crane (1940) such variation is obviously correlated with the tetraploid nature of the plant. He states that "it is a commonplace to find a more complex and wider range of variation in polyploid species, and especially in high polyploids, than in diploids .....Where two or more genes govern the expression of the same character, as is common in polyploids their effect is often cumulative and consequently a given character may intergrade from one extreme to the other."

It is interesting to note that C. dactylon is highly fertile, whereas C. transvaalensis rarely produces mature seed. To quote Crane (1940): "From very considerable evidence it appears possible to predict that the doubling of the

PLATE 26

FIG. 1



Camera lucida drawing of root metaphase of
Cynodon transvaalensis Burtt Davy ×3000.

FIG. 2



3300 ×

FIG. 3



2150 ×

Photomicrographs of metaphase plate shown in Fig. 1.

chromosomes of sterile hybrids will lead to increased fertility, but in fertile forms will lead to a reduction of fertility." Darlington (1940) observes that a polyploid which has arisen from a non-hybrid diploid is less fertile than the diploid parent, whereas doubling of the chromosomes in a more or less sterile hybrid results in a polyploid which is fairly fertile and, in proportion to its fertility, true-breeding. These latter properties, he maintains, are "due to the dissimilar chromosomes of opposite parents no longer pairing with one another but with the new identical mates produced by their own doubling." It would appear, therefore, that the origin of a fertile tetraploid has a sound genetic basis, and that C. dactylon possibly arose from the doubling of chromosomes in a fairly sterile diploid ancestor.

C. dactylon var. densus ("Hall's Selection") resembles C. dactylon in many respects; both have the same chromosome number, their leaf anatomy is almost identical, and as regards most features of external morphology they are closely similar. But whereas C. dactylon is a vigorous grass which may reach a height of 40 cm. and is fairly fertile, C. dactylon var. densus is a slow-growing, prostrate, tufted grass which rarely sets seed. This peculiar growth form appears to be a constant character; in the experimental plots at Frankenwald these two grasses have been growing under exactly similar conditions for several years, and the variety has remained true to type through this period. The available data, therefore, suggest that "Hall's Selection" is merely a form of C. dactylon. Its origin (see p. 6) might lead one to suspect that it arose as the result of a mutation which produced an alteration in growth form. It is certain that "Hall's Selection" is not an ecological or geographical form of C. dactylon induced by peculiar environmental conditions, since both these grasses when transplanted to a common testing-ground retained their original distinguishing features.

chromosomes of sterile hybrids will lead to increased fertility, but in fertile forms will lead to a reduction of fertility." Darlington (1940) observes that a polyploid which has arisen from a non-hybrid diploid is less fertile than the diploid parent, whereas doubling of the chromosomes in a more or less sterile hybrid results in a polyploid which is fairly fertile and, in proportion to its fertility, true-breeding. These latter properties, he maintains, are "due to the dissimilar chromosomes of opposite parents no longer pairing with one another but with the new identical mates produced by their own doubling." It would appear, therefore, that the origin of a fertile tetraploid has a sound genetic basis, and that C. dactylon possibly arose from the doubling of chromosomes in a fairly sterile diploid ancestor.

C. dactylon var. densus ("Hall's Selection") resembles C. dactylon in many respects; both have the same chromosome number, their leaf anatomy is almost identical, and as regards most features of external morphology they are closely similar. But whereas C. dactylon is a vigorous grass which may reach a height of 40 cm. and is fairly fertile, C. dactylon var. densus is a slow-growing, prostrate, tufted grass which rarely sets seed. This peculiar growth form appears to be a constant character; in the experimental plots at Frankenwald these two grasses have been growing under exactly similar conditions for several years, and the variety has remained true to type through this period. The available data, therefore, suggest that "Hall's Selection" is merely a form of C. dactylon. Its origin (see p. 6) might lead one to suspect that it arose as the result of a mutation which produced an alteration in growth form. It is certain that "Hall's Selection" is not an ecological or geographical form of C. dactylon induced by peculiar environmental conditions, since both these grasses when transplanted to a common testing-ground retained their original distinguishing features.

