TAXONOMIC STUDIES AND GENERIC DELIMITATION IN THE GRASS SUBTRIBE *Sorghinae.*

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Dedicated to the memory of my father,
Tonkana, and to my mother, **Kerileng**.

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Contents.

Abstract.

Genera and species of the grass subtribe *Sorghinae* were investigated. This study covered taxa from the whole range of their morphological variation and geographic distribution. In order to make the study feasible in the time permitted, a representative sample was chosen. Parameters used in choosing this sample are outlined in Chapter 1. The objective of the study was to determine and ascertain generic boundaries in the subtribe and hence reveal relationships between them. Fourteen genera are recognised in the subtribe. These are *Asthenochloa*, *Bothriochloa*, *Capillipedium*, *Chrysopogon*, *Cleistachne*, *Dichanthium*, *Euclasta*, *Hemisorghum*, *Pseudodichanthium*, *Pseudosorghum*, *Sorgahstrum*, *Sorghum*, *Spathia* and *Vetiveria*. They were confirmed to form clearly distinct genera despite suggestions by some authors to the contrary, some of whom have advocated merging some genera in the subtribe. The genera divide into two groups. The first group consists of *Sorghum* and allies, while the second group is centred around *Dichanthium* (Chapter 3).

Numeric analysis were used to highlight both phenetic and phylogenetic relationships between the genera (Chapter 7). The phenetic analysis broadly revealed a somewhat similar picture to the one I held. Species of the same genus cluster in the same place. Also those genera that are least similar separate at low phenon levels. The cladogram produced, however, was totally different from my intuitive classification of the subtribe.

Formal taxonomic descriptions incorporating keys and specimens seen can be found in Chapter 8. An attempt was made to document a lot of information about the taxa studied, e.g., chromosome number(s), even if these were not a direct result of the research. A new combination in *Euclasta*, *E. oligantha* (Hotchst. ex Steud.) M.P. Setshogo, was recognised (Appendix 11.2).

Three factors consistently affecting the taxonomy of the subtribe are suggested to be (i) intergeneric hybridisation in the generic complex *Bothriochloa-Capillipedium-Dichanthium*; (ii) man induced interspecific hybridisation in *Sorghum* and (iii) specific complexes whose member species overlap morphologically (Chapter 3).

Several sources of evidence were tapped to address these problems. These were the use of micro- and macro-morphology and anatomy. The research was based on the use of herbarium material as well as living plants. Leaf anatomy confirmed the C4 physiological anatomy associated with the grasses (Chapter 6). Scanning Electron Microscopy (SEM) was used to study glume pits in the genera *Bothriochloa* and *Dichanthium* (Chapter 5).

Distribution and ecogeography revealed that the subtribe *Sorghinae* occurs in the tropics and subtropics of the Old World, with a high concentration of species and genera in the Indian subcontinent (Chapter 9). Except for a few species of *Bothriochloa*, *Chrysopogon* and *Sorghum* reportedly introduced into the Western Hemisphere, only *Sorghastrum*, has a substantial representation there.

As well as producing a comprehensive revision of the subtribe, part of the work was published in Flora Zambesiaca for those genera that occur in the region. The manuscript sent for publication appears in Appendix 11.1.

Chapter 1. Introduction.

1.1. Project background.

It is generally recognised that the *Andropogoneae* is, in general terms, a well defined taxonomic entity. This has resulted in most workers favouring the use of the tribal rank because it is easier to recognise. While taxonomists differ in their views on generic limits, especially in the larger genera such as *Andropogon*, there is almost complete agreement on the limit of the tribe itself (Bews, 1929; Avdulov, 1931; Hubbard, 1934; Keng, 1939; Pilger, 1940; Hitchcock, 1951). Hackel's work (in De Candolle, *Monographiae Phanerogamarum* VI (1889)) forms the first general account of the *Andropogoneae*. During Hackel's time, the genus *Andropogon* was central to the taxonomy of the tribe. Stapf (in Prain, *Flora of Tropical Africa* IX (1917)) started the splitting of this genus, and recognised generic groups in the *Andropogoneae*. Taxonomic studies in the 30 years that followed were based on Stapf's circumscription of the *Andropogoneae* genera. Following on from Stapf (1917), the main taxonomic studies on the *Andropogoneae* were contributions from floras and monographs (Hitchcock, 1935, 1936, 1951; Bor, 1940, 1960; Blake, 1944; Backer & Brink, 1968; Clayton, 1972, 1982; Gould, 1975). None of these works, however, delimited the genera into subtribes, but studied them as members of a wider taxonomic entity, the tribe. An only attempt at a subtribal study was by Celarier (1959), in the taxonomic study of his subtribe *Sorgheae*. Most of the research has concentrated on those genera considered central to man's economic activities. In the 1950's, Celarier, Harlan, De Wet and their students began investigating the cytogenetic mechanisms within the generic complex *Bothriochloa-Capillipedium-Dichanthium*. These studies concentrated on species complexes in these genera and their relationships. Similarly, Snowden (1935, 1936, 1955) initiated taxonomic studies on cultivated and fodder sorghums. Garber (1950) also did some cytotaxonomic studies in sorghum. The work on sorghums was continued by De Wet, Harlan and others in the 1960's and 1970's, and more recently, by Lazarides et al (1991) who revised the sorghums of Australia. Another monographic work in the *Sorghinae* is that of the genus *Sorghastrum* by Davila (1988).

From the above, the realisation dawned upon me that a thorough taxonomic revision of the subtribe would be worth while. When studying a group as large as the *Sorghinae*, information on the group will be found to be available and accessible at varying levels of detail. Soliciting ideas from the rich literature that exists, and incorporating my own observations should help strengthen and define the subtribe and generic concepts applied to the *Sorghinae*. There are some genera (e.g. *Bothriochloa*, *Capillipedium*, and *Dichanthium*) whose boundaries are reportedly rather weak and perhaps arbitrary, and the evidence to keep them apart is not at all convincing. There was a need to investigate these. Intergeneric hybrids with the neighbouring subtribe *Saccharinae* have also been reported. Also apparent is the morphological overlap between these subtribes.

1.2. Aims and objectives.

This thesis is presented primarily as an investigation intended to provide a taxonomic revision of the subtribe *Sorghinae*. This is a world-wide revision of the subtribe. The main objective of the study was to come up with a generic delimitation based on the genus concept as applied within the subtribe. The study looked at a series of apparent anomalies which could be best tackled by looking at the following related studies:

(a) a search for characters consistent enough to support keeping the genera separate or, otherwise, combining them;

and (b) numerical/cladistic analysis of all data to seek signs of phenetic and evolutionary relationships in the subtribe.

1.3. Sampling procedure.

There are about 152 species reported in the subtribe, so a taxonomic review of the subtribe had to be representative enough to cover all the genera, the range of their variability and geographic distribution. In order to make the study feasible in the time permitted, a sample was chosen. A number of parameters were considered in choosing this sample. After due consultation with the Flora Zambesiaca (FZ) Editorial Committee at the Royal Botanic Gardens, Kew, an agreement was reached that part of the research be a formal taxonomic account of the Flora of this region. The FZ region covers five southern African countries of Botswana, Malawi, Mozambique, Zambia and Zimbabwe. Therefore with this in mind, the following criteria were used in determining the sample:

(i) all *Sorghinae* taxa in FZ;

(ii) representative taxa (i.e., species and genera) of the subtribe that do not otherwise occur in FZ;

(iii) taxa from a representative variety of habitats and ecological niches from which the subtribe is normally found, and;

(iv) the material chosen was to reflect the karyogamy of the subtribe, i.e., if there are diploids, tetraploids etc., the sample should include members from all these ploidy levels. Information on this aspect of the sample was obtained from the literature.

Inevitably, availability of plant material (both herbarium and living specimens) had an influence on the size and composition of the sample. The study has therefore managed comprehensively to investigate 61 species (Table 1.1).

Table 1.1. Species distribution among *Sorghinae* genera and representative numbers of species investigated in the study*.

Genus	Number of species reported	Number of these species in the sample
Asthenochloa Büse	1	1
Bothriochloa Kuntze	±35	10
Capillipedium Stapf	±14	5
Chrysopogon Trin.	±26	11
Cleistachne Benth.	1	1
Dichanthium Willemet	±20	6
Euclasta Franch.	3	3
Hemisorghum C.E. Hubbard	2	2
Pseudodichanthium Bor	1	1
Pseudosorghum A. Camus	2	1
Sorghastrum Nash	±16	9
Sorghum Moench	±20	6
Spathia Ewart	1	1
Vetiveria Bory	±10	5
Total	±152	61

* - The approximate number of species in the different genera follows Clayton & Renvoize (1986).

The following is a conspectus of the genera and their species in the sample. The list is arranged alphabetically.

Asthenochloa Büse, in Miq. Pl. Jungh.: 367 (1854).

Asthenochloa tenera Büse, in Miq. Pl. Jungh.: 368 (1854).

Bothriochloa Kuntze, Rev. Gen. 2: 762 (1891).

Bothriochloa biloba S.T. Blake, in Univ. Queensl. Papers, Dept. Biol.,ii No.3: 27 (1944).

Bothriochloa bladhii (Retz.) S.T. Blake, in Proc. Roy. Soc. Queensl. 80: 62 (1969).

Bothriochloa decipiens (Hackel) C.E. Hubbard, in Kew Bull. 1934: 444 (1934).

Bothriochloa insculpta (Hochst.) A. Camus, in Ann. Soc. Linn. Lyon 76: 165 (1931).

Bothriochloa ischaemum (L.) Keng, in Contrib. Biol. Lab. Sc. Soc. China, Bot. Ser. X: 201 (1936).

Bothriochloa kuntzeana (Hackel) Henrard, in Blumea 3: 456 (1940).

Bothriochloa macera (Steud.) S. T. Blake, in Proc. Roy. Soc. Queensl. 80: 64 (1969).

Bothriochloa pertusa (Willd.) A. Camus, in Ann. Soc. Linn. Lyon 76: 164 (1931).

Bothriochloa radicans (Lehm.) A. Camus, in Ann. Soc. Linn. Lyon 76: 164 (1931).

Bothriochloa saccharoides (Swartz) Rydb, in Brittonia 1: 81 (1931).

Capillipedium Stapf, in Prain, Fl. Trop. Afr. IX: 169 (1917).

Capillipedium assimile A. Camus, in Lecomte, Fl. Gen. Indo-Chine VII: 314 (1922).

Capillipedium filiculme Stapf, in Hook. Ic. Pl.: t 3085 (1922).

Capillipedium huegelii (Hackel) Stapf, in Hook. Ic. Pl.: t 3085 (1922).

Capillipedium parviflorum Stapf, in Prain, Fl. Trop. Afri. IX: 169 (1917).

Capillipedium spicigerum S.T. Blake, in Univ. Queensl. Papers, Dept. Biol., ii. No.3: 43 (1944).

Chrysopogon Trin., Fund. Agrost.: 187 (1820).

Chrysopogon aciculatus Trin., Fund. Agrost.: 188 (1820).

Chrysopogon aucheri Stapf, in Kew Bull. 1907: 211 (1907).

Chrysopogon fallax S. T. Blake, in J. M. Black, Fl. S. Austral., ed. 2: 60 (1943).

Chrysopogon fulvus (Spreng.) Chiov., Fl. Somala 1: 327 (1929).

Chrysopogon gryllus Trin., Fund. Agrost.: 188 (1820).

Chrysopogon latifolius S. T. Blake, in Univ. Queensl. Papers, Dept. Biol., ii. No.3: 7 (1944).

Chrysopogon orientalis A. Camus, in Lecomte, Fl. Gen. Indo-Chine 7: 332 (1922).

Chrysopogon pallidus Trin. ex Steud., Nom. ed. 2(i): 360 (1840).

Chrysopogon plumulosus Hochst., in Jahreshefte Württ. 3: 62 (1847).

Chrysopogon serrulatus Trin., in Mem. Acad. Peters. Ser. 6(2): 318 (1832).

Chrysopogon sylvaticus C. E. Hubbard, in Hook. Ic. Pl.: t 3365 (1938).

Cleistachne Benth., in Hook. Ic. Pl.: t 1379 (1882).

Cleistachne sorghoides Benth., in Hook. Ic. Pl.: t 1379 (1882).

Dichanthium Willem., in Usteri, Ann. Bot. 18: 11 (1796).

Dichanthium annulatum Stapf, in Prain, Fl. Trop. Afr. IX: 178 (1917).

Dichanthium aristatum (Poir.) C. E. Hubbard, in Kew Bull. 1939: 654 (1939).

Dichanthium caricosum (L.) A. Camus, in Bull. Mus. Hist. Nat. Paris 27: 519 (1921).

Dichanthium foveolatum (Delile) Roberty, in Boissiera 9: 170 (1960).

Dichanthium micranthum T. A. Cope, in Publ. Cairo Univ. Herb. 78: 325 (1977).

Dichanthium sericeum (R. Br.) A. Camus, in Bull. Mus. Hist. Nat. Paris 27: 549 (1921).

Euclasta Franch., in Bull. Soc. Hist. Nat. Autun 8: 335 (1895).

Euclasta clarkei (Hack.) T. A. Cope, in Kew Bull. 35(3): 704 (1980).

Euclasta condylotricha Stapf, Fl. Trop. Afr. IX: 181 (1917).

Euclasta oligantha (Hochst. ex Steud.) M.P. Setshogo, *comb. nov.*

Hemisorghum C. E. Hubbard, in Bor, Grasses Burma Ceyl. Ind. & Pakist.: 687 (1960).

Hemisorghum mekongense (A. Camus) C. E. Hubbard, in Bor, Grasses Burma Ceyl. Ind. & Pakist.: 687 (1960).

Hemisorghum venustum (Thw.) Clayton, in Kew Bull. 27(3): 448 (1972).

Pseudodichanthium Bor, in Indian For. 66: 271 (1940).

Pseudodichanthium serrafalcoides (Cooke et Stapf) Bor, in Indian For. 66: 272 (1940).

Pseudosorghum A. Camus, in Bull. Mus. Hist. Nat. Paris 26: 662 (1920).

Pseudosorghum fasciculare A. Camus, in Bull. Mus. Hist. Nat. Paris 26: 662 (1920).

Sorghastrum Nash, in Britton, Man. Fl. Northern U. S.: 71 (1901).

Sorghastrum elliottii (Mohr) Nash, North Amer. Flor. 17: 13 (1912).

Sorghastrum friesii (Pilger) Pilger, in Notizbl. Bot. Gart. Berlin XIV: 96 (1938).

Sorghastrum fuscescens (Pilger) Clayton, in Kew Bull. 30 (3): 509 (1975).

Sorghastrum incompletum (Presl.) Nash var. ***bipennatum*** (Hackel) Davila, Systematic revision of the genus *Sorghastrum* (1988).

Sorghastrum minarum (Nees) Hitchcock, Contr. U. S. Nat. Herb. 24: 501 (1927).

Sorghastrum nutans Nash, in Small, Fl. Southeast U. S.: 66 (1903).

Sorghustrum pogonostachyum (Stapf) Chippind. & Pole Evans, in Bot. Surv. S. Afr., Mem.: 247 (1948).

Sorghastrum setosum (Griseb.) Hitchcock, Contr. U. S. Nat. Herb. 12(6): 195 (1909).

Sorghastrum stipoides (Kunth) Nash, in N. Amer. Fl. 17: 129 (1912).

Sorghum Moench, Meth.: 207 (1794) nom. conserv.

Sorghum arundinaceum (Desv.) Stapf, in Prain, Fl. Trop. Afr. IX: 113 (1917).

Sorghum halepense Pers., Syn. Pl. 1: 101 (1805).

Sorghum nitidum Pers., Syn. Pl. 1: 101 (1805).

Sorghum plumosum (R. Br.) Beauv., Agrost.: 132 (1812).

Sorghum stipoideum (Ewart & J. White) C. A. Gardner & C. E. Hubbard, in Hook. Ic. Pl. 34: t 3364 (1938).

Sorghum versicolor Anderss., in Peters, Reise Mossamb.: 563 (1863).

Spathia Ewart, in Ewart & Davies, Fl. N. Terr.: 26 (1917).

Spathia neurosa Ewart & Archer, in Ewart & Davies, Fl. N. Terr.: 26 (1917).

Vetiveria Bory, in Lem.-Lisanc., Bull. Sc. Soc. Philom: 42 (1822).

Vetiveria elongata (R. Br.) Stapf ex C. E. Hubbard, in Kew Bull. 1934: 444 (1934).

Vetiveria filipes (Benth.) C. E. Hubbard, in Kew Bull. 1934: 444 (1934).

Vetiveria fulvibarbis Stapf, in Prain, Fl. Trop. Afr. IX: 158 (1917).

Vetiveria nigritana Stapf, in Prain, Fl. Trop. Afr. IX: 157 (1917).

Vetiveria zizanoides (L.) Nash, in Small, Fl. Southeast U. S.: 67 (1903).

A full synonymy for all taxa in this sample has been incorporated in the taxonomic descriptions (Chapter 8).

Chapter 2. Classification.

2.1. Introduction.

The grass family, *Gramineae,* has about 650 genera and 10 000 species, forming one of the largest families in the flowering plants (Clayton & Renvoize, 1986). The family is ecologically the most dominant and economically by far the most important throughout the world (Heywood, 1993). It is widely dispersed in all the regions of the world wherever vascular plants can survive and sometimes dominates the aspect of the vegetation. There are about six subfamilies with more than fifty tribes. The subtribe *Sorghinae* is in the tribe *Andropogoneae* of the subfamily *Panicoideae*. The *Andropogoneae* includes about 85 genera and about 960 species (Clayton & Renvoize, 1986). The tribe is tropical in distribution, particularly inhabiting the savannah zone, extending into warm temperate regions. Clayton & Renvoize (1986) divide the tribe into 11 subtribes. The subtribe *Sorghinae* reportedly consists of 14 genera. These are *Asthenochloa* Büse, *Bothriochloa* Kuntze, *Capillipedium* Stapf, *Chrysopogon* Trin., *Cleistachne* Benth., *Dichanthium* Willemet, *Euclasta* Franch., *Hemisorghum* C.E. Hubbard, *Pseudodichanthium* Bor, *Pseudosorghum* A. Camus, *Sorghastrum* Nash, *Sorghum* Moench, *Spathia* Ewart and *Vetiveria* Bory. Genera are assembled into subtribes according to overall morphological similarity.

2.2. *Sorghinae* and other related *Andropogoneae* subtribes.

An attempt at a detailed discussion on subtribal classification of the *Andropogoneae* will not be made here, but a brief outline is essential for a proper understanding of the evolution and systematic position of the subtribe *Sorghinae* in relation to other supposedly related subtribes of the *Andropogoneae*. The salient differences between the different subtribes of the tribe are outlined in Table 2.1 below. These character differences are used in the discussion that follows.