PLATE 87

FIG. 1



Camera lucida drawing of root metaphase of

Cynodon Magennisii Hurcombe sp. nov. x3000.

FIG. 2



3300 x

FIG. 3



1170 x

Photomicrographs of metaphase plate shown in Fig. 1.

Stent (1927a) considers both C. Bradleyi and C. transvaalensis to be natural hybrids between C. dactylon and C. hirsutus. This does not seem probable in the light of a numerical comparison of the chromosomes of the three first-mentioned species. However, the chromosome number of C. hirsutus must be determined before any statement can be made. Certainly, the fact that C. transvaalensis rarely sets seed and that C. Bradleyi is completely sterile does suggest that these two species might have a hybrid origin. Systematists have been accustomed to define a hybrid as a cross between individuals of two different species. The geneticist, however, defines a hybrid as a cross between two gametes of different genetic constitution, and therefore recognises interspecific and intraspecific hybrids. If this wider use of the term is recognised by the "New Systematics", it is quite possible that a hybrid origin could be attributed to most, if not all, of the Cynodon forms studied.

Comparison of the chromosome numbers with those recorded in the literature. (See p. 47)

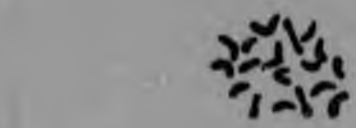
Hunter's chromosome number of 30 for C. dactylon supports the writer's assumption that 10 is the basic number of the Cynodon genus. But, whereas the writer found C. dactylon to be a tetraploid, Hunter finds it to be a triploid.

The numbers obtained by both Janaki Ammal and Avdulow for Cynodon species are at variance with those determined by the writer. These two workers maintain that the basic number of the Cynodon genus is 9, since they both find 36 chromosomes in C. dactylon and Janaki Ammal records a diploid count of 18 for C. diploidum.

To assume that the Cynodon genus has two basic numbers of 9 and 10 corresponding to two separate lines of development would appear to solve this problem of conflicting chromosome

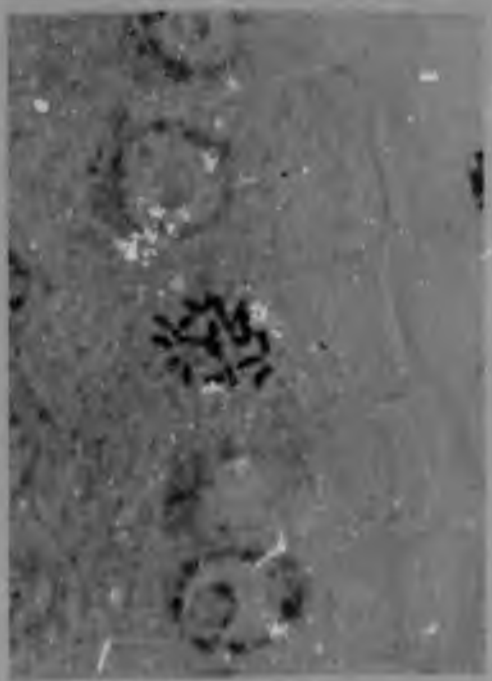
PLATE [illegible]

FIG. 1



Camera lucida drawing of root metaphase of *Cynodon Bradleyi* Stent x30[illegible].

FIG. 2



[illegible]300 x

Fig. 3



1150 x

Photomicrographs of metaphase plate shown in Fig. 1.

numbers. However, the reasons why the writer considers C. Bradleyi to be an aneuploid species derived from an ancestor with a basic number of 10 rather than a diploid species with a basic number of 9, have been given on p. 59 . Also, C. dactylon according to Jan ki Ammal and Avdulow should fall into the 9-series, while according to the writer it should be included in the 10-series. From a study of the literature and of this present work, it is clear that C. dactylon is reported to have three different chromosome numbers - 30, 36 and 40. Unfortunately not one of the workers mentioned describes the morphology of the grass studied, so that it is impossible to make any comparison. It is, therefore, probable that these three numbers refer not to one species, but to three different species of Cynodon.

In the writer's opinion, the problem concerning the basic number of the Cynodon genus cannot be solved until the chromosome complements of all the known species within the genus have been critically examined. The writer is also convinced that such a cytological examination must be accompanied by a careful morphological description of each grass studied.

CONCLUSIONS.

The problem of the taxonomic relationships of the Cynodon species selected was elucidated by a study of their external morphology, leaf anatomy, and chromosome number. The results of the cytological and morphological research showed a remarkable uniformity, and it is certain that the number of chromosomes is a useful additional character in the determination of the position of these species whose relationships would otherwise have been uncertain.

A detailed examination of the external morphology showed that the species do not differ greatly. The only reliable and constant characters are the vernation of the leaves, the presence or absence of rhizomes, the nature of the produced rachilla, and the length of the glumes in relation to that of the spikelet. The species differed also as regards the length, width, and hairiness of the leaf, the number of spikes, the nature of the ligule, and size, but these characters were often found to be very variable and could be considered only in conjunction with other characters.

From a critical study of the leaf anatomy the writer concluded that the only reliable diagnostic features are the nature of the abaxial epidermis and the number of first order bundles present. A diagnostic key to the species was based on characters of external morphology in conjunction with anatomical characters.

The chromosome numbers indicated that the basic number of the genus was 10 and that the species formed a polyploid series in which C. transvaalensis was the diploid form, C. Magennisii the triploid, and C. dactylon and C. dactylon var. aridus both tetraploid forms. C. Bradleyi with a somatic number of 18 was assumed to be an aneuploid species.

A careful study of all the available data, cytological, morphological and historical, led to the following conclusions as regards the systematic relationship of the Cynodon species studied:

(1) C. dactylon Pers., C. transvaalensis Burtt Davy and C. Bradleyi Stent were found to be well-defined species.

(2) C. Wagenniaii Hurcombe sp. nov. was found to be a hybrid between C. dactylon and C. transvaalensis. The writer conferred specific rank on this hybrid because it is a lawn grass in common use, and because it remains true to type as it reproduces only by vegetative means.

(3) The grass known commonly as "Hall's Selection" differed from C. dactylon only as regards size and growth form. The writer therefore considered this grass to be a variety of C. dactylon and referred to it as C. dactylon Pers. var. densus Hurcombe var. nov.

SUGGESTIONS FOR FURTHER RESEARCH

Unfortunately time did not permit a revision of the entire Cynodon genus. The writer, however, intends to continue with this work and hopes to include a study of C. incompletus Nees, C. hirsutus Stent, C. Polevansii Stent, and C. plectostachyum Pilg., as well as other Cynodon grasses yet undetermined which are being extensively used as lawn grasses.

In the writer's opinion, a valuable contribution to cytological studies in the Gramineae would be the evolution of a squash technique particularly suitable for the anthers of Cynodon and other similar grasses. Certainly such a rapid method of obtaining counts in pollen mother cells would assist greatly in the solution of problems of taxonomy and genetics.

ACKNOWLEDGMENTS

I wish to thank Dr. John Phillips, Professor of Botany in the University of the Witwatersrand, in whose Department this work was carried out, for suggesting the subject of the investigation; Dr. S. Krupko for his inspiring guidance; Mrs. M. Moss for her valuable advice; Dr. D. Meredith for his practical co-operation; Mr. A. Malbany for the photomicrographs. To all these I am greatly indebted.

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Author Hurcombe R
Name of thesis A Cytological and Morphological study in Cyndon species 1947

PUBLISHER:
University of the Witwatersrand, Johannesburg
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