Table 2.1. *Sorghinae* and related *Andropogoneae* subtribes.

Subtribe	Descriptive notes
Saccharinae	Inflorescence terminal, of solitary, digitate or paniculate racemes. Spikelets paired, alike (i.e., both fertile and bisexual); lower floret empty, represented by a lemma, occasionally male. Divides into two groups: (i) paniculate inflorescence (*Sacchastrae*) - have thin glumes and weak awns (all these thought to be primitive states); plumose spikelets and spreading callus hairs, and (ii) digitate inflorescence (*Eulaliastrae*)- variability in the lower floret.
Germainiinae	Inflorescence terminal, of solitary or digitate racemes. Spikelets paired, dissimilar; sessile spikelets male or barren, sometimes involucral at the base of the raceme; pedicellate spikelet bisexual, sometimes suppressed at the base of the raceme.
Sorghinae	Inflorescence terminal or rarely axillary, of single or digitate or paniculate racemes, the latter often in whorls. Homogamous spikelet pairs occasionally present at the base of the raceme. Spikelets dissimilar; sessile spikelet bisexual, lower floret empty; pedicellate spikelet male or neuter.
Andropogoninae	Inflorescence of single, paired or sometimes digitate racemes, these terminal, or axillary and aggregated into a compound panicle. Homogamous spikelet pairs present or absent. Spikelets paired, dissimilar; sessile spikelet bisexual; pedicellate spikelet male or neuter.

According to Clayton & Renvoize (1992), evolution in the tribe *Andropogoneae* has followed a course of increasing morphological complexity which can be summarised as follows:

(i) Modification of the panicle: reduction of a large terminal inflorescence to a short single raceme, followed by expansion into a compound panicle.

(ii) Fragile racemes bearing paired spikelets: initially the spikelets in each pair were similar, becoming dissimilar, with the pedicellate spikelet reduced in the more advanced genera.

(iii) Emphasis on internode and pedicel evolution: the rachis internodes vary from simple and slender in the primitive genera to shortened, swollen and fused with the pedicel in the advanced genera.

The *Sorghinae* is often divided into two generic groups on the basis of inflorescence type (Clayton, 1972), the *Sorghastrae* with paniculate inflorescence, and the *Bothriochloastrae* with racemose inflorescence. The *Sorghastrae* would therefore be the primitive group on the basis of the inflorescence type. Using the same reasoning, the *Sorghastrae* would therefore be closely related to the generic group *Sacchastrae* of the subtribe *Saccharinae* (see Table 2.1). Both have primitive paniculate inflorescences, and their common origin is suggested by the close similarity between *Saccharum* and *Sorghum* (Clayton & Renvoize, 1986). Similarly, the *Bothriochloastrae* would be closer to the *Eulaliastrae* of the *Saccharinae* and share some features with genera in the *Andropogoninae*.

On the basis of the arguments advanced above, the subtribe *Sorghinae* would therefore seem to be intermediate between the subtribes *Saccharinae* and *Andropogoninae*.

The members of the *Sorghinae* (except *Cleistachne*, *Asthenochloa* and *Sorghastrum*), like those of all other subtribes of the *Andropogoneae* (except *Dimeriinae*), are characterised by the presence of the spikelets in pairs, one sessile, the other pedicellate. It is common practice to use sexuality and the general shape of these spikelet pairs to determine the evolutionary hierarchy in the tribe. Using this criterion, the most primitive subtribe becomes the *Saccharinae*, since both spikelets of the pair retain their fertility and are very similar. Both spikelets are awned, an adaptation often associated with dispersal. In the *Sorghinae*, the sessile and the pedicellate spikelets differ in sexuality. The pedicellate spikelet is always either male or neuter and awnless, except in two species of *Sorghastrum, S. fuscescens and S. pogonostachyum*, and one of *Dichanthium*, *Dichanthium annulatum* var. *fecundum*, where the pedicellate spikelet is bisexual and awned. These species share most of their other characters with members of their respective genera except for the well developed and awned bisexual pedicellate spikelets. In most of the literature (Blake, 1944; Clayton & Renvoize, 1986), it has been suggested that these species show affinities with members of the subtribe *Saccharinae*, especially *Saccharum* and

Eulalia. Evidence from morphological and cytogenetical studies however overwhelms any suggestions that these species belong to these other genera. Borgaonkar & De Wet (1964) demonstrated that the gene determining bisexual pedicellate spikelets is inherited as a simple dominant character over male pedicellate spikelets.

One other observable trend in the *Sorghinae* is the loss of fertility of the pedicellate spikelet. The pedicellate spikelet can be either male or neuter, represented by barren pedicels or completely suppressed. The genera *Sorghum*, *Hemisorghum*, *Pseudosorghum*, *Pseudodichanthium*, *Bothriochloa*, *Dichanthium*, *Euclasta*, *Capillipedium*, *Spathia*, *Chrysopogon* and *Vetiveria*, have the pedicellate spikelet either male or neuter. The genera *Sorghastrum* and *Asthenochloa* have the pedicellate spikelet represented by a barren pedicel. The pedicellate spikelet is completely suppressed in *Cleistachne*.

It must be said that, among the subtribes of the *Andropogoneae*, an aberrant position is represented by the genera *Trachypogon* and *Germainia* of the subtribe *Germainiinae*. These genera have adopted the opposite course, reducing the sessile spikelet and transforming it into a shield behind which the fertile pedicellate spikelet shelters until maturity (Clayton, 1969). What is actually the case here is that the sexuality of the spikelets has been reversed. The sessile spikelet is male or neuter while the pedicellate spikelet is bisexual. There are however occasional specimens with both spikelets fertile in certain species of *Apocopis* and *Trachypogon*, therefore breaking down the consistency of spikelet sexuality as a character (Clayton, 1969).

2.3. Taxonomic history of subtribe *Sorghinae*.

A summary of the taxonomic history of the subtribe is given in Table 2.2. The subtribe as known today, has its foundations in Bluff, Nees & Schauer's (in *Comp. Fl. Germ.* ed. 2(1): 46 (1836)) subtribe *Sorgha*. This became *Sorghinae* when the ending *-nae* (for the subtribal rank) was incorporated as stipulated in the International

Code of Botanical Nomenclature. Bluff, Nees & Schauer followed Linnaeus (1753) classification system. They recognised classes and orders in the angiosperms. They classified all the grasses into Class Triandria Order Digynia. This was on the basis of them having three (tri-) anthers (-andria) and two (di-) stigmas (-gynia). They put *Sorghum*, *Chrysopogon*, *Imperata*, *Heteropogon*, *Erianthus*, and *Andropogon* in the tribe *Saccharinae*. They then subdivided the *Saccharinae* into subtribes *Sorgha* and *Andropogones*, mainly on the basis of the inflorescence type. *Sorghum* and *Chrysopogon* were put in subtribe *Sorgha*, because of their paniculate inflorescences, and the rest of the genera in subtribe *Andropogones* because of their racemose inflorescences (These inflorescence types are described in Chapter 4). Nees Von Esenbeck (1843) put *Sorghum* and *Chrysopogon* in the tribe *Sacchareae* (now a synonym for the tribe *Andropogoneae*). These two genera were also put in the tribe *Andropogoneae* by Steudel (1855), and Bentham & Hooker (1883). Bentham and Hooker (1883) also put *Cleistachne* in tribe *Tristigeneae* (now a synonym of the tribe *Paniceae*). Hackel (In De Candolle, *Monographiae Phanerogamarum* VI (1889)) subdivided the genus *Andropogon* of the subtribe *Euandropogoneae* into 13 subgenera. Members of the subtribe *Sorghinae* were interspersed in subgenera *Schizachyrium*, *Amphilophis*, *Sorghum*, *Vetiveria*, *Chrysopogon*, *Dichanthium*, and *Heteropogon*. *Cleistachne* was treated as a separate genus of the same tribe. He grouped his subgenera into two: Series A, the Isozygi, whose lowermost sessile spikelets in the raceme are of the same sexuality and form as the upper ones, and Series B, the Heterozygi, which have the lowermost sessile spikelets differing in sexuality or form from the upper ones. Hooker (*Flora of British India* VII (1897)) followed Hackel's subdivision but hastened to add that the groupings of the subgenera into Isozygi and Heterozygi tended to separate widely subgenera of close affinity in habit and all other characters, except those adopted to distinguish between these groups. He writes "Of the best defined I should, following older authors, have preferred to have treated them as genera, especially *Chrysopogon*, *Cymbopogon* and *Heteropogon*..." It was after this assertion made by Hooker that the realisation began that *Andropogon* was too broad a genus and needed splitting. It was not until the work of Stapf (in Prain, *Flora of Tropical Africa* IX (1917)) that the different genera became widely recognised as distinct from *Andropogon.* Stapf not only recognised them as distinct genera but demarcated them as the groups *Sorghastrae* and *Amphilophiatsrae* of the tribe *Andropogoneae*. The *Sorghastrae* contained *Sorghum*, *Cleistachne*, *Vetiveria* and *Chrysopogon,* while the *Amphilophiatsrae* consisted of *Capillipedium*, *Bothriochloa* (as *Amphilophis*), *Dichanthium*, *Euclasta*, and *Eremopogon.* He had in 1896 (In *Hooker's Icones Plantarum* 25: t 2494) removed the genus *Asthenochloa* from the *Andropogoneae* and placed it in a different tribe *Agrostideae*, "for it had affinities with *Garnotia*"! Keng (1939) proposed that the *Sorghastrae* be given a status of a subtribe under the name *Sorgheae*. Pilger (1940) independently came to the same conclusion and called his subtribe the *Sorgenae.* He then put the genera *Capillipedium*, *Bothriochloa, Euclasta, Pseudosorghum, Dichanthium* and *Spathia,* together with a number of other genera, in the subtribe *Andropogoninae*.

As can be noted from the above historic outline, most genera in the subtribe came into being due to the genus *Andropogon* being split up. The genera *Sorghum* (1794), *Dichanthium* (1796), *Chrysopogon* (1822), *Vetiveria* (1822), *Asthenochloa* (1854), and *Cleistachne* (1883) were described before Hackel's (1889) monograph of the tribe *Andropogoneae.* The remaining members of the classically defined *Sorghinae* were described in the late 19th century and early 20th century. These genera are *Bothriochloa* Kuntze (1891), *Euclasta* Franch. (1895), *Sorghastrum* Nash (1901), *Capillipedium* Stapf (1917), *Spathia* Ewart (1917), *Pseudosorghum* A. Camus (1920), *Pseudodichanthium* Bor (1940) and *Hemisorghum* C. E. Hubbard (1960). These genera, together with *Asthenochloa* and *Cleistachne*, show affinities to the original four (*Sorghum, Chrysopogon, Dichanthium* and *Vetiveria*) and/or are segregates of them.

The problem of the composition of the subtribe has persisted at length resulting in *Sorghinae* genera being put in different and often unrelated tribes and genera. Most of the classifications that followed were in agreement with Stapf (1917) that these genera all belonged to the tribe *Andropogoneae*. Most workers (Bor, 1940, 1960; Celarier, 1960; Clayton, 1972) preferred to group the genera of the *Andropogoneae* into informal generic groupings without according them any taxonomic rank. However, these became so established with repeated usage that they inevitably have bred a somewhat formalised classification. Celarier et al (1961) recognised section *Bothriochloininae* of the subtribe *Andropogoninae* to include six apparently closely related genera *Bothriochloa*, *Capillipedium*, *Dichanthium*, *Eremopogon* (Hack.) Stapf, *Euclasta* and *Pseudosorghum*.

Clayton (1972) recognised three informal generic groups, two of which contained genera now generally recognised to be in subtribe *Sorghinae*. These are:

(a) *Sorghastrae*, containing *Sorghum*, *Hemisorghum*, *Pseudosorghum*, *Cleistachne*, *Asthenochloa*, *Vetiveria*, and *Chrysopogon*.

(b) *Arthraxonastrae*, made up of a single genus, *Arthraxon*.

(c) *Bothriochloastrae*, comprising *Bothriochloa*, *Capillipedium*, *Euclasta*, *Dichanthium*, *Pseudodichanthium*, *Spathia* and *Eremopogon*.

He puts these three generic groups in the subtribe *Arthraxoninae* which include two additional genera, *Arthraxon* and *Eremopogon* (now a synonym of *Dichanthium*).

Clayton & Renvoize (1986) suggest that the *Sorghinae* consists of two main groups of genera, centred upon *Sorghum* and *Dichanthium* respectively, linked by *Pseudosorghum*. Celarier (1958) came to a similar conclusion by making the observation that *Pseudosorghum* linked his subtribes *Sorgheae* and *Bothriochloeae* to which *Sorghum* and *Dichanthium* belonged respectively.

It should be noted that botanists still prefer to put all *Sorghinae* genera under the tribe *Andropogoneae*. Certainly up to the present, the subtribal classification is far from being stabilised. Clayton and Renvoize (1986) put all the fourteen genera in subtribe *Sorghinae*. Simon (1990) puts eight of them, that occur in Australia, in subtribe *Arthraxoninae*. Watson & Dallwitz (1992) also put all the fourteen genera in subtribe *Andropogoninae*. They divide the tribe *Andropogoneae* into two subtribes, the subtribe *Andropogoninae* ('awned *Andropogoneae*') and the subtribe *Rottboelliinae* ('awnless *Andropogoneae*'). The conclusions of the present study agree with Clayton & Renvoize (1986) classification of the subtribe. I recognise two generic groups, the *Bothriochloastrae* and the *Sorghastrae*, which I use in my discussion on morphological trends in the *Sorghinae* (see Chapter 3).

Table 2.2. Taxonomic history of the *Sorghinae*: a summary.

Author (year)	Taxonomic rank	Genera put in the taxonomic rank
Linnaeus (1753)	Polygamia Monoecia	Sorghum, Holcus, Andropogon, Musa, Celtis, Veratrum, Ischaemum, Cenchrus, Aegilops, Valantia, Atriplex, Dalechampia, Acer, Begonia, Ophioxylon.
Persoon (1805)	Triandria Digynia	Sorghum, and 60 other genera including Andropogon, Agrostis, Hordeum, Triticum, etc.
Bluff, Nees & Schauer (1836)	Triandria Digynia Tribe Saccharinae Subtribe Sorgha	Sorghum, Chrysopogon.
Nees Von Esenbeck (1843)	Sacchareae	Sorghum, Chrysopogon.
Steudel (1855)	Andropogoneae	Sorghum, Chrysopogon, and 33 other genera including Andropogon, Anthistiria, Zoysia, Apluda, etc.
Bentham & Hooker (1883)	Andropogoneae	Sorghhum, Chrysopogon, Imperata, Miscanthus, Saccharum, Erianthus, Spodiopogon, Pollinia, Pogonatherum, Apocopsis, Dimeria, Arthraxon, Ischaemum, Andropogon, etc.
	Tristegineae	Cleistachne, Thunbergia, Limnas, Garnotia, Arundinella, Phaenosperma, Melinis, etc.
Stapf (1917)	Sorghastrae	Sorghum, Cleistachne, Chrysopogon, Vetiveria, Lasiorrhachis, Rhaphis.
	Amphilophiastrae	Capillipedium, Amphilophis, Dichanthium, Euclasta, Eremopogon.
Keng (1939)	Sorgheae	Chrysopogon, Cleistachne, Sorghum, Vetiveria, Lasiorrachis, Rhaphis.
Pilger (1940)	Sorgenae	Chrysopogon, Cleistachne, Sorghum, Vetiveria, Lasiorrachis, Rhaphis.
	Andropogoninae	Capillipedium, Bothriochloa, Euclasta, Pseudosorghum, Dichanthium, Spathia, Arthraxon, Hypogynium, Pseudanthistiria, Eremopogon, etc.
Celarier (1961)	Bothriochloininae	Bothriochloa, Capillipedium, Dichanthium, Eremopogon, Euclasta, Pseudosorghum.
Clayton (1972)	Arthraxoninae	Bothriochloa, Capillipedium, Euclasta, Dichanthium, Pseudodichanthium, Spathia, Eremopogon, Arthraxon, Sorghum, Hemisorghum, Pseudosorghum, Cleistachne, Asthenochloa, Vetiveria, Chrysopogon.
Clayton & Renvoize (1986)	Sorghinae	Bothriochloa, Capillipedium, Euclasta, Dichanthium, Pseudodichanthium, Spathia, Eremopogon, Sorghum, Hemisorghum, Pseudosorghum, Cleistachne, Asthenochloa, Vetiveria, Chrysopogon.
Simon (1990)	Arthraxoninae	Bothriochloa, Capillipedium, Dichanthium, Spathia, Arthraxon, Sorghum, Vetiveria, Chrysopogon.
Watson & Dallwitz (1992)	Andropogoninae ('Awned Andropogoneae')	Bothriochloa, Capillipedium, Euclasta, Dichanthium, Pseudodichanthium, Spathia, Eremopogon, Sorghum, Hemisorghum, Pseudosorghum, Cleistachne, Asthenochloa, Vetiveria, Chrysopogon.

2.4. Nomenclatural origins, and types of *Sorghinae* genera.

2.4.1. ***Hemisorghum*** C.E. Hubbard, in Bor, *Grasses of Burma, Ceylon, India & Pakistan*: 686 (1960) - *H. mekongense* (A. Camus) C.E. Hubbard.

The genus *Hemisorghum* used to be sunk in *Sorghum* as *Sorghum halepense* (L.) Pers var. *mekongense*. A. Camus later described this species as *Sorghum mekongense* in 1922. Later synonyms of *S. mekongense* came from Rhind (1945), and Schmidt (1958). Hubbard (1960) put it in a new genus, *Hemisorghum*. He distinguished it from the species of *Sorghum* subgenus *Sorghum* by ' the slender, more loosely spiculate, sessile or subsessile racemes, the awnless upper lemma, glabrous (not ciliate) lodicules, and by the much reduced pedicellate spikelets '. The type species is *H. mekongense*, and is distributed in Indo-China.

2.4.2. ***Spathia*** Ewart, in Ewart & Davies, *Flora of the Northern Territory*: 26 (1917)- *S. neurosa* Ewart & Archer.

The generic name is derived from Greek *spathê*, a blade or spatula, referring to the enlarged leaf sheaths on the upper culm which constitute spathes. Ewart (1917) put the genus *Spathia* in subtribe *Euandropogoneae*, with such genera as *Ischaemum, Pollinia* and *Andropogon*. He suggested that it was intermediate between *Pollinia* and *Andropogon*, but differed from both genera by having sheathing spathes, which are probably a xerophytic adaptation. The type species is *Spathia neurosa* Ewart & Archer, and is distributed south east of Newcastle Waters, Australia.

2.4.3. ***Pseudodichanthium*** Bor, in *Indian Forester* 66: 27 (1940) & in *Hooker's Icones Plantarum* 36: t 3598 (1962)- *P. serrafalcoides* Bor.

Pseudodichanthium serrafalcoides is the only species of the genus *Pseudodichanthium*. The type species description is based on *Andropogon* *serrafalcoides* Cooke et Stapf. This genus was first placed in *Andropogon* and *Dichanthium* presumably because of the imbricate spikelets of which the lower two or three are homogamous. Apart from these purely superficial similarities the genus is absolutely distinct from *Dichanthium.* Rather it can be said to have some close relationship with the genus *Heteropogon.* In both *Pseudodichanthium* and *Heteropogon* the raceme is dorsiventral, the spikelets are winged and the lower axis of the raceme is continuous. However, the sessile hermaphrodite spikelets in *Heteropogon* are utterly different from the pedicellate, in *Pseudodichanthium* they are very similar and all are broadly winged. In *Heteropogon* there is a very sharp barbed callus to the fruit, there is no such callus in *Pseudodichanthium* (Bor, 1962). The genus *Pseudodichanthium* was created by Bor (1954) based on the species *Dichanthium serrafalcoides* (Cooke et Stapf) Blatt. et McCann. The main reason for singling out this species of *Dichanthium* to form a new genus was because it differed from other *Dichanthium* species in appearance, in the texture and disposition of the glumes, in the pedicellate spikelet being larger than the sessile, and in the winged glumes (Bor, 1940). The notation of the type species is as follows:

Pseudodichanthium serrafalcoides (Cooke et Stapf) Bor, comb. nov. Syn. *Andropogon cookei* Stapf ex Woodrow, in *Journ. Bomb. Nat. Hist. Soc.* XII: 438 (1893). *A. serrafalcoides* Cooke et Stapf, in *Kew Bull.*: 450 (1908). *Dichanthium serrafalcoides* Blatt. et McCann, in *Journ. Bomb. Nat. Hist. Soc.* XXXII: 426 (1928). *P. serrafalcoides* is a species confined to Bombay, India, and the monsoon forests of Oman.

2.4.4. ***Cleistachne*** Benth., in *Hook. Ic. Pl.* 14: t 1379 (1882)- *C. sorghoides* Benth.

The generic name is derived from Greek *kleistos*, closed, and *achne*, chaff (husks), alluding to the spikelets that remain closed even at maturity. This genus was put in the tribe *Tristegineae* (now a synonym of the tribe *Paniceae*) by Bentham (1883). He states that at first the plant resembles specimens of *Sorghum fulvum*, but the total absence of the second spikelet (whether perfect or rudimentary) to each node or notch removes it from the *Andropogoneae*, and brings it into connection with *Arundinella*! It was moved back to the *Andropogoneae* subtribe *Euandropogoneae* by Hackel (1889). The complete suppression of the pedicellate spikelet certainly can be misleading as it misled Bentham but this genus shows a close similarity with *Sorghum* and allies in a majority of its features. The type species is *C. sorghoides* Benth., and occurs in tropical Africa and India.

2.4.5. ***Sorghum*** Moench, Meth.: 207 (1794) nom. conserv.; Hubbard, in *Hook. Ic. Pl.* 34: t 3364 (1938); Garber, in *Univers. California Publ. Bot.* 23: 283-361 (1950); Snowden, in *Journ. Linn. Soc. Bot.* 55: 191-260 (1955); Celarier, in *Cytologia* 23: 395-418 (1959); Ivanyukovich & Doronina, *Trudy Prikl. Bot. Genet. Selek.* 69: 18-27 (1980)- *S. bicolor* (L.) Moench. *Blumenbachia* Koel., *Descr. Gram.*: 28 (1802) nom rej. non Schrad. (1825)- *B. halepensis* (L.) Koel. *Sarga* Ewart & White, in *Proc. Roy. Soc. Victoria* 23: 296 (1911)- *S. stipoidea* Ewart & White.

The generic name is derived from the Latin *surgum*, giant millet. The first taxonomic description of *Sorghum* was given by Linnaeus (1753), under the name *Holcus.* Other than those species now referred to *Sorghum*, Linnaeus also included several species (*H. lanatus, H. laxus* etc.) that have since been transferred to another tribe, the *Aveneae* (Celarier, 1959). The first use of *Sorghum* as a generic name was made by Adanson (1763) but apparently he used it only as a substitute for *Holcus* of Linnaeus. It remained for Moench (1794) to distinguish *Sorghum* from *Holcus* in those materials originally considered under *Holcus* by Linnaeus (Celarier, 1959). *Sorghum* was for a long time considered a subgenus of *Andropogon* but has now gained its status as a distinct genus. Stapf (1919) in his study of the grasses of tropical Africa, included in *Sorghum* the genus *Sorghastrum*, and his procedure was followed by Garber (1950) who gave *Sorghastrum* a subgeneric rank. He put *Sorghum* in the subtribe *Sorghastrae.* He split the subtribe into two main genera, *Sorghum* and *Cleistachne*, and then subdivided the genus *Sorghum* into six subgenera as follows: *Eu-sorghum, Chaetosorghum*, *Heterosorghum*, *Sorghastrum*, *Para-sorghum*, and

Stiposorghum. Celarier (1959) accepted most of this classification, but retained *Sorghastrum* as a separate genus. Extensive taxonomic studies by Stapf (1919), Snowden (1935, 1936, 1955), Garber (1950), Vinall et. al (1936) and others have demonstrated that *Sorghum* is a genus of considerable variability. Most writers have always preferred to treat the cultivated sorghums as taxonomically separate from the wild ones. This has resulted in an ambiguous situation of giving the genus two type species, one for the cultivated sorghums and the other for the wild ones. Doggett (1970) suggested that the type species for the cultivated sorghums be *S. bicolor* (L.) Moench, and *S. arundinaceum* Stapf be the type species for the wild ones. This anomalous situation has been rectified by De Wet (1978). He relegated *S. arundinaceum* to subspecies status as *S. bicolor* subsp. *arundinaceum*, which therefore effectively means that the type species is truly *S. bicolor*.

2.4.6. ***Chrysopogon*** Trin., *Fund. Agrost.*: 187 (1822) nom. conserv.- *C. gryllus* (L.) Trin. *Rhaphis* Lour., *Fl. Cochin.*: 552 (1790) nom. rejic.- *R. trivialis* Lour. (= *C. aciculatus*). *Pollinia* Spreng., *Pl. Pugill. 2*: 10 (1815) nom. rejic.- *P. gryllus* (L.) Spreng. *Centrophorum* Trin., *Fund. Agrost.*: 106 (1822)- *C. chinense* Trin. (= *C. aciculatus*). *Trianthum* Desv., *Opusc.*: 69 (1831). *Chalcoelytrum* Lunell, in *Amer. Midl. Nat.* 4: 212 (1915).

The generic name *Chrysopogon* derives from Greek *chrysos,* golden, and *pogon,* beard, alluding to the hairs on the inflorescence. The genus was described by Trinius (1822) in his *Fundamenta Agrostographiae.* This name is a conserved name since two other people had given it different names before Trinius. These were Louriero (1790) who called it *Rhaphis*, and Sprengel (1815) who called it *Pollinia.* Trinius' *Chrysopogon* consisted of two species: *C. gryllus* (*Andropogon gryllus* L.), and *C. aciculatus* (*A. aciculatus* Retz.). The type species is *C. gryllus* (L.) Trin. Trinius' description of *Chrysopogon* is so general that Davila (1988) suggested that it may be applied to *Sorghastrum.* She in fact suggested that the genus *Chrysopogon* is in part a synonym of *Sorghastrum.* In 1883, Bentham & Hooker mentioned that the genera

Chrysopogon and *Sorghum* were related. They divided *Chrysopogon* into two ' natural ' sections: the typical one, section *Chrysopogon*, and section *Stipoides*, which is exclusively American. Davila (1988) suggests that the latter section represents a synonym of the genus *Sorghastrum*. Hackel (1889) put *Chrysopogon* in *Andropogon* subgenus *Chrysopogon*.

2.4.7. ***Sorghastrum*** Nash, in Britton, *Man. Fl. North. States*: 71 (1901)- *S. avenaceum* (Michaux) Nash (=*S. nutans*). *Poranthera* Raf., in *Bull. Bot. Geneve* 1: 221 (1830) non Rudge (1811)- *P. nutans* (L.) Jacks. *Dipogon* Steud., *Nom. Bot.* ed 2, 1: 518 (1840) nom. nud.- *S. stipoides*.

The first person to recognise *Sorghastrum* as a separate entity was Rafinesque (1830). He proposed the name *Poranthera* for the genus. The name was rejected as it was a homonym of *Poranthera* Rudge published in 1811 for a different genus. Fournier (1881) included the genus *Sorghastrum* within *Andropogon* section *Sorghastrum*. Fournier's classification has however been disputed by Celarier (1959), and Clayton and Renvoize (1986) who argue that *Andropogon* and *Sorghastrum* represent probably two different evolutionary lines in the *Andropogoneae*. Stapf (1917), in his study of the grasses of tropical Africa, considered *Sorghastrum* to be only a subdivision of *Sorghum*, and this procedure was followed by Garber (1950) who however gave it a subgeneric rank. Nash (1901) recognised the present genus as a different taxonomic entity. He gave it a new name *Sorghastrum*. He separated *Sorghastrum* from *Sorghum* on the basis of the reduction of the pedicellate spikelets to simple pedicels (i.e. lacking a spikelet) in *Sorghastrum*. The name is derived from *Sorghum* and the Latin suffix *-astrum*, a poor imitation of, alluding to the resemblance of the genus to *Sorghum*. The type species is *S. nutans* (L.) Nash.

2.4.8. ***Vetiveria*** Bory, in Lem-Lisanc, *Bull. Sc. Soc. Philom.*: 43 (1822)- *V. odoratissima* Bory (= *V. zizanioides*). *Lenormandia* Steud., in *Flora* 33: 229 (1850). *Mandelorna* Steud., *Syn. Pl. Glum.* 1: 359 (1854)- *M. insignis* Steud. (= *V. nigritana)*.

The name *Vetiveria* is from the Tamil *vettivêru*, a root dug up. This name was given to this genus in recognition of the fact that most of its members have aromatic roots. The taxonomic history of this genus is probably best represented by that of the type species *V. zizanioides*. This species, best known as the 'Khas Khas' or 'Vetiver', has been popular with the peoples of Northern India for a very long time (see Table 2.3-Uses). Prior to Bory's description of the genus in 1822, this species had been moved from genus to genus. Specimens of the grass sent to Linnaeus and Retzius by Koenig were given differing names by the two authors. Linnaeus (*Mant. Alt.*: 183 (1771)) described it as something new under the name *Phalaris zizanioides*, while Retzius (*Observ. Bot.* 3: 43 (1783)) described it as *Andropogon muricatus* (Stapf, in *Kew Bull.* (1906)). The latter name was subsequently and so repeatedly used by most botanists that it gained some popularity. When Bory (1822) described his genus *Vetiveria*, he used the epithet '*odoratissima*', which alludes to the fragrance of the roots of this grass. Hackel (In DC., *Monogr. Phan.* VI (1889)) placed this genus in *Andropogon* subgenus *Vetiveria*. This was repeated by Hooker (*Fl. Brit. Ind.* (1897)). They both classified it as *Andropogon squarrosus* Linn. f. The name *A. squarrosus*, however, turned out to be wrong because it was based on a completely different specimen from those of *Phalaris zizanioides* and *Andropogon muricatus*. R. Brown (*Prodr. Fl. Nov. Holl.* (1810)) correctly identified the specimen as *Chamaeraphis spinescens*. When the genus *Andropogon* was split up, and *Vetiveria* regained its generic status, it was the earlier epithet, '*zizanioides*', first coined by Linaeus (1771), which was adopted. Therefore *V. zizanioides* (L.) Nash became the type species.

2.4.9. ***Euclasta*** Franch, in *Bull. Soc. Hist. Nat. Autun* 8: 335 (1895)- *E. glumacea* Franch. (= *E. condylotricha*). *Indochloa* Bor, in *Kew Bull.* 9: 75 (1954)- *I. clarkei* (Hack.) Bor.

This genus was described by Bor (1954) as a new genus *Indochloa* Bor. The description was based on *Dichanthium clarkei* (Hack.) Haines. Hackel, originally described the species as *Andropogon clarkei* Hack. (in *Oesterr. Bot. Zeitschr.* 41: 49

(1891)). Bor (1954) erected a new genus *Indochloa,* which included *Dichanthium clarkei,* and *Heteropogon oliganthus* (Hochst. ex Steud.) Blatt. et McCann, because he thought they had been misplaced, for the similarities between the two far outweighed the differences. *H. oliganthus* had been placed in *Dichanthium* because it differed extensively with other *Heteropogon* species. The name *Indochloa* Bor, was rejected however, because the genus had already been described as *Euclasta* by Franchet in 1895, who based his description on *E. glumacea* (=*E. condylotricha*). Cope (1980) moved species belonging to *Indochoa* to *Euclasta* in order to conform to recent work on generic limits in the tribe *Andropogoneae.* He however moved *I. oligantha* to *Dichanthium.* After a thorough examination, I made a new combination and transferred this species to *Euclasta* as *E. oligantha* (Hochst. ex Steud.) M.P. Setshogo. This species clearly belongs here (see taxonomic description). The type of the genus is *E. condylotricha* (Hochst.) Stapf.

2.4.10. ***Pseudosorghum*** A. Camus, in *Bull. Mus. Hist. Nat. Paris* 26: 662 (1920)- *P. fasciculare* (Roxb.) A. Camus.

This is an Asian genus described by A. Camus in 1920. Before then, its species were put by Hackel (1889) in *Andropogon* subgenus *Sorghum.* Hackel had noticed that species *A. fascicularis* Roxb. did not satisfactorily fit in *Andropogon* subgenus *Sorghum* and hence preferred to list it among 'species dubious' at the end of his descriptions. Hooker (*Fl. Brit. Ind.* VII: 177 (1897)) followed Hackel's subgeneric classification but chose to include it in *Andropogon* subgenus *Amphilophis.* To settle this confusion, Camus (1920) erected the new genus, *Pseudosorghum,* for this species. It resembles *Sorghum* but differs in its contracted panicle. From *Bothriochloa* (*B. bladhii*) it differs by its solid rachis internodes and pedicels. The type species of the genus is *P. fasciculare* (Roxb.) A. Camus.

2.4.11. ***Asthenochloa*** Büse, in Miq., *Pl. Jungh.*: 367 (1854)- *A. tenera* Büse. *Garnotiella* Stapf, in *Hook. Ic. Pl.* 25: t 2494 (1896)- *G. philipinensis* Stapf (= *A. tenera)*.

This genus was described by Büse in 1854. Stapf (1896) placed it, as *Garnotiella* Stapf, in the tribe *Agrostideae*. This genus, like most of the *Sorghinae*, was placed in the genus *Andropogon* by Hackel (in DC., *Monogr. Phan.* VI, (1889)). He placed it in *Andropogon* subgenus *Schizachryrium* as *A. tenera* Kunth. The type species is *A. tenera* (Kunth.) Büse.

2.4.12. ***Capillipedium*** Stapf, in *Fl. Trop. Afr.* 9: 169 (1917)-*C. parviflorum* (R.Br.) Stapf. *Filipedium* Raiz. & Jain, in *J. Bombay Nat. Hist. Soc.* 49: 682 (1951)-*F. planipedicellatum* (Bor) Raiz. & Jain.

The name *Capillipedium* is from Latin *capillus*, hair, and *pes*, foot, alluding to the fine pedicels. This genus was created by Stapf (1917) to embrace a small number of closely allied species from the tropical regions of Asia, Australia and Africa, comprising Hackel's section *Capillipedes* of *Andropogon* subgenus *Amphilophis* (Blake, 1944). Ohwi (in *Acta Phytotax. & Geobot.* 11: 165-166 (1942)) referred species of *Capillipedium* to *Bothriochloa*, thus treating the genus as taxonomically equivalent to Hackel's (1889) circumscription of *Andropogon* subgenus *Amphilophis*. Intergeneric hybrids have been produced between the genera *Bothriochloa, Capillipedium* and *Dichanthium* through *Bothriochloa bladhii* (De Wet & Harlan, 1966). This led these authors to suggest that the three genera be combined, with the generic name *Dichanthium* taking priority. The type species is *C. parviflorum* (R.Br.) Stapf.

2.4.13. ***Dichanthium*** Willlemet, in Usteri, *Ann. Bot.* 18: 11 (1796); De Wet & Harlan, in *Bol. Soc. Arg. Bot.* 12: 206-227 (1967)- *D. nodosum* Willemet (= *D. annulatum*) *Lepiocercis* Trin., *Fund. Agrost.*: 203 (1822)- *L. serrata* (Retz.) Trin. (=

D. annulatum). *Diplasanthum* Desv., *Opusc.*: 66 (1831)- *D. lanosum* Desv. (= *D. caricosum*). *Eremopogon* Stapf, *Fl. Trop. Afr.* 9: 182 (1917)- *E. foveolatus* (Del.) Stapf.

The generic name derives from the Greek words *dicha* meaning "at variance", and *anthos*, flower, referring to the lowest spikelet pairs which differ from the upper pairs in sexuality (Wheeler, Jacobs & Norton, 1982). Bentham's (1878) concept of *Andropogon* included *Schizachyrium* Nees, *Cymbopogon* Spreng., *Hyparrhenia* Anderss. ex Stapf, and *Dichanthium* Willm., as well as the group of species later referred to *Amphilophis* (Trin.) Nash and *Bothriochloa* Kuntze (Blake, 1969). *Dichanthium* was treated as a subgenus of *Andropogon* L. by Hackel (1889, 1896). This classification was later adopted by Hooker and Stapf (1896) and Hitchcock (1935). However, Stapf (1917) and Camus (1921) suggested that the genera *Andropogon* and *Dichanthium* differed from each other so conspicuously that both deserved generic rank, and Blake (1944) and Bor (1960) further emphasised the necessity of recognising both genera. Roberty (in *Boissiera* 9: 156 (1960)) treated *Dichanthium* and *Bothriochloa* as congeneric with *Eremopogon*, *Euclasta* and *Pseudodichanthium*, but retained *Capillipedium* as a distinct genus. The type species is *D. annulatum* (Forssk.) Stapf.

2.4.14. ***Bothriochloa*** Kuntze, *Rev. Gem. Pl.* 2: 762 (1891)- *B. anamatica* Kuntze (= *B. bladhii*). *Andropogon* subgen. *Gymnandropogon* Nees, *Fl. Afr. Austr.*: 103 (1841)- *A. radicans* Lehm. *Gymnandropogon* (Nees) Duthie, in Atkinson, *Gaz. N.W.Prov.* & Oude 10: 638 (1882). *Andropogon* subgen. *Amphilophis* Hack., in DC., *Monogr. Phan.* VI (1889) and Hooker, *Fl. Brit, Ind.* VII: 171 (1897). *Amphilophis* Nash, in Britton, *Man. Fl. North. States*: 71 (1901)- *A. toneyanus* Nash.

The generic name is derived from Greek *bothros*, a spot, and *chloa*, grass, which alludes to the pitted glumes of some species of this genus. *Bothriochloa* was initially often included in the subgenus *Amphilophis* of the genus *Andropogon*. This subgenus was described by Trinius (1833), and was later adopted by Hackel (1889). It was raised to generic rank by Nash (1901) and was called *Amphilophis*. Nash presented a more detailed description of the genus and described many species. However, Kuntze (1891) had earlier described the group as a new genus, *Bothriochloa*, based on a specimen of *Andropogon glaber* Roxb. He called the new type species *B. anamatica* (= *B. bladhii*). *Bothriochloa*, *Capillipedium*, *Eremopogon*, and *Euclasta* were suggested as a group by Stapf (1917) under the name *Amphilophiastrae*, and treated as a 'section' under the name *Bothriochloininae* by Celarier et al (1961). Ohwi (in *Acta Phytotax. & Geobot.* II: 165-166 (1942)) treated *Bothriochloa* as taxonomically equivalent to Hackel's circumscription of *Andropogon* subgenus *Amphilophis*. He also combined *Bothriochloa* and *Capillipedium* on the basis of morphological similarities. Gardner (in *Fl. W. Aus.* 1: 325 (1952)) treated *Bothriochloa* as a section of *Dichanthium*. Roberty (in *Boissiera* 9: 156 (1960)) likewise treated *Dichanthium* and *Bothriochloa* as congeneric together with *Eremopogon*, *Euclasta* and *Pseudodichanthium*. Celarier pioneered a cytotaxonomic study of *Bothriochloa*, *Capillipedium* and *Dichanthium* at the University of Oklahoma in the mid 1950's. In a series of papers from 1956 onwards, together with Harlan, De Wet, Mehra, Borgaonkar and others, he made an extensive study of the breeding behaviour and chromosomes of most of the species of these genera and produced a large number of interspecific and intergeneric hybrids. The production of intergeneric hybrids led these workers to suggest that *Bothriochloa*, *Capillipedium* and *Dichanthium* were not genetically distinct. De Wet & Harlan (1966, 1967) treated *Bothriochloa* and *Capillipedium* as sections of *Dichanthium* using the generic names as sectional epithets although there are earlier epithets available in the required rank (*Andropogon* section *Amphilophis* Trin. and section *Apananthus* Fourn. for the first, and *Andropogon* subgenus *Amphilophis* (Trin.) Hack. section *Capillipedes* Hack. for the other). Most people who have worked with the genera, however, advocate keeping them separate, and this I agree with and hence have treated the three genera separately in the present study. The type species is *B. bladhii* (Retz.) S.T. Blake.

2.5. Species of economic importance.

Most of the *Sorghinae* grasses are available as fodder. *Sorghum* is exploited for its grain. Other members are cultivated for their aromatic oils (used in perfumery), and as horticultural plants. The economic importance of some members of this group is summarised in Table 2.3 below:

Table 2.3.: Species of economic importance in the *Sorghinae*: a sample.

Species	Use
Bothriochloa bladhii	AF.
Bothriochloa pertusa	AF; LU; WS.
Bothriochloa insculpta	AF; MT; LU.
Bothriochloa ischaemum	LU; WS.
Bothriochloa radicans	LU.
Bothriochloa saccharoides	AF; MT; WS.
Capillipedium parviflorum	WS.
Chrysopogon aciculatus	LU; WS.
Chrysopogon gryllus	AF; MT; LU.
Chrysopogon plumulosus	AF; MT; LU.
Dichanthium annulatum	AF; HF; MD; MT; LU; WS.
Dichanthium aristatum	AF; WS.
Dichanthium caricosum	AF; LU; WS.
Dichanthium foveolatum	AF.
Dichanthium sericeum	LU.
Sorghastrum nutans	AF; LU.
Sorghum arundinaceum	LU.
Sorghum bicolor	HF; WS.
Sorghum halepense	AF; WS.
Vetiveria nigritana	MT; LU.
Vetiveria zizanioides	CEO; MT; LU.

AF	animal food	MD	medicine
CEO	commercial essential oils	MT	materials
HF	human food	WS	weed species
LU	land use		

Chapter 3. Concepts of categories and generic delimitation in the *Sorghinae*.

3.1. Introduction.

Botanical classification involves the assembling of plants into taxonomic groups (taxa) on the basis of their relationships (Davis & Heywood, 1963). These relationships may be assessed in different terms according to the purpose for which the classification is made. They may be phenetic, genetic, biochemical, etc. These groups are assembled into more inclusive groups, and these in turn into still more inclusive groups. The different levels of groups so produced are recognised as a series of hierarchical categories. Categories frequently used in the Gramineae are Family, Subfamily, Tribe, Subtribe, Genus and Species. At the higher levels of the hierarchy, no single diagnostic character may distinguish the taxa. The present project concerns itself with the categories Subtribe, Genus and Species. Still, in a few cases, the categories of Subspecies, Variety and Race are used. The following sections are therefore an attempt to define these categories.

3.2. The subtribe concept.

Taxonomic delimitation of subtribes is based on facies differences shown by generic groups. The definition of a subtribe is therefore solely based on the overall morphological similarity of the genera. A subtribe, ideally, should consist of genera which share certain characters. This description of the subtribe category makes it difficult to define and most researchers have always preferred to use the tribe category which is relatively easy to conceptualise.

Genera of the subtribe *Sorghinae* are characterised by the occurrence of spikelets in pairs, one sessile, the other pedicellate. All sessile spikelets are bisexual, while the pedicellate spikelet can be either male, neuter (sterile) or even absent altogether (as in *Asthenochloa, Cleistachne* and *Sorghastrum*). The inflorescence can be either a panicle of racemes, or consist of digitate or subdigitate racemes, or even a single raceme. The *Sorghinae* genera, though sharing a common facies because of their inflorescence morphology and spikelet configuration, have many other features whose combinations make them distinct from each other. The overall distribution of characters among *Sorghinae* genera is discussed in detail in Chapter 4.

3.3. The genus concept.

The concept of the genus is as old as folk science. Its most important function is to bring related species together. Davis and Heywood (1963) suggested three primary parameters that should provide guidelines for the delimitation of generic status, mainly (i) naturalness, (ii) delimitation from closely related genera, and (iii) practicability of keeping them distinct or including them in other genera.

One way of defining the naturalness of genera has been by the use of the concept of morphology. Legendre and Vaillancourt (1969) defined the genus as a monophyletic group (i.e., all descendants of a single ancestor) of species that occupies a given adaptive zone. In order to be logical, they also introduced the concept of phyletic closure, by which all the species descending from a common ancestor have to be included in the same genus. Thus, the cladistic approach, seeking monophylesis for generic delimitation, contains a 'valuable logical formation' (Legendre, 1971). However, fears have been expressed that this approach will lead to the splitting up of established, easily recognisable genera into many 'splinter groups'. The goal is to develop a classification that will recognise monophyletic groups, but disrupt the present classification as little as possible (Funk, 1985a). Pragmatism has always outweighed other considerations in the establishment and circumscription of genera. It may be preferable to split also monophyletic genera, however, if their circumscription, i.e., their artificially chosen size, is too wide for a practicable definition to be made (Bremer, 1978). The circumscription of genera has remained, by and large, a function of the morphological cohesiveness and discreteness of the species groups (Sivarajan, 1991).

The concept of the genus is more problematic in ‘definable families’ than in ‘undefinable families’ (Sivarajan, 1991). Character discontinuities may be difficult to find in ‘definable families’. Sivarajan (1991) identifies two attitudes governing our concept of genus, which he calls puristic and pragmatic. The puristic approach demands nothing short of a definition of genera based strictly on cladistic relationships (Hennig, 1966; Stevens, 1985). However, the difficulty is that it requires one to distinguish between primitive and advanced character-states, something which can seldom be done with any confidence, because it involves too many speculative conjectures to provide a satisfactory basis for defining the concept (Clayton, 1983). The more pragmatic among the taxonomists hold the genus to be a ‘composite idea’ which must seek to reconcile several parallel lines of thought, a multipurpose system (Clayton, 1983).

The formal definition of the genus remains substantially the same, i.e., an abstract and arbitrary level of morphological difference. The key question is where and how we draw the delimiting lines. Clayton (1983) has discussed this problem in great detail and has explained a few operational criteria for generic definition (selection of characters, extent and density of the gap between adjacent clusters, and predictive value). Cladists still disagree, and hold that genera can, and should, be based phylogenetically (Sivarajan, 1991). This would be to define a taxon in terms of the historical process deemed to have produced it - an educated guess, rather than in terms of tangible phenetic pattern per se.

The problem of the origin of plant genera is discussed much less often than that of the species and speciation, and most students of plant evolution are inclined to believe that no processes are required for the origin of genera which are not operating already in the origin of species (Stebbins, 1956). The Gramineae is one plant family in which greatly divergent opinions have existed as to the status of genera. To what extent are genera artificial aggregates of species, grouped together for the convenience of taxonomists, and to what extent are they natural groupings which reflect the result of evolutionary processes? From a practical standpoint, the genus is an inclusive category whose species have more in common with each other than with species of other genera within the same family. Genera, therefore, are aggregates of closely related species. It is the sum total of all characteristics used to group closely related species which helps conceptualise the genus as a unit. Genera must therefore be delimited following a world-wide study of their species.

3.4. Species concepts.

Over the past century or so, many authors have proposed their own definitions of what a species is. Species concepts in essence fall into three categories: the widely referred to biological species concept based on reproductive isolation; phylogenetic species concepts based on basic evolutionary units as revealed by phylogenetic analysis; and morphological species concepts based on degrees of phenotypic or genotypic distinctiveness. Some authors, e.g., Simpson (1961) add a fourth one, the evolutionary species concept.

(i) Biological species concept - The definition of this concept was proposed just over 50 years ago by Mayr (1942), and can be summarised as follows:

> **A species is a group of interbreeding populations that are genetically isolated from other groups by reproductive isolating mechanisms such as hybrid sterility or mate acceptability.**

This definition has been the target of much criticism particularly from phylogeneticists. Donoghue (1985) noted that the biological species concept does not necessarily yield monophyletic species, whilst Baum (1992) pointed out that the potential for gene exchange is only loosely coupled to historical relatedness - the central consideration of systematics. Further, many botanists, because of the general ease with which plants can hybridise, have specifically rejected the biological species concept. There are reported intergeneric and interspecific hybrids in the genera *Bothriochloa*, *Capillipedium*, *Dichanthium* and *Sorghum*. In the strict sense of the biological species concept, all the species involved would be regarded as belonging to the same species because they belong to the same gene pool. This would lead to a taxonomic 'grey area' if adopted where important differences could not be reflected in classification: hence communication difficulties.

(ii) Phylogenetic species concepts - A number of species concepts have been discussed in the last decade under the common title of phylogenetic species concepts. These were mainly a reaction to the biological species concept and were thought of as alternatives that did not rely on the knowledge of breeding potential. The main difference between these and the biological species concept is that they do not consider present biological characteristics directly but rather the acquisition of defining features during evolution (Donoghue, 1985; Baum, 1992). The role of a phylogenetic species concept is to reveal the smallest units that are analysable by cladistic methods and are interpretable as the result of phylogenetic history. One widely held definition is as follows:

> **A species is the smallest possible group of sexually reproducing organisms that possesses at least one diagnostic character which is present in all group members but is absent from all close relatives of the group.**

This definition has however been criticised for allowing the use of plesiomorphies (primitive characters) as well as autapomorphies (uniquely derived characters), and therefore species thus defined by a plesiomorphy could potentially be paraphyletic. Therefore requirements for monophyly were added to the definition (Donoghue, 1985; De Queiroz & Donoghue, 1988, 1990). Monophyly requires the use of only synapomorphic characters (shared derived characters). Wheeler (1990) points out that the application of the phylogenetic species concept would almost certainly give far larger estimates of the total number of species than the more traditional biological species concept.

(iii) Evolutionary species concept - The evolutionary species concept was first proposed by Simpson (1951) though as with most other species concepts has undergone a series of revisions and improvements. Wiley (1981) describes a species as:

> **a single lineage of ancestor-descendant populations which maintains its identity from other such lineages and which has its own evolutionary tendencies and historical fate.**

This lineage concept of species emphasises reproductive continuity through time. Many authors have pointed out that the division into 'biological' versus 'evolutionary' species concepts is unfortunate because both concepts (Mayr's and Simpson's) are, in a sense, biological and evolutionary (Minelli, 1993). It is however sufficient to note that the biological species concept envisages species as reproductive communities whereas the evolutionary species concept is primarily ecological. One other criticism is that this evolutionary species concept regards the species taxon as a class of individuals sharing a common role in the 'economy of nature' (Minelli, 1993). Changes in classes are restricted to the membership of individuals within it, whereas a species actually changes or evolves as a whole.

(iv) Morphological species concept - Davis & Heywood define the morphological species as:

> **assemblages of individuals with morphological features in common and separable from other such assemblages by correlated morphological discontinuities in a number of features.**

It is intended as a generally applicable concept and takes into account all available evidence, but insists that the species so recognised must be delimitable by morphological characters. Morphological species may then be subjected to experimental investigation and be shown to represent some particular evolutionary situation. As a result of the evidence revealed by such study, the taxonomist may consider the treatment of the individual case and redraw his specific boundaries, provided they are still recognisable morphologically, but he may not be unduly influenced by certain kinds of evidence (Valentine & Löve, 1958).

The problem of species definition might be more or less resolved if it were accepted that no one definition will suffice equally satisfactorily for all organisms and perhaps for all purposes. It is indeed true that most taxonomists always draw positive aspects of these species concepts to justify their studies without necessarily admitting such actions. Definitions of species are concepts, which means that they are basically pictures of patterns in nature. Interpretations of these pictures differ from one person to the other.

In the present study, I used the morphological species concept to delimit species. Species distinctiveness was recorded by recognising discontinuities in morphology. Representative specimens from the geographical range of distribution and morphological variation were investigated. It is my feeling that for a project of this nature, morphological species are an essential first step and the key to further information. I however did not ignore evidence from other taxonomic sources, but rather incorporated this into my findings. It is simply helpful to collate as much information about taxa being studied which will be an organised source of raw material for further studies.

3.5. Subspecies.

These are groups of plants, more or less separated by a combination of characters, but not usually isolated genetically (Valentine & Löve, 1958). They have sufficient attributes in common that they are regional representatives of the one species. An example is that of species *Chrysopogon gryllus* Trin. This species has two subspecies, subspecies *gryllus* and subspecies *echinulatus*. Subspecies *gryllus* has a remarkably disjunct distribution. In the western part of its range it is centred mainly on the Mediterranean region and southeast Europe, extending eastwards to northern Iraq and the Caucasus Mountains. There is then a gap of nearly 5 000km before an eastern morphologically indistinguishable population is found in Assam, India. Between these two centres lies subspecies *echinulatus*. This subspecies occurs from the extreme northeastern part of Afghanistan eastwards through northern Pakistan and Kashmir, and along the Himalayas to central Nepal. *C. gryllus* subspecies *echinulatus* has (i) a contracted panicle with rather firm, erect branches; (ii) spikelets in racemes of 2-3(-5) joints; and (iii) awns rather fine, 12-20mm long. *C. gryllus* subspecies *gryllus* has (i) an open panicle with long capillary branches; (ii) spikelets strictly in triads; and (iii) awns stout, 25-35mm long.

The subspecies concept also covers cases where taxa differ in chromosome number or are partly or incompletely intersterile and exhibit some correlated geographical or ecological differentiation but have an insufficient degree of morphological differentiation to permit satisfactory treatment as separate species (Heywood, 1958; Heslop-Harrison, 1957). The subspecies has therefore been widely accepted as a considerable segment of a species with a distinct area and more or less distinct morphology, often showing some intergradation, and clearly fulfils a useful purpose (Davis & Heywood, 1963). Such variants need a name, for communication purposes.

Subspecies are recognised by some authors as major morphological subdivisions of the species without particular reference to geographical distribution. This tendency has been condemned as an artificial means of reducing the number of species. I am in no doubt that this was particularly the case in delimiting subspecies in *Sorghum bicolor* (L.) Moench (the grain sorghums). This species was recognised as 24 'species' by Snowden (1936), but all these are now considered variants of only one species, *S. bicolor*. The species has since been divided into three subspecies on the basis of whether they are cultivated, wild or appear to be a combination of the two (hybrids). Subspecies *bicolor* contains all known cultivated grain sorghums. Subspecies *arundinaceum* incorporates all wild sorghums associated with the grain sorghums. Subspecies *drummondii* incorporates derivatives from hybridisation between subspecies *bicolor* and *arundinaceum*. This highly artificial delimitation of subspecies is not at all satisfactory and has not helped in resolving classification of the grain sorghums. I have in the present study, for ease of understanding, retained the following nomenclature: *S. bicolor* (strictly for *S. bicolor* subsp. bicolor) and *S. arundinaceum* (for *S. bicolor* subsp. *arundinaceum*).

3.6. Variety.

This is a local facies of species morphologically distinct and occupying a restricted area. Emphasis is on the small scale, more localised range of the variety, compared with the large scale, regional basis of the subspecies (Heywood, 1959a). An example is that of species *Bothriochloa decipiens* S.T. Blake. This species has two varieties, var. *decipiens* and var. *cloncurrensis*. Both these varieties are endemic to Australia. Var. *decipiens* occurs in New South Wales and Queensland, while var. *cloncurrensis* is found only in Queensland. In addition, most people would agree that a variety has few, minor (1 or 2 features) characters distinguishing it, and that it has a random distribution, i.e., not ecogeographically distinct. Another concept would be of a 'weak' subspecies, i.e., ecogeographically distinct but with very few distinguishing characters.

The terms subspecies and variety are often used interchangeably or regarded as synonymous. In the *Sorghinae* there are varieties which to me would be best regarded as subspecies. *Sorghastrum incompletum* has two varieties, var. *incompletum*, which is restricted to tropical South America, and var. *bipennatum*, which occurs only in the tropics and subtropics of central and southern Africa. In addition, the main morphological difference between the two is the reduction of racemes to a triplet of a single sessile spikelet flanked by two pedicels in var.

bipennatum. Var. *incompletum* has racemes which have 1-3 spikelet pairs. This may involve several genes. One of the reasons put forward (Grant, 1960) for the interchangeable use of subspecies and variety, and for the continued use of variety where subspecies would fit best, is that, Linnaeus used the term variety, and hence some people prefer to do likewise even in instances where it is inappropriate. This seems a very unfortunate archaism.

3.7. Race.

A further category, race, is rarely inserted between the subspecies and variety to cover geographical groupings which are intermediate between the two in a particular situation (Davis & Heywood, 1963). The problem is that this category is sometimes translated as meaning subspecies and can lead to serious problems of interpretation and nomenclature (Heywood, 1958). Harlan & De Wet (1972) divide *Sorghum bicolor* subsp. *bicolor* into five basic races, and ten hybrid races that combine characteristics of any two or more basic races. The five basic races are Bicolor, Guinea, Caudatum, Kaffir and Durra. Race Bicolor sorghums are grown across the range of sorghum cultivation in Africa and Asia. Race Guinea is primarily a sorghum of West Africa, but is grown in Chad, Sudan, north-eastern Nigeria and Uganda. Race Kaffir sorghums are important staples across the eastern and southern savannah from Tanzania to South Africa. Finally, race Durra sorghums are widely grown along the fringes of the southern Sahara, across arid West Africa, the Near East and parts of India. De Wet (1978) similarly recognises four races for *Sorghum bicolor* subspecies *arundinaceum*: race Aethiopicum of the arid African Sahel; race Virgatum of north-eastern Africa; race Arundinaceum of the African tropical forest; and race Verticilliflorum of the African savannah. This therefore effectively means that there are 19 races between the two subspecies, and is not taxonomically much of a simplification or clarification (a faction of taxonomy). It would probably be better to accept such races as groups of 'land races', in the sense of cultivated types, and not to suggest that they have formal taxonomic status.

3.8. Generic delimitation in the *Sorghinae*.

The main objective of the project was to firstly determine generic boundaries in the *Sorghinae*, to find out whether genera exist in the number that they have been suggested to. Secondly to find out any unifying theme between all the *Sorghinae* genera. As mentioned in the preceding section, it obviously becomes a lot more difficult with the higher taxonomic categories to set up strict character limits within which members should be found. Genera are relatively easy to conceptualise but very difficult to define. Cytogeneticists have in many instances discovered that species placed by all taxonomists in separate genera or even different tribes of the grass family, show degrees of genetic relationship which in other groups are characteristic of species belonging to the same genus. The genera *Sorghum* and *Saccharum* have been reported to hybridise (Clayton & Renvoize, 1986).

Each genus includes genetically related and morphologically similar species, and related genera usually include the extremes of what was once a single genus in which the intermediary species became extinct (De Wet & Harlan, 1966). It has been shown through experimentation and from field observations made by Celarier, De Wet, and Harlan and their students in the 1950's, that intergeneric hybrids are possible between the genera *Bothriochloa*, *Capillipedium* and *Dichanthium*. Hybrids have been produced between morphologically similar genera in the *Andropogoneae*. A series of hybrids have been produced between *Saccharum* as the one parent, and *Erianthus*, *Imperata*, *Miscanthidium*, *Miscanthus*, *Narenga*, and *Schlerostachya* as the pollen parents (De Wet & Harlan, 1966). The concept of monophyly, therefore, does not hold in the instances quoted above. If one uses cladistic reasoning, there seems to be paraphyletic generic groups in the *Andropogoneae* (see Chapter 7 for cladistic concepts).

There are basically three situations that present confusion in the taxonomy of subtribe *Sorghinae*. These are:

(a) intergeneric natural hybridisation, which has been proven experimentally, in the *Bothriochloa-Capillipedium-Dichanthium* generic complex. The species

Bothriochloa bladhii (Retz.) S.T. Blake, is capable of crossing with *Capillipedium assimile* A. Camus, *C. parviflorum* (R. Br.) Stapf, *Dichanthium annulatum* (Forssk.) Stapf (De Wet & Harlan, 1970). It is primarily a tetraploid species but 5n, 6n, and 8n have been obtained (Harlan & De Wet, 1962). Over its complete distribution range, extending from Southern Africa to Southern Australia, tetraploid *B. bladhii* hybridises with tetraploid *C. parviflorum* (De Wet & Harlan, 1970). These hybrids are commonly recognised as *Bothriochloa glabra* (Roxb.) A. Camus. *B. glabra* is often sunk under *B. bladhii* (Faruqi, 1969) following the trend of regarding *B. bladhii* as a very variable species. Simon (1989) proposed a rank of subspecies for *B. glabra*, as *B. bladhii* subsp. *glabra* (Roxb.) Simon, a pragmatic move I totally agree with because otherwise a lot of potentially valuable information would be lost if the taxon is put into synonymy with *B. bladhii*. Also, according to De Wet (1987), in northern Australia, *B. bladhii* introgresses with *C. parviflorum*, producing a series of intergrades. One of the introgression products (in addition to *B. glabra*) is called *Capillipedium spicigerum* Blake, which is said to be a product of a back-cross between *B. glabra* and *C. parviflorum* (De Wet, 1987). The species *B. glabra* is characteristic of African and South east Asian floras (Stapf, 1917; Bor, 1960), while *C. spicigerum* is widely spread over the coastal and subcoastal districts of eastern Australia. Blake (1944) however, questions the wisdom of considering the species *C. spicigerum* a hybrid and contends that it is very unusual to find the three at all close together, and that *C. spicigerum* is more abundant than either of its presumed parents. I found the species a morphologically distinct entity and have therefore treated it as a species in its own right. Also, according to Simon (1989), *B. glabra* does not occur naturally in Australia. I have treated it as a morphologically distinct subspecies of *B. bladhii* in this study.

Hybrids between *B. bladhii* and *D. annulatum* are usually recognisable as *B. grahamii* and occur in the Gangentic plains of India, and scattered colonies in Africa (De Wet & Harlan, 1970), across Southern Asia and in Australia. De Wet and Harlan (1962) introduced a new term compilospecies, which they defined as a genetically aggressive species, plundering related species of their heredities, and in some instances completely assimilating a species, causing it to become extinct. They applied this concept to the *Bothriochloa-Dichanthium-Capillipedium* complex based upon the behaviour of *Bothriochloa bladhii.* Their studies suggested that *B. bladhii* was itself of hybrid origin from germplasm assembled from at least 5 species belonging to the three genera!

The genera *Bothriochloa*, *Capillipedium* and *Dichanthium* are otherwise very distinct.

(b) interspecific man-induced hybridisation, best exemplified in the genus *Sorghum* (subgenus *(Eu)Sorghum*) which has resulted in a unidirectional improvement or selection for desired traits. The species *Sorghum bicolor* (L.) Moench incorporates all cultivated, semi-wild (subspecies *bicolor*) and wild species (subspecies *arundinaceum*) of the genus *Sorghum* subgenus *(Eu)Sorghum.* This has resulted in a very broad *S. bicolor.* To compound the situation further, nomenclatural subdivisions occur under each subspecies into races and forms. Hybrids between subspecies *bicolor* and *arundinaceum,* which tend to be intermediate between them are grouped together under *S. bicolor* subsp. *drummondii.* Taxonomy is quite consistent in the other subgenera of *Sorghum*, which are *Stiposorghum*, *Chaetosorghum*, *Heterosorghum* and *Parasorghum.*

(c) species complexes in the different genera, whose members overlap morphologically and will cross with ease. These are noticeable as a group of species whose boundaries are arbitrary and are separated by a few characters often correlated with different geographic regions. Examples include the *Dichanthium annulatum* complex which consists of *Dichanthium annulatum, D. aristatum* and *D. caricosum*; the *Chrysopogon fulvus* complex which consists of *Chrysopogon fulvus*, *C. serrulatus*, *C. aucheri* and *C. plumulosus*, etc. A detailed study of these would constitute numerous other projects.

Despite the problems listed above, I found the genera of *Sorghinae* to be quite distinct from a morphological standpoint. I think that one has to have operational concepts to delimit taxa that one is studying. The study was based on macromorphological investigation of a wide range of species in the *Sorghinae*. As mentioned earlier, I admit that no single concept is adequate to wholly define a given group of plants. It is probably this nature of taxonomic studies that always invokes further research. It is common practice to divide subtribes into generic groups (Stapf, 1917; Pilger, 1954; Clayton, 1969, 1972). These generic groups end in '*-astrae*' and have been applied informally to aid in taxonomic discussions without according them any formal taxonomic rank. To aid in discussing morphological trends in the subtribe *Sorghinae*, I have divided the subtribe into two generic groups, the *Sorghastrae* and the *Bothriochloastrae* (following Clayton, 1972) (Figure 3.1).

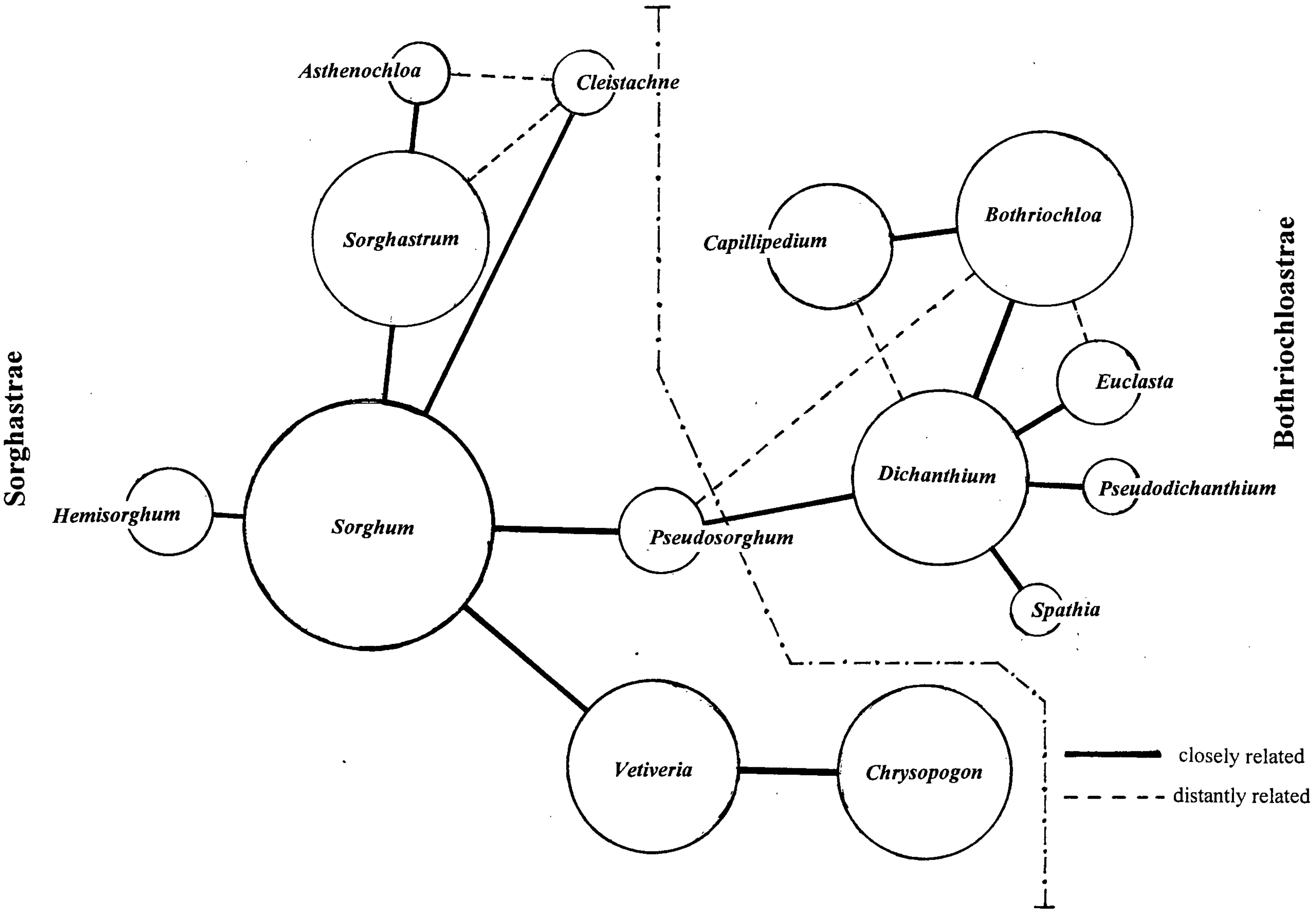


Figure 3.1 Putative relationships between *Sorghinae* genera (see text for details).

3.8.1. The *Sorghastrae.*

Members of this group have the following characteristics:

Paniculate inflorescence. Sessile spikelet dorsally or laterally compressed; callus blunt or pungent; upper lemma bilobed (occasionally entire), awned from the sinus. No homogamous spikelet pairs.

The genera found in this group are *Sorghum*, *Hemisorghum*, *Pseudosorghum*, *Sorghastrum*, *Cleistachne*, *Asthenochloa*, *Vetiveria* and *Chrysopogon.* Within the *Sorghastrae*, four clusters can be recognised: (i) *Sorghum* and allies (*Hemisorghum*, *Pseudosorghum*) with well developed and dorsally compressed sessile and pedicellate spikelets. In this group are found paniculate inflorescences which can be either open (spreading) or compact, and usually with profusely divided branches (see Chapter 4). Members of this cluster show affinities with those of the subtribe *Saccharinae* (generic group *Sacchastrae*), differing, among other things, in the nature of the pedicellate spikelet, which is bisexual in the *Saccharinae*; (ii) the *Vetiveria-Chrysopogon* alliance, with laterally compressed spikelets which sometimes display a pungent callus and predominantly have an entire upper lemma. Inflorescences here, though still a panicle, have simple pedunculate racemes. Also found here are awned glumes and aculeolate lower glumes of both the sessile and pedicellate spikelets; (iii) the *Sorghastrum-Asthenochloa* cluster with barren pedicels; and (iv) *Cleistachne* on its own group with completely suppressed pedicellate spikelets. The following brief accounts are an attempt to highlight the similarities between the different genera.

Sorghum- A genus with large simple or divided paniculate inflorescences. These bear short dense racemes. Other characteristic features include convex lower glumes, which are rounded on the flanks and 2-keeled near the tip, and ciliate lodicules. Members of the subgenus *(Eu)Sorghum* are perhaps related to *Saccharum* with which they will hybridise (Clayton & Renvoize, 1986). *S. bicolor*, the grain sorghum is a member of this genus.

Sorghum is the only genus of the *Sorghinae* for which an extensive infra-generic classification exists, that I think is worth discussing in detail here. The most comprehensive subgeneric treatment of the genus was initiated by Garber (1950) who recognised six subgenera. Garber's subgenus *Sorghastrum* has now been widely accorded a generic status, and therefore only five subgenera now remain in the genus. I agree with this treatment. The five subgenera are:

(i) *(Eu)Sorghum* (Stapf) Garber - Old World, e.g. *S. bicolor*, *S. halepense* (introduced to the Americas), etc.;

(ii) *Chaetosorghum* Garber - Australian; monotypic, e.g. *S. macrospermum*;

(iii) *Heterosorghum* Garber - Australian; monotypic, e.g. *S. laxiflorum*;

(iv) *Parasorghum* (Snowden) Garber - Old World; e.g. *S. nitidum*, *S. versicolor*;

(v) *Stiposorghum* Garber - Australian; e.g. *S. plumosum*, *S. stipoideum*.

Taxonomy in the subgenera *Chaetosorghum*, *Heterosorghum*, *Parasorghum*, and *Stiposorghum* has been comprehensively investigated. As is often the case with genera which include domesticated taxa, the subgenus *(Eu)Sorghum* contains many nomenclatural inconsistencies, which has resulted in the existence of an extensive synonymy. The subgenus consists of cultivated grain sorghums, a complex of closely related annual taxa from Africa, and a complex of perennial taxa from Southern Europe and Asia. The subgenus is usually divided into two groups, the *Halepensia* complex, and the *Arundinacea* complex (De Wet, 1978). The subgenus is now considered to consist of three species: two rhizomatous taxa, *S. halepense*, and *S. propinquin* (both in the *Halepensia*), and the large and complex *S. bicolor* to include all annual wild, weedy and cultivated taxa (in the *Arundinacea*). Snowden (1936) recognised 24 'species' which are all now considered to be variants of *S. bicolor*.

The grain sorghums are artifacts of human selection and cultivation (De Wet & Huckabay, 1967; De Wet, Harlan & Price, 1970), and the different cultivated kinds deserve at most racial status (Harlan & De Wet, 1972). The species *S. bicolor* has three subspecies:

(a) *S. bicolor* subsp. *bicolor* (grain sorghums). Based on *S. bicolor* (L.) Moench. A detailed comparative morphological study of grain sorghums led Harlan & De Wet (1972) to recognise five basic races, and ten hybrid races that combine characteristics of any two or more basic races. The five basic races are Bicolor, Guinea, Caudatum, Kaffir, and Durra.

(b) *S. bicolor* subsp. *arundinaceum*. Based on *S. arundinaceum* (Desv.) Stapf, this subspecies incorporates all wild sorghums associated with the grain sorghums. It therefore represents the 'wild' component of *S. bicolor*. De Wet (1978) recognises four races of this subspecies: Aethiopicum, Virgatum, Arundinaceum and Verticilliflorum.

(c) *S. bicolor* subsp. *drummondii*. Based on *S. drummondii* (Steud.) Millsp. et Chase, this subspecies incorporates derivatives from hybridisation between subspecies *bicolor* and *arundinaceum*. It occurs as a weed in Africa wherever cultivated grain sorghums and their closest wild relatives are sympatric (De Wet, 1978). This subspecies is extremely variable, a variability undoubtedly enhanced by human selection of grain races, which then introgress with the wild species (Clayton, 1982).

In the present treatment of the genus, for the sampled taxa belonging to the subgenus *(Eu)Sorghum*, the following nomenclature has been retained for ease of understanding:

S. halepense; *S. bicolor* (strictly for *S. bicolor* subsp. *bicolor*) and *S. arundinaceum* (for *S. bicolor* subsp. *arundinaceum*).

Hemisorghum- This genus can be easily confused with members of the genus *Sorghum*. The main differences lie in the flattened and glabrous lower glume of the sessile spikelet which is 2-keeled for most of its length. It is because of this character of the glumes that this genus has been suggested to form a link between *Sorghum* and

Saccharum (Clayton & Renvoize, 1986). *Saccharum* has flat broadly convex, 2-keeled lower glumes while those of *Sorghum* are convex, rounded on the flanks and becoming 2-keeled only near the tip. Also the lodicules in *Hemisorghum* are glabrous in contrast to the ciliate ones of *Sorghum*. However, the resemblance is quite striking.

Pseudosorghum- This genus is also very similar to *Sorghum*. The inflorescence is contracted or relatively dense, with subdivided but short primary branches, bearing relatively long narrow racemes (up to 10 or more spikelet pairs - the racemes fairly long, by contrast to *Sorghum*). The lodicules are glabrous. Members of this genus, especially *P. fasciculare*, are often likened to *Bothriochloa bladhii* S.T. Blake. I must say I find this misleading because, the inflorescence of *B. bladhii*, though paniculate, has a completely different facies with spikelets which are relatively imbricate. Also its primary branches are undivided (simple). I, however, agree with Clayton & Renvoize (1986) that the genus probably forms a link between the two main generic groups (*Bothriochloastrae* and *Sorghastrae*) of the *Sorghinae*, centred upon *Sorghum* and *Dichanthium*. If the assumption of a change from a paniculate inflorescence to a racemose one entails the reduction in the length of the inflorescence axis, the change from divided primary branches to simple ones, and an increase in spikelet pairs (and hence the raceme length), then the above description of *Pseudosorghum* inflorescence would make it evolutionarily intermediate between these two generic groups of the *Sorghinae*. *Sorghum* and allies have paniculate inflorescences with very short dense racemes (2-3(-5) spikelet pairs) while *Dichanthium* and allies have digitate or subdigitate inflorescences with long racemes (> 10 spikelet) pairs.

Sorghastrum- This genus is characterised by sessile spikelets which are accompanied by conspicuous barren pedicels, very stiff membranous ligules and sheath auricles. Inflorescence is a panicle with subdivided primary branches bearing short racemes, these sometimes reduced to triads (*S. incompletum* var. *bipennatum*, *S. minarum* and *S. elliottii*). Two species investigated in the study, *S. fuscescens* and *S.*

pogonostachyum, have many of the pedicels with bisexual (fertile) pedicellate spikelets. Bisexual pedicellate spikelets are associated with members of the subtribe *Saccharinae*, particularly *Saccharum*, hence these two species have been suggested to indicate a link with this genus (Clayton & Renvoize, 1986). In addition to having the bisexual pedicellate spikelet, *S. pogonostachyum* has an involucral beard at the base of the spikelets, a character which again is found in the genus *Saccharum*. Other than the sexuality of the pedicellate spikelet, the spikelets are so typical of *Sorghastrum* that the species would be misplaced in any other genus. I have therefore retained them in *Sorghastrum*.

Asthenochloa- The inflorescence is a panicle with variously divided branches. This is one other genus of the subtribe with barren pedicels. In this instance, the pedicel has been reduced to an inconspicuously minute axis hidden by callus hairs. Another characteristic feature of the genus is the absence of lodicules, a condition often used as an indication of evolutionary advancement. This genus also has the smallest sessile spikelets (2mm) in the subtribe. The barren pedicels suggest a relationship with *Sorghastrum*.

Cleistachne- The trend towards a suppression of the pedicellate spikelet which started in *Sorghastrum* and *Asthenochloa* is taken further in *Cleistachne*, with the total suppression of both the pedicellate spikelet and its pedicel. The complete raceme actually consists of a single sessile spikelet such that the raceme peduncle appears to be a pedicel. This contrasts with the situation in the genus *Dimeria* (subtribe *Dimeriinae*), where, though the spikelets are single, in this case are pedicellate and not sessile. Therefore in this genus the racemes consist of fertile (bisexual) pedicellate spikelets arranged along a tough rachis. The sessile spikelet has been completely suppressed. The ciliate lodicules, the convex lower glumes (rounded on the flanks) and the obtuse callus, all ally *Cleistachne* to *Sorghum*.

As mentioned earlier, the remaining two genera of the *Sorghastrae*, ***Chrysopogon*** and ***Vetiveria***, differ from the other members by having paniculate inflorescences with simple branches. The inflorescence consists of whorls of pedunculate racemes at regular intervals along a common main axis. Additionally, these genera have awned glumes. *Chrysopogon* has racemes which are single-jointed while *Vetiveria* has racemes with more than one joint. The species, *Chrysopogon sylvaticus*, which has 2-3-spikelet pairs, is often suggested to form a link between the two genera. Lower glumes of the spikelets are often aculeolate (prickly) in most of the species of the genera. The growth form of *Vetiveria* with characteristically flabellate leaves and short culms distinguishes it from *Chrysopogon*. Similarly, the long awned spikelets of *Chrysopogon* inflorescences give it a very different facies from those of *Vetiveria* whose awns tend to be short and often inconspicuous.

3.8.2. The *Bothriochloastrae*.

Members of this group share the following characteristics:

Racemes solitary, digitate or paniculate; rachis internodes and pedicels often with a translucent middle line. Sessile spikelet with a blunt callus; lower glume often pitted; upper lemma entire, awned from the tip. Homogamous spikelets sometimes present.

The genera found in this group are *Bothriochloa*, *Capillipedium*, *Euclasta*, *Dichanthium*, *Pseudodichanthium* and *Spathia*. The paniculate inflorescence of *Capillipedium* gives it a different facies from the other genera, but the general similarity of the spikelet structure shows that it belongs to this generic group and not to the *Sorghastrae*.

Dichanthium- *Dichanthium* may be recognised by its homogamous spikelet pairs and obtuse sessile spikelets, but some species lack these features and approach closely to

Bothriochloa, from which they are separated by the solid pedicels. This genus has a few species with pitted glumes. These can be distinguished from those of *Bothriochloa* by the solid joints and pedicels.

Sessile spikelets of *Bothriochloa* tend to be acute at the apex compared to the more obtuse apices of *Dichanthium* sessile spikelets. *Dichanthium* has many jointed sessile / subsessile and digitate racemes. Therefore raceme peduncles are very short in this genus.

The three genera *Bothriochloa*, *Capillipedium* and *Dichanthium* look very different as can be seen from the observations made under each. The certainty and precision of separating them however breaks down when one looks at the species *Bothriochloa bladhii*, *Capillipedium parviflorum* and *Dichanthium annulatum*. These species are highly variable, and in some instances, the specimens I have looked at suggest some germplasm mixing between them. It is the behaviour of these species, particularly *B. bladhii*, which prompted De Wet & Harlan (1966) to suggest a treatment of these genera as one. However, I think other species of the three genera are so different that they support keeping them separate.

Pseudodichanthium- This genus is presumably related to *Dichanthium* (Clayton & Renvoize, 1986). A monotypic genus with imbricate spikelets arranged in short solitary racemes. It has characteristic scarious lower glumes which are broadly winged with inflexed margins. The culms are slender, ascending from a slender base. It could be misplaced in *Dichanthium*, but is very different in appearance, in texture and disposition of the glumes, in the pedicellate spikelet being larger than the sessile, and in the winged lower glumes. It resembles the genus *Dichanthium* only in the imbricate spikelets.

Spathia- The genus has plump *Sorghum*-like spikelets, but the internode tip and pedicellate spikelet callus suggest derivation from *Dichanthium*. This is the only member of the *Sorghinae* which has a spatheate inflorescence, one other feature associated with advancement in the *Andropogoneae*. These spatheate inflorescences are both terminal and axillary. Also found at the base of the raceme are 1-3 homogamous spikelet pairs.

Capillipedium- A homogenous genus related to *Bothriochloa. B. bladhii* probably lies midway between the two genera. Species of this genus have a very delicate paniculate inflorescence. In *Bothriochloa*, *Capillipedium* and *Euclasta*, the rachis internodes and pedicels are grooved along the middle of their length, with thin tissue in the groove. This is commonly referred to as a translucent middle line (furrow). The absence of glume pits and the capillaceous nature of the inflorescence help in distinguishing the two genera. It is quite a homogenous genus, and differentiation at species level proved very demanding due to a close similarity between the species.

Bothriochloa- The boundaries between *Bothriochloa, Capillipedium*, and *Dichanthium* are somewhat blurred, largely due to a complex pattern of hybridisation created by rapacious introgression of *B. bladhii* (Clayton & Renvoize, 1986). Some *Bothriochloa* species generally have a depressed glandular area, glume pit, in the middle or upper portion of the lower glume of the spikelets. These can be found on the glumes of either or both the sessile and the pedicellate spikelets.

The genera *Bothriochloa* and *Capillipedium* are characterised by having the lower sessile spikelets fertile (bisexual), the spikelet pairs on each raceme always heterogamous on the branches of the inflorescence, and by the pedicels and rachis internodes having a translucent longitudinal groove. *Dichanthium* has the lower spikelet pairs on the racemes similar and unawned (homogamous, i.e., male or neuter), no groove along the rachis internodes and pedicels, and frequently a sub-apical fringe of hairs on the lower glume. In addition it differs by the cuneate and obtuse (rather than acute) glumes and the highly imbricate spikelets.

Euclasta- *Euclasta* has *Bothriochloa*-like pedicels and rachis internodes, i.e., these have a translucent longitudinal groove. The inflorescence in *Euclasta* is a single terminal raceme (except in *E. condylotricha*). The cuneate lower glumes of the spikelets ally it to *Dichanthium*. It is probably because of this reason that the genus was once wholly included in *Dichanthium*.

3.9. Conclusion.

From the observations made from the species sampled (see Chapter 8), it is my contention that the genera of the *Sorghinae* are quite distinct. Separate taxonomic revisions of the genera would undoubtedly reveal detailed evolutionary trends at specific level, but I am in no doubt that these are all separate genera. There are two generic groups, the *Bothriochloastrae* and the *Sorghastrae,* on the basis of the characters of the inflorescence and spikelets. These groups are a useful aid to taxonomic discussions because character differences between them are suggestive of evolutionary trends in the subtribe. They are therefore not intended as formal additions to nomenclature. Subtribal delimitation is based mainly on morphological criteria. This unfortunately results in character overlaps between the *Sorghinae* and other subtribes of the *Andropogoneae*, particularly the *Saccharinae* and the *Andropogoninae*. The *Saccharinae* are visualised as closest to the ancestral stock. Evolutionary trends in the *Andropogoneae* are often explained in terms of the sexuality of the spikelets, the nature of the panicle, and the thickness of the rachis internodes. The subtribe *Sorghinae* probably evolved from the *Saccharinae* by loss of sexual function in the pedicellate spikelet (its reduction, loss and total suppression in some genera), and modification of the inflorescence from a panicle through subdigitate or digitate racemes to a single raceme. The so-called highly evolved subtribes of the *Andropogoneae* tend to have racemose and spatheate inflorescences.

Chapter 4. Macromorphology.

4.1. Introduction.

This chapter is an evaluation of characters observed. According to Davis and Heywood (1963), a character is any attribute (or descriptive phrase) referring to form, structure and behaviour which the taxonomist separates from the whole organism for a particular purpose such as comparison or interpretation. Characters used in the present study were chosen after a thorough investigation of a wide range of material. Character states cover a wide range of variation. Examples are drawn in from the sample to put the discussion in context with the study. The same characters were used in numeric studies (Chapter 7).

4.2. Sources of plant material.

Observations were made mostly from herbarium material. Living material for some species grown in glasshouses was also used to complement information on characters and helped enhance appreciation of form and its development. Herbarium material consulted covered the whole range of the geographical distribution of the *Sorghinae*. Specimens from the following herbaria were studied: BM, E, GAB, K, MAL, PRE, UCGB, SRGH and WAG (codes following *Index Herbariorum*, 1981).

4.3. Evaluation of principal taxonomic characters.

4.3.1. Longevity and Perennating organs.

Most of the species in the sample are perennials. Annuals are found in the genera *Cleistachne*, *Euclasta*, *Pseudodichanthium*, *Pseudosorghum*, *Spathia* and some species of *Sorghum*. The subtribe therefore consists almost exclusively of perennials.

These perennials form loose or dense tufts. In some of the grasses, perennating organs observable are rhizomes and stolons. Stolons are distinguished from rhizomes in bearing complete green leaves, with sheath and blade, at each node, whereas rhizomes develop only small, thin, whitish or brownish, scale-like leaves at these points (Hubbard, 1968). Of interest here are rhizomes of the economically important species *Chrysopogon aciculatus* and *Sorghum halepense*. *Chrysopogon aciculatus* is used in lawns and playfields because of its rhizomatous creeping habit. However, the plant needs constant trimming to keep it in the vegetative state lest it flowers and produces its long pungent calli which are a menace. *Sorghum halepense* is very difficult to eradicate and quite often becomes an obnoxious weed in cultivated fields.

4.3.2. Culms.

Culms of all the species are herbaceous. The orientation of these is variable. They can be erect or decumbent and spreading. There is some considerable branching at the base of the culm that produces lateral shoots. These culms die back annually and are replaced by shoots from the basal buds. The perennial grass resulting from several seasons' growth is thus made up of lateral shoots, hence the tufted habit.

Culms vary in the number of nodes, thus making this character inconsistent. Culm nodes can be either glabrous or hairy. Again this was found to be a highly unreliable character. There is a considerable variation between specimens of the same species and between nodes on the same plant specimen.

4.3.3. Leaves.

Leaf blades are mostly linear or linear-lanceolate in shape. They also are narrow (<1cm) except in the genera *Hemisorghum*, *Pseudosorghum* and *Sorghum*, which have characteristically broad (>1cm) and flat leaves. The leaf characters were found to be highly variable.

4.3.4. Sheaths.

Typically a leaf sheath has the general shape of a hollow cylinder split down one side. The margins of the sheath commonly overlap, both at the point of attachment and for all or most of the length of the sheath. Projections of tissue termed auricles may be developed laterally at the apex of the sheath or base of the blade. The former, which are called sheath auricles, are present in the genus *Sorghastrum.* The other genera do not have either sheath auricles or blade auricles. In two species of *Chrysopogon*, *C. fallax* and *C. pallidus*, lower leaf sheaths disintegrate into fibres. It is by this reason that the species are called "woolly-butt" in Queensland (Blake, 1944). These are often wrongly referred to as rootstocks.

The junction of the sheath and blade is typically marked by a band of mechanical tissue that is different in appearance and texture from either the sheath or the blade. The abaxial surface of this area is termed the collar. It is at the collar region that the blade bends away from the sheath, and hence make the two organs easily distinguishable from each other. The collar is conspicuous in most genera of the *Sorghinae* except in *Vetiveria.* In this genus, both the sheath and blade are sharply keeled and thus conduplicate. The collar is recognisable as a lateral indentation, while the ligule is represented by a short unfringed membrane appearing as a scar.

4.3.5. Ligule.

The ligule is usually a thin, white or brownish membrane, but in some grasses, it may be a fringe of hairs or be absent. *Sorghastrum* species have a stiff ligule that is usually divided into a rounded central lobe and two stiff, pointed lateral projections. The latter have been referred to as sheath auricles. In the other genera of the subtribe, variation of the ligule is mainly whether the membrane is fringed or unfringed. The fringed membrane can be either ciliate or short toothed (lacerate). In none of the material studied was the ligule absent. The type of ligule has been suggested to be consistent for all species of a genus (Gould & Shaw, 1983).

4.3.6. Inflorescence.

The *Sorghinae* is characterised by inflorescences of paniculate, digitate or subdigitate racemes. The subtribe divides into two on the basis of inflorescence type. These are what I have called the paniculate and racemose inflorescence types, and are defined as follows (see Figures 4.1 - 4.4):

Figure 4.1 Inflorescence types in the *Sorghinae* (diagrammatic). A. Spatheate inflorescence, e.g., *Spathia neurosa*. B. Paniculate inflorescence, branches simple (all species of *Chrysopogon*). C. Racemes solitary, e.g., *Euclasta clarkei*, *Dichanthium micranthum*.

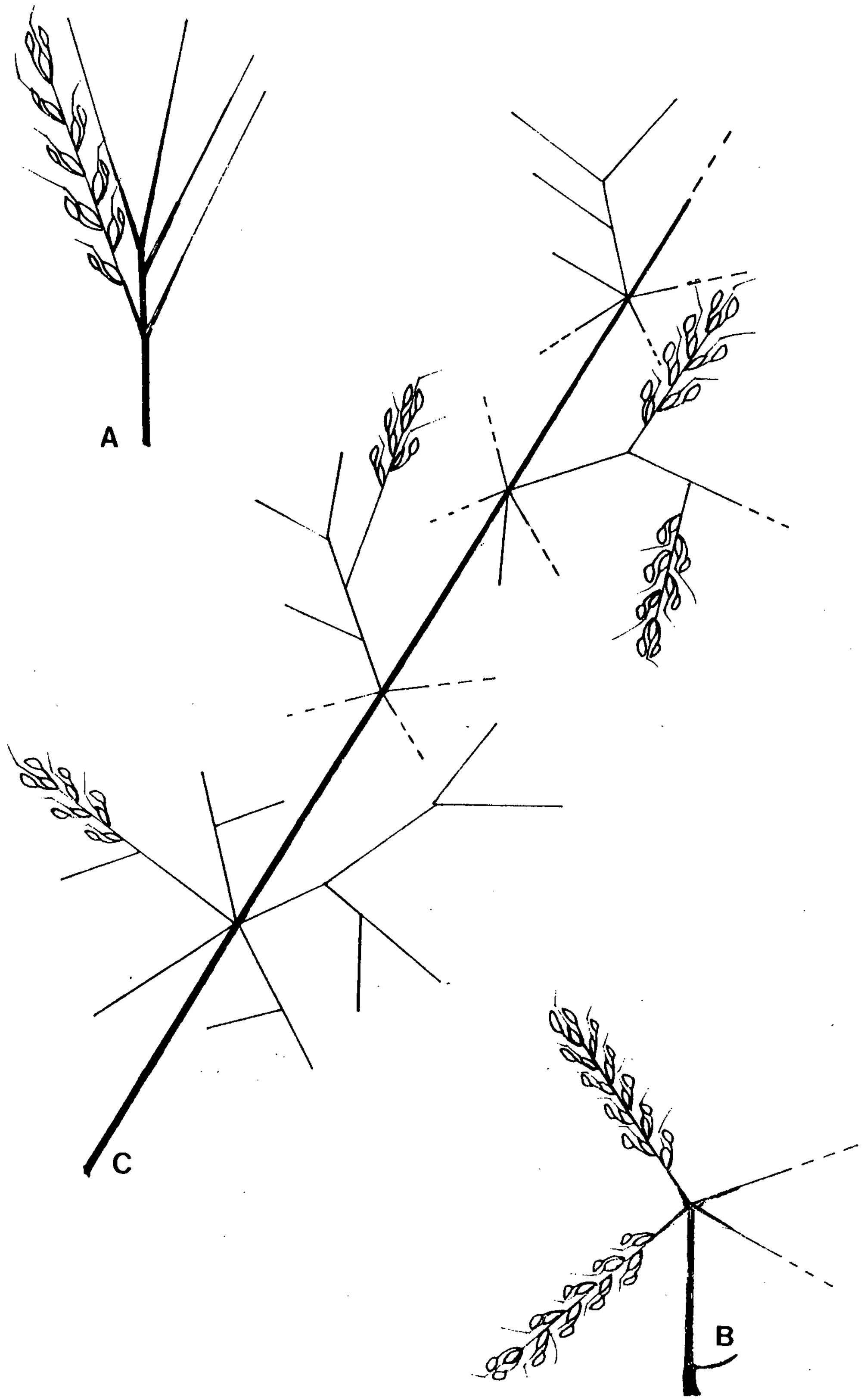


Figure 4.2 Inflorescence types in the *Sorghinae* (diagrammatic). Racemose inflorescences: A. Subdigitate racemes, e.g., *Bothriochloa insculpta*. B. Digitate racemes, e.g., *Dichanthium sericeum*. C. Paniculate inflorescence, branches divided, e.g., *Sorghum arundinaceum*.

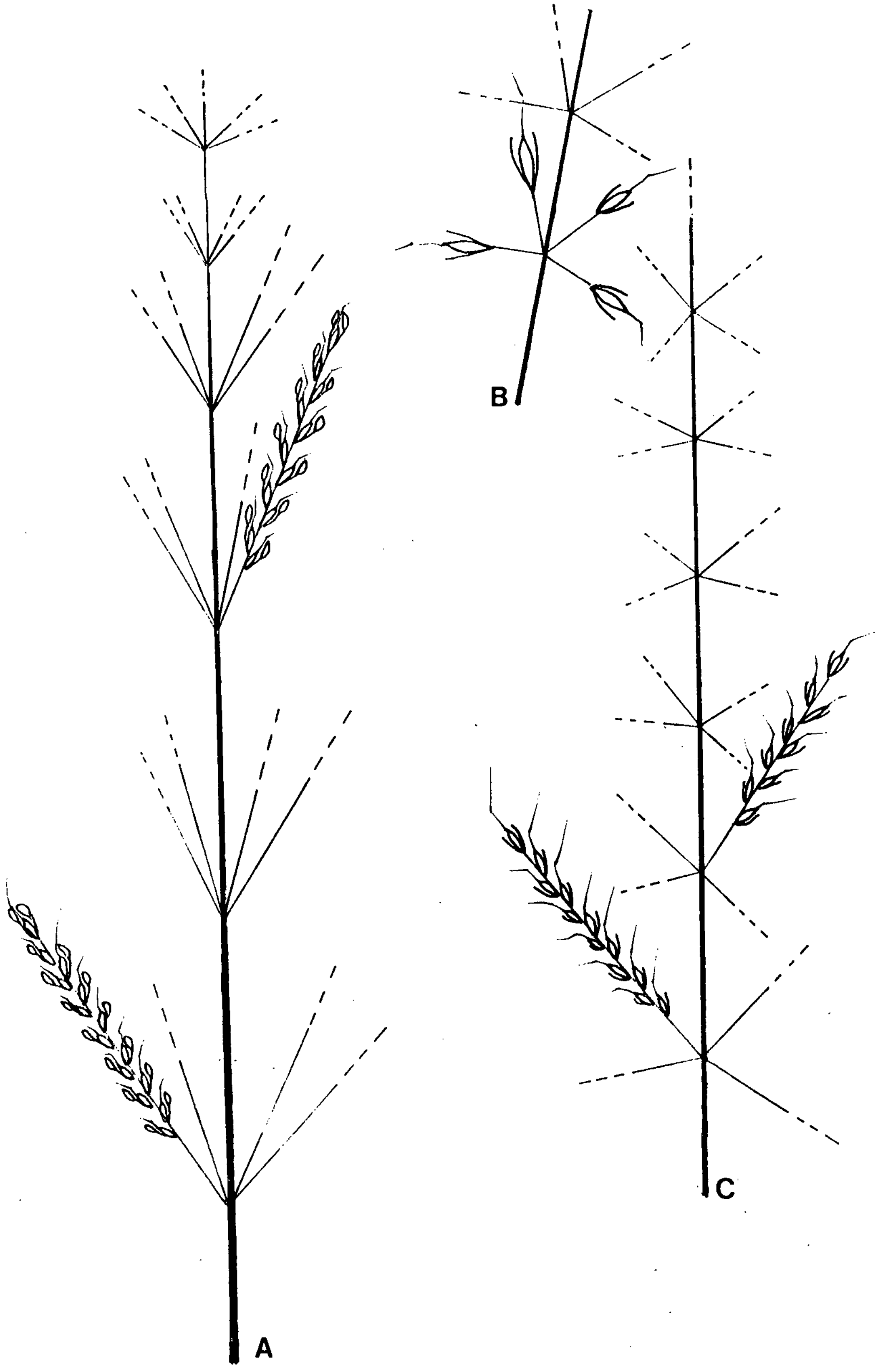


Figure 4.3 Inflorescence types in the *Sorghinae* (diagrammatic). Paniculate inflorescences: A. *Vetiveria* species. B. *Sorghastrum incompletum* var. *bipennatum*. C. *Sorghastrum nutans*.

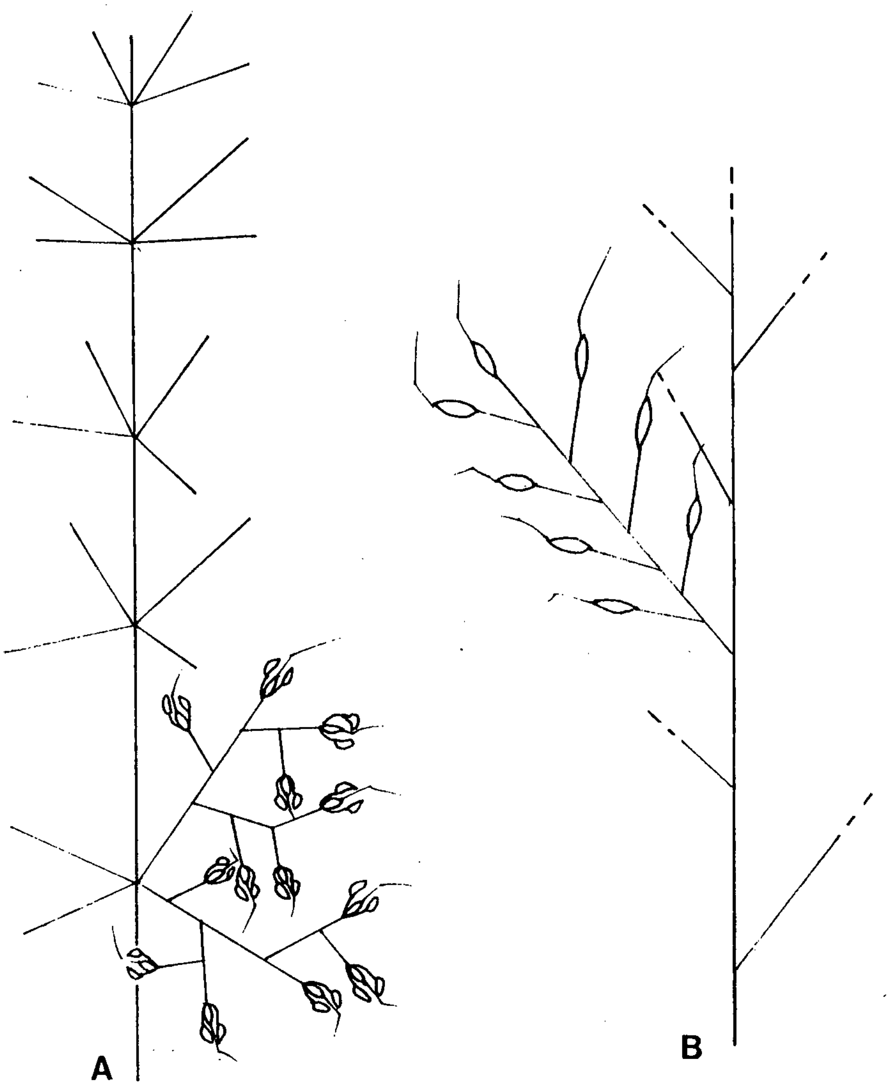


Figure 4.4 Inflorescence types in the *Sorghinae* (diagrammatic). Paniculate inflorescences: A. *Capillipedium parviflorum*, branches divided. B. *Cleistachne sorghoides*.

(1) **Paniculate inflorescence** - an inflorescence having a central axis with few to many simple branches or branches that are themselves divided, often profusely. These are found in the genera *Sorghum*, *Hemisorghum*, *Pseudosorghum*, *Sorghastrum*, *Asthenochloa*, *Cleistachne*, *Capillipedium*, *Chrysopogon* and *Vetiveria*. Clayton (1972) refers to these as the *Sorghastrae* (excluding *Capillipedium*). In addition to the paniculate inflorescence these are characterised by having an upper lemma bilobed (occasionally entire) which is awned from the sinus. Two main clusters can be recognised within the *Sorghastrae*: *Sorghum* and allies with dorsally flattened sessile spikelets; and the *Vetiveria-Chrysopogon* alliance with laterally compressed sessile spikelets, awned glumes, and panicles with verticellate racemes which give the inflorescence a distinct facies.

(2) **Racemose inflorescence** - spikelets borne directly on a jointed unbranched axis (rachis). This inflorescence type is found in *Bothriochloa, Dichanthium*, *Euclasta*, *Pseudodichanthium* and *Spathia*. These are the *Bothriochloastrae*. In addition to the racemose inflorescence they have an entire upper lemma (barely wider than the awn base) awned from the tip (except in two Australian species of *Bothriochloa*, *B. biloba* and *B. erianthoides*, which have bilobed upper lemma). The racemes can be arranged in one of the following ways:

(a) A single raceme terminal or axillary e.g., *Euclasta* (except *E. condylotricha*) and *Pseudodichanthium* species.

(b) Two or more racemes arranged in one of the following ways:

(i) radiating from the apex of the culm, i.e. arranged in a whorl that terminates the culm. These are said to be arranged digitately, e.g., *Spathia neurosa, Bothriochloa pertusa* and *Dichanthiium sericeum.*

(ii) borne on a short central axis. When it is conspicuously shorter and overtopped by the racemes, these are described as subdigitate, e.g., *Bothriochloa insculpta* and *Euclasta condylotricha.*

It is, however, not uncommon to find a species with a paniculate inflorescence in a genus predominantly characterised by species with racemose inflorescences, e.g. *Bothriochloa bladhii.* Also a lot of other permutations occur in the group with racemose inflorescences such that it is not necessarily correct to exclusively associate digitate or subdigitate racemose inflorescences with a particular genus or indeed a particular species.

4.3.7. Racemes.

Racemes of the *Sorghinae* are characterised by the occurrence of spikelets in pairs, one sessile, the other pedicellate. The raceme terminates in a triad of 2 pedicellate spikelets and 1 sessile, and those below in sessile/pedicellate pairs. A deviation from this spikelet arrangement occurs in the genera *Cleistachne*, *Asthenochloa*, *Sorghastrum* and *Chrysopogon*. The genus *Chrysopogon* has spikelets in a triad (1 sessile and 2 pedicellate) forming a raceme. In *Cleistachne*, the pedicellate spikelet is completely suppressed, such that the raceme comprises of a single sessile spikelet. In *Asthenochloa,* the pedicellate spikelet is represented by a minute axis hidden by callus hairs. Finally, in *Sorghastrum*, the pedicellate spikelet is represented by a barren pedicel, such that the spikelet 'pairs' along the raceme axis consist of a sessile spikelet and a pedicel, and the terminal triad is a sessile spikelet and two barren pedicels.

The racemes are mostly more than single-jointed in most of the genera. Joints here referring to the number of spikelet pairs along the raceme axis (rachis). In contrast to all the other *Sorghinae* genera, the genus *Chrysopogon,* is characterised by racemes which are single-jointed (Figure 4.1). It is on the bases of this that Clayton & Renvoize (1986) distinguish this genus from the genus *Vetiveria.* The species *Chrysopogon sylvaticus* has been suggested to form a link between these genera by having racemes with 2-to-3-joints. There are also some species in *Sorghastrum*, e.g., *S. incompletum* var. *bipennatum*, and *Capillipedium*, e.g., *C. parviflorum*, that have single-jointed racemes. It has been a tradition to use the number of spikelet pairs (raceme joints) in distinguishing species complexes in *Bothriochloa* (Celarier & Harlan, 1955). A problem encountered in the present study was incomplete racemes in the herbarium sheets due to the upper spikelet pairs having disarticulated and fallen off.

One other feature consistently used as a character in genera with racemose inflorescence, particularly *Bothriochloa* and *Dichanthium*, is the number of racemes per inflorescence. The range, characteristic of a species, is usually present within a single plant. For this reason, the average number of racemes per inflorescence is a relatively stable character to use.

The rachis internodes are mostly solid except in *Bothriochloa*, *Capillipedium*, and *Euclasta*. In these three genera can be found, running the length of both the rachis internode and pedicel, a translucent longitudinal groove made of a hyaline tissue in contrast to that of the raised lateral edges. This character has been used consistently with a combination of other characters to identify species of these genera.

The most characteristic feature of the *Sorghinae* is the fragile rachis disarticulating with each pair of spikelets. The disseminule is thus a composite unit made up of sessile spikelet, rachis internode, pedicel and pedicellate spikelet. The raceme either disarticulates at the joints, when there are more than one spikelet pairs, or falls entire, when it is single-jointed. The overall morphology of this unit is variable in the *Sorghinae*. There are however various components which seem to play a role in dispersal. From the morphological investigations made, the glumes, awn, lemma of the upper floret, and the callus, appear to be the organs mostly involved in dispersal. Even though not supported by any experimental proof, features such as hairiness, size and lightness of these organs are likely to provide an extra aid.

4.3.8. Spikelets.

Most classifications of grasses are based on the structure and arrangement of their spikelets. These organs, by the great diversity in their formation and organisation, and by the amazing range in shapes and peculiar modifications of their separate parts, provide a far greater variety of distinguishing characters than do other parts of the grass plant.

Spikelet configuration in the *Sorghinae* is as follows (see Figure 4.5):

Sessile spikelet: (1) Glumes (2) (a) lower and (b) upper;

(2) lower floret (empty or barren) represented by (a) a lower lemma;

(3) upper floret (bisexual) consisting of (a) palea (or absent); (b) pistil (ovary, 2 styles and 2 feathery stigmas); (c) stamen (1-3 anthers); (d) 2 fleshy lodicules; (e) upper lemma (may be bilobed, entire, awned, aristulate, mucronulate, and variable in breadth).

Pedicellate spikelet (absent in *Cleistachne*, *Asthenochloa*, most of *Sorghastrum*, and some *Sorghum)*:

(1) Glumes (2) (a) lower (always present) and (b) upper (sometimes absent);

(2) lower floret (empty or barren or absent) consisting of (a) lower lemma (maybe absent);

(3) upper floret (male, neuter, or absent) consisting of (a) upper lemma; (b) palea (absent in most cases); (c) 2 fleshy lodicules and (d) stamen (1-3 anthers); awn (absent in most cases).

The spikelet configuration of the pedicellate spikelet differs when it is bisexual, in which case it is similar to the sessile one, i.e., it will have similar organs present and similar ones absent.

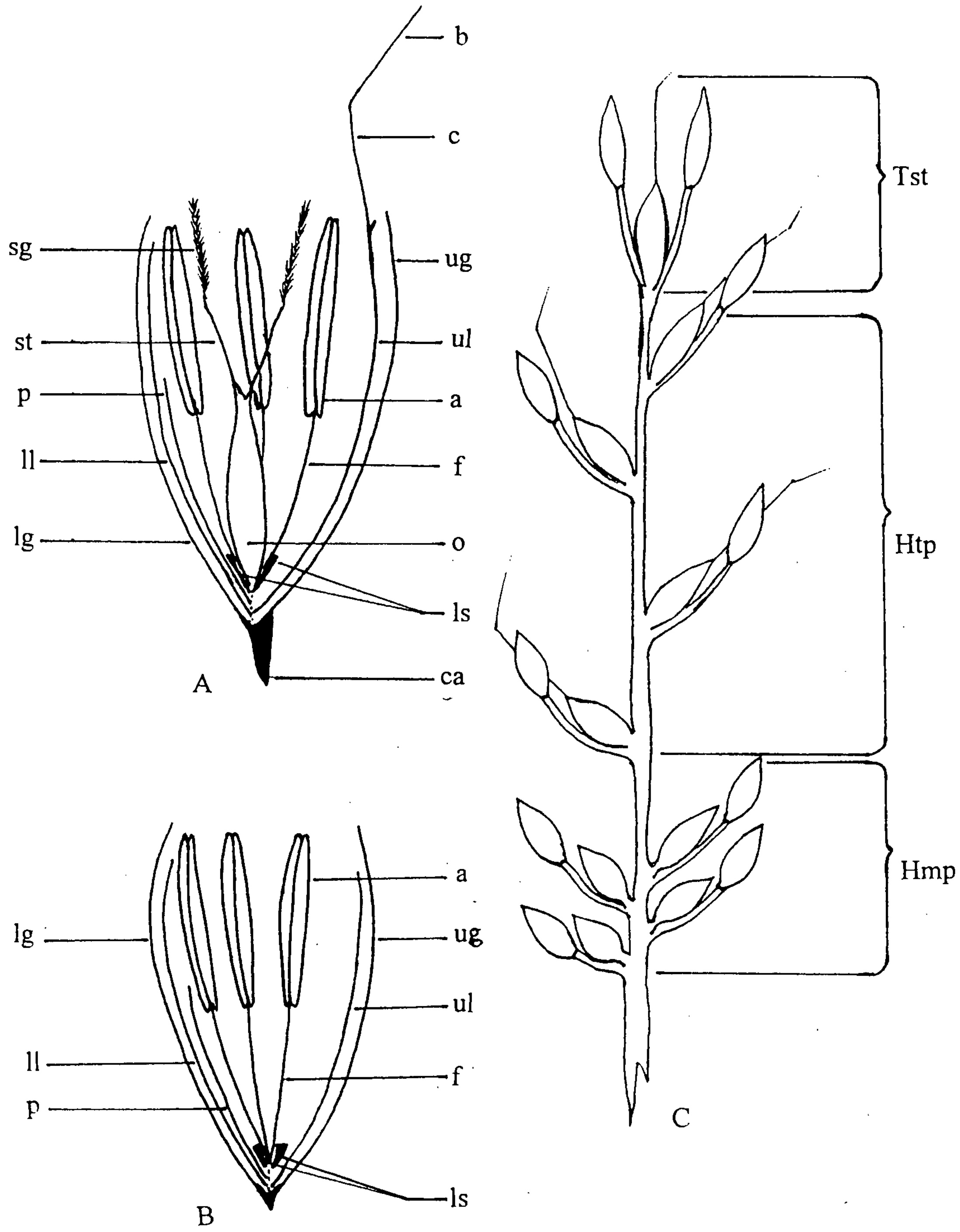


Figure 4.5 Spikelet configuration in the *Sorghinae* (Diagrammatic). A. Sessile spikelet. B. Pedicellate spikelet. C. Location of spikelet pair types along the raceme axis. a, anther; b, bristle; c, column; ca, callus; f, filament; Hmp, homogamous spikelet pairs; Htp, heterogamous spikelet pairs; lg, lower glume; ll, lower lemma; ls, lodicules; o, ovary; p, palea; sg, stigma; st, style; Tst, terminal spikelet triad; ug, upper glume; ul, upper lemma.

4.3.9. Sessile spikelet.

As mentioned earlier, there are two kinds of spikelets in the *Sorghinae*, the pedicellate and the sessile. In all the genera of the *Sorghinae*, the sessile spikelet is a specialised female organ due to the loss of function in the lower floret. The lower floret is represented by a lemma while the upper is always bisexual. The upper lemma always bears a geniculate awn (when present) from its sinus or tip. The pedicellate spikelets are nearly always preserved as functioning male organs. Clayton (1969) suggested that, for sexual dimorphism to be so strongly expressed even in cases where the spikelet and the disseminule are almost equivalent, might be due to the fact that the callus forms an essential part of the disseminule, and that this structure has evolved primarily by modification of the rachis segment. He further suggested that the callus of the pedicellate spikelet presumably evolved independently, and opened the way to a reversal of the sexual roles of the sessile and the pedicellate spikelets such as occurs in *Trachypogon* Nees and *Germainia* Bal. & Poitr. The sexuality of the sessile spikelet is not useful as a diagnostic character since it is bisexual in all members of the subtribe.

4.3.10. Pedicellate spikelet.

The shape of the pedicellate spikelet and the degree of its development varies within the *Sorghinae*. Pilger (1954) assumed that the development of the bisexual pedicellate spikelet represented a primitive character in the subtribes of the *Andropogoneae*. Clayton and Renvoize (1986) however noted that though the sexuality of the pedicellate spikelet has been regarded as taxonomically important, allowance must be made for occasional anomalous species. For instance, the pedicellate spikelet was found to be bisexual in the species *Sorghastrum fuscescens*, *Sorghastrum pogonostachyum* and *Dichanthium annulatum* var. *fecundum*. The pedicel and hence pedicellate spikelet are completely suppressed in *Cleistachne*. The pedicellate spikelet is represented by a barren pedicel in *Sorghastrum* and *Asthenochloa*. In *Asthenochloa*, the pedicel is actually rudimentary, represented only by a minute axis hidden by the callus hairs. It can be represented by a barren pedicel, empty glumes or well developed in *Sorghum*. In instances where the pedicellate spikelet is developed, it is either male or neuter. This is so in the remaining members of the subtribe which are *Capillipedium*, *Bothriochloa*, *Dichanthium*, *Spathia*, *Pseudodichanthium*, *Pseudosorghum*, *Hemisorghum*, *Chrysopogon* and *Vetiveria*.

4.3.11. Homogamous spikelet pairs.

One other prevalent feature in the *Sorghinae* is the occurrence of homogamous spikelet pairs at the base of the raceme in some genera (Figure 4.5). Stearn (1992) defines homogamous as "with only one kind of flower in the cluster". In the *Sorghinae*, sexuality of the homogamous spikelet pairs deviates from the norm of bisexual sessile spikelet and male or neuter pedicellate spikelet combination by being either male or neuter. These pairs are usually more or less sessile. In general, they resemble the pedicellate spikelet in being male or neuter, somewhat larger than the sessile, but always awnless. These occur in the genera *Euclasta* (1-3 pairs), *Pseudodichanthium* (2-3 pairs), *Dichanthium* (1-6 pairs) and *Spathia* (1-2 pairs). In some *Andropogoneae* genera these have become involucral and have thus been suggested to aid as a protective measure against bush fires (Clayton, 1969). This phenomenon of homogamous spikelet pairs at the base of the raceme prompted Hackel (1889) to subdivide his genus *Andropogon* into two principal groupings (series):

(i) Series A. Isozygi - sessile spikelets of all the pairs alike in sex and form throughout the spikes;

(ii) Series B. Heterozygi - lowest one or more sessile spikelets differing from all above in sex or form.

The function of the homogamous spikelet pairs has been suggested to be that of protecting the upper fertile spikelets against fire. The upshot of the modifications is often to place additional protective envelopes around the flower and fruit, variously derived from the pedicel, pedicellate spikelet, rachis internode, homogamous spikelets and subtending leaf sheath (Clayton & Renvoize, 1986). The authors also suggest that this may "be related to the tribe's (*Andropogoneae*) success in open savannah habitats ... where bush fires are an annual event". Having the seed up in the raceme protected by these sexually non-functional organs below, increases the seed's chances of survival.

4.3.12. Callus.

The term callus is applied to a thickened hard swelling, rounded or bolster-shaped or even prolonged downwards as an appendage, often sharp, rarely needle-like or forked, situated at the base of fertile lemmas or below the glumes (Bor, 1960). These occur at the base of the sessile spikelet and occasionally at that of the pedicellate one. The callus forms an important part of the disseminule, and has evolved primarily by the modification of the rachis segment (Clayton, 1969). The needle-like callus is found in most species of the genus *Chrysopogon*, where at the base of the glumes it will be found extending some distance down the rachis internode. A number of species of this genus have a very sharp callus which is always furnished with a beard of stiff hairs pointing away from the tip of the callus. This means that if the callus penetrates the earth, clothing or flesh, the withdrawal of the fruit is made much more difficult. These are a menace to grazing animals when they gradually work their way into the flesh and cause abscesses. The callus in the other genera of the subtribe are mostly blunt and obtuse.

4.3.13. Glumes.

Grasses have their flowers, which consist merely of reproductive organs surrounded, subtended or more or less enclosed in stiff bracts commonly known as glumes. Generally speaking, if the protection of the grain is taken over by the lemma and palea, the glumes tend to be membranous or hyaline. If the glumes themselves are the protecting scales, they tend to be tough, as is the case in the *Sorghinae*. The spikelets are generally dorsally or laterally compressed hence the lower glume is mostly two-keeled while the upper is navicular.

There are various means by which the grain gets released from the dispersed unit. In many of the smaller grasses the grains become once detached from the glumes in falling. In some other instances, the grain remains enclosed in the glume surrounding it, and shut in by the palea. Specialisation often occurs in the spikelet to facilitate grain release. There are some grasses which have toughened lemmas and paleas which clasp the grain tightly, while the glumes are reduced in size compared to the rest of the spikelet and become lax with maturity. In case of the *Sorghinae* grasses, the glumes are the same size as the spikelets and toughened, while paleas are reduced or absent, and lemmas hyaline and membranous. The texture of the glumes of the sessile spikelet, in most cases, is different from those of the pedicellate spikelet. It is those of the sessile spikelet, hence those enclosing the grain, that are toughened while those of the pedicellate spikelet are papery, an adaptation which might be associated with dispersal for lightening the load. It would seem probable that the grain is dispersed whilst still between the two glumes and gets dislodged as the glumes wither away due to the elements. In the cultivated species of *Sorghum,* e.g. *S. bicolor*, the glumes are gaping at maturity, and hence a third to a half of the grain is exposed. This makes it easy for the grain to be released from the husk. It is quite probable that this is a result of continuous selection by breeders to improve grain release. Most of the *Sorghinae* grasses have the lower glumes of the sessile spikelets covered with hair, but only in a comparatively small number is the hair sufficiently long and silky to be of any use in transporting the grain.

Pseudodichanthium serrafalcoides (Cooke et Stapf) Bor, is the only species with a notably winged lower glume of the sessile spikelet. Ridley (1930) notes that glumes are boat-like and light, project beyond the sides of the grain and hence act as wings, so that the grains in them are readily blown away to a considerable distance. Frequently in other grasses of the *Sorghinae*, the pedicellate spikelet is barren (and consequently light) and just represented by empty glumes and remains attached to the dispersal unit. These glumes probably also serve as wings to aid in dispersal. The glumes do not increase in size nor alter in shape during the fruiting stage, but remain the same as during the flowering stage.

Glumes of certain species in the genera *Bothriochloa* and *Dichanthium* have a glandular depression, commonly referred to as a glume pit, on the back, at or above the middle. These are found on the lower glumes of the pedicellate and sessile spikelet. No particular function has yet been associated with the glume pit, but Heslop-Harrison (1961) suggested that it might have a role to play in cleistogamy (see Chapter 5). The character is obviously useful at generic level, but its consistency is rather wanting at species level. The presence of the glume pit is so variable within the same inflorescence and between specimens that it can not be used reliably at species level.

One other noteworthy development on the glumes of the genera *Vetiveria* and *Chrysopogon*, is the presence of awns at the tips of these. The awns are well developed in *Chrysopogon* species, and occur in varying frequencies on the glumes of both spikelets. They are also pubescent to varying degrees, and this state can be used with some consistency to distinguish different species of the genus. In *Vetiveria,* the awns tend to be short and mucronate. The glume awns do not occur in the other genera of the subtribe.

4.3.14. Lower lemma.

There are two florets, the upper and the lower, in the spikelets of the *Sorghinae*. The lower floret is always represented by a lemma, the lower lemma, in the sessile spikelet. This lemma is always hyaline and ciliate along the margins. The lower lemma can be present or absent in the pedicellate spikelet. If present, it is usually of the same texture and length as that of the sessile spikelet.

4.3.15. Upper lemma.

As mentioned earlier, both spikelets, i.e., the sessile and pedicellate, have two florets, the upper and the lower. There is an upper lemma in both spikelets. The upper lemma in the pedicellate spikelet, if present, is hyaline, about the same size as the upper glume and awnless (awned in *Dichanthium annulatum* var. *fecundum*, *Sorghastrum fuscescens* and *S. pogonostachyum*). The upper lemma of the sessile spikelet is hyaline in texture and is characteristically awned for members of the subtribe. The apex of this lemma can be either entire or bilobed, and ciliate or glabrous. The subtribe divides roughly into three groups on the basis of this character. Firstly in the *Sorghum, Asthenochloa, Cleistachne,* and *Pseudosorghum* group, the lemma is ciliate and bilobed. The second group has a glabrous and entire lemma. Here is found the genera *Bothriochloa, Capillipedium, Dichanthium,* and *Spathia.* In addition to being entire, the lemma is so reduced in width that it is merely a hyaline base of the awn (stipiform). The last group consists of *Vetiveria, Chrysopogon, Hemisorghum,* and *Sorghastrum*, in which no state of the character is dominant. Here, however, if the lemma in entire, it is still wider than the base of the awn. The nature of the lemma tip, usually given great prominence in artificial keys, seems not to follow any discernible evolutionary trend in the subtribe.

4.3.16. Palea.

The grass floret is enclosed on the outside by a lemma, and a palea on the inside. Heywood (1993) likens the spikelet to a branch system in which the glumes and lemmas represent modified leaf-sheaths and the palea a prophyll (a special bract replacing the first leaf on the inner side of an axillary branch). The palea is absent in a majority of the species sampled. The absence of the palea is often suggested to be an indication of evolutionary advancement in the Gramineae.

4.3.17. Awn.

Awns are frequently developed on glumes and lemmas of grasses. In the *Sorghinae*, these are developed from the tips or sinuses of the lemma of the fertile (bisexual) upper floret. Awns have been suggested to act as guiding propellers to the windblown disseminules. These are variously hairy and in most instances coiled (twisted) and will easily adhere to any moving (animate) dispersal agent. Awns also occur at the apex of glumes in the genera *Chrysopogon* and *Vetiveria*.

The twisted column of the awn reacts to hygroscopic changes by coiling and uncoiling, a movement which maybe of some value in freeing the grain from the tangle of the inflorescence. This function of the awn in conjunction with the retrorsely bearded callus, has been suggested to facilitate in propelling the grain along the ground. The awn hairs have also been suggested to have some relation to the retention of dew, improving efficiency of the hygroscopic mechanism (Clayton, 1969).

4.3.18. Lodicules.

The lodicules are taken to represent vestigial perianth members. They are two diminutive bodies lying between the lemma and the ovary base in the grass floret, which by expanding rapidly at the time of anthesis, lever away the rigid lemma allowing anthers and stigmas to emerge (Heslop-Harrison & Heslop-Harrison, 1996). The essential feature of functional lodicules is the presence of a cushion of tissue at the base made of cells which by undergoing enlargement at anthesis, cause the basal part to swell, so generating a considerable force necessary to prise apart the stiff outer perianth components. Heslop-Harrison & Heslop-Harrison (1996) demonstrated that this is driven by the influx of water associated with the accumulation of potassium ions in the cells of the cushion. This function of the lodicules is therefore associated with chasmogamous flowers. A balance between chasmogamy and cleistogamy in grasses has been suggested to be affected by environmental conditions, including day-length (Heslop-Harrison, 1959). The two phenomena are therefore equally common in most grasses.

Lodicules of most members of the *Sorghinae* are fleshy, cuneate in shape, visibly vascularised, and glabrous. An exception occurs in the genera *Cleistachne* and *Sorghum*, which have lodicules ciliate on the apex or apical corners. The lodicules are absent in the genus *Asthenochloa*. One would therefore assume that this genus is necessarily cleistogamous. Also taxa whose florets do not have lodicules are often considered evolutionarily advanced (Hubbard, 1984).

4.3.19. The androecium.

The spikelets of the grasses of the *Sorghinae* have 2 or 3 anthers. An unusual situation occurs in the species *Bothriochloa decipiens*, which possesses a single anther. This character, unique in the subtribe, has been suggested to be an adaptation associated with cleistogamy (Heslop-Harrison, 1961). One observation I made was that whenever the pedicellate spikelet was male, the anthers were mostly larger than those of the bisexual sessile spikelet. It was found to be of the same size as those of the sessile spikelet in a few cases but very rarely smaller in any of the material studied.

4.3.20. The gynoecium.

The pistil of the grasses of the *Sorghinae*, like that of most grasses, consists of a unilocular ovary with a single ovule, and two styles with feathery stigmas. Much variation is exhibited in the shape of the ovary. It may be ovate, ellipsoid, obovate, oblong, or more or less flattened. According to Arber (1934), the ovule of the Gramineae has two integuments, each usually composed of two cell layers. The outer integument is gradually absorbed after fertilisation, but the inner persists to form the seed coat. The inner portion of the pericarp (ovary wall) also breaks down and is absorbed, and the remaining pericarp tissue becomes united with the seed coat. The resulting dry, indehiscent, one-seeded fruit, in which the pericarp and seed are fused, is called a caryopsis. Some specimens in the sample were found at this fruiting stage. One observation made was that, for the cultivated sorghums, the caryopsis was found to be partially exposed between the gaping glumes. This is to facilitate in the release of the grain for processing. In the others members of the *Sorghinae*, the grain was found to be always between the tightly closed glumes, and one always had to prise very hard to release the grain.

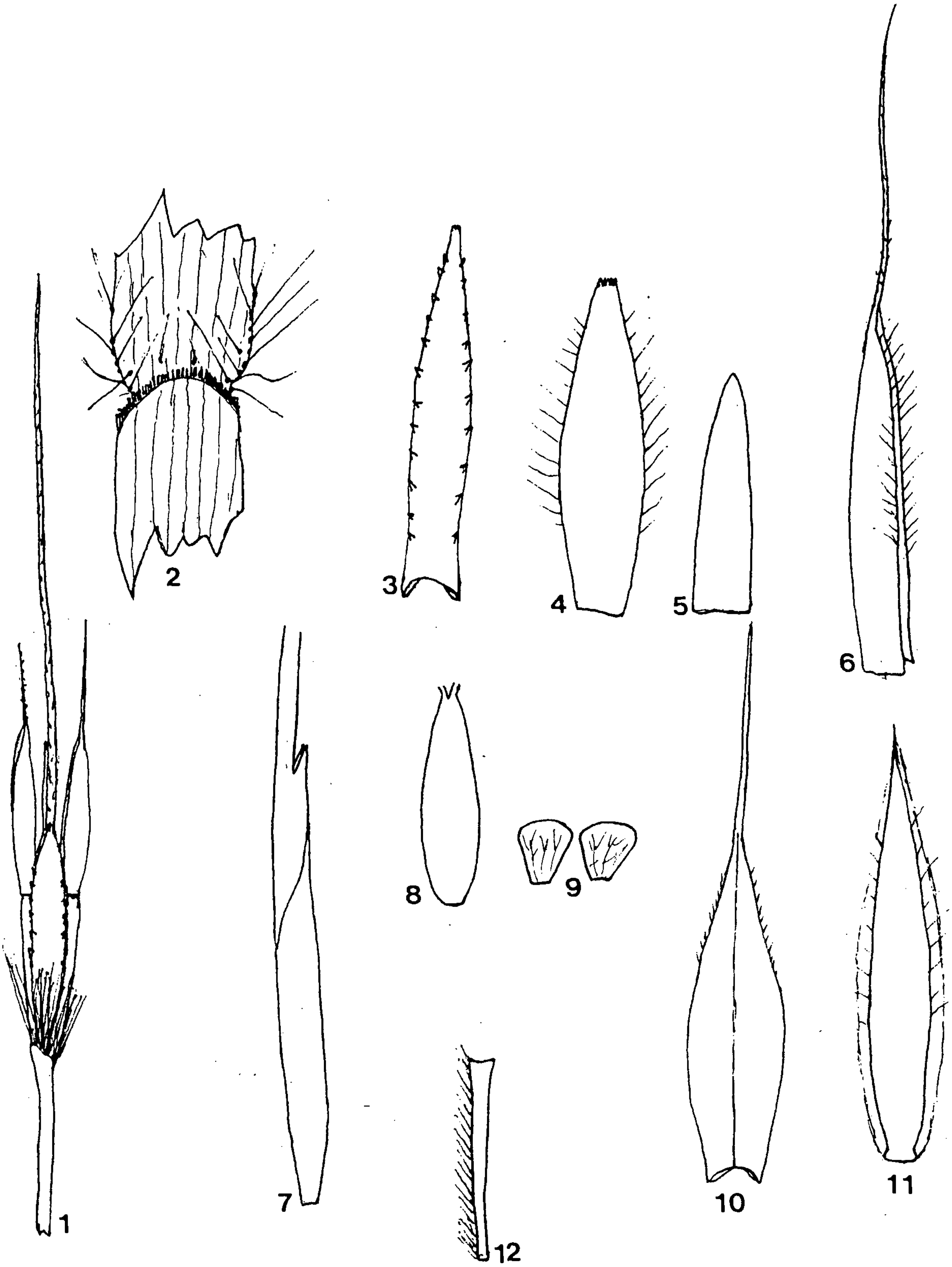


Figure 4.6 ***Chrysopogon gryllus*** **subsp.** ***gryllus***. 1. Spikelet triad (x2). 2. Ligule (x5). Sessile spikelet: 3. Lower glume (x10). 4. Lower lemma (x12). 5. Palea (x11). 6. Upper glume (x8). 7. Upper lemma (x13). 8. Ovary (x12). 9. Lodicules (x10). Pedicellate spikelet: 10. Lower glume (x7). 11. Upper glume (x7). 12. Pedicel (x7).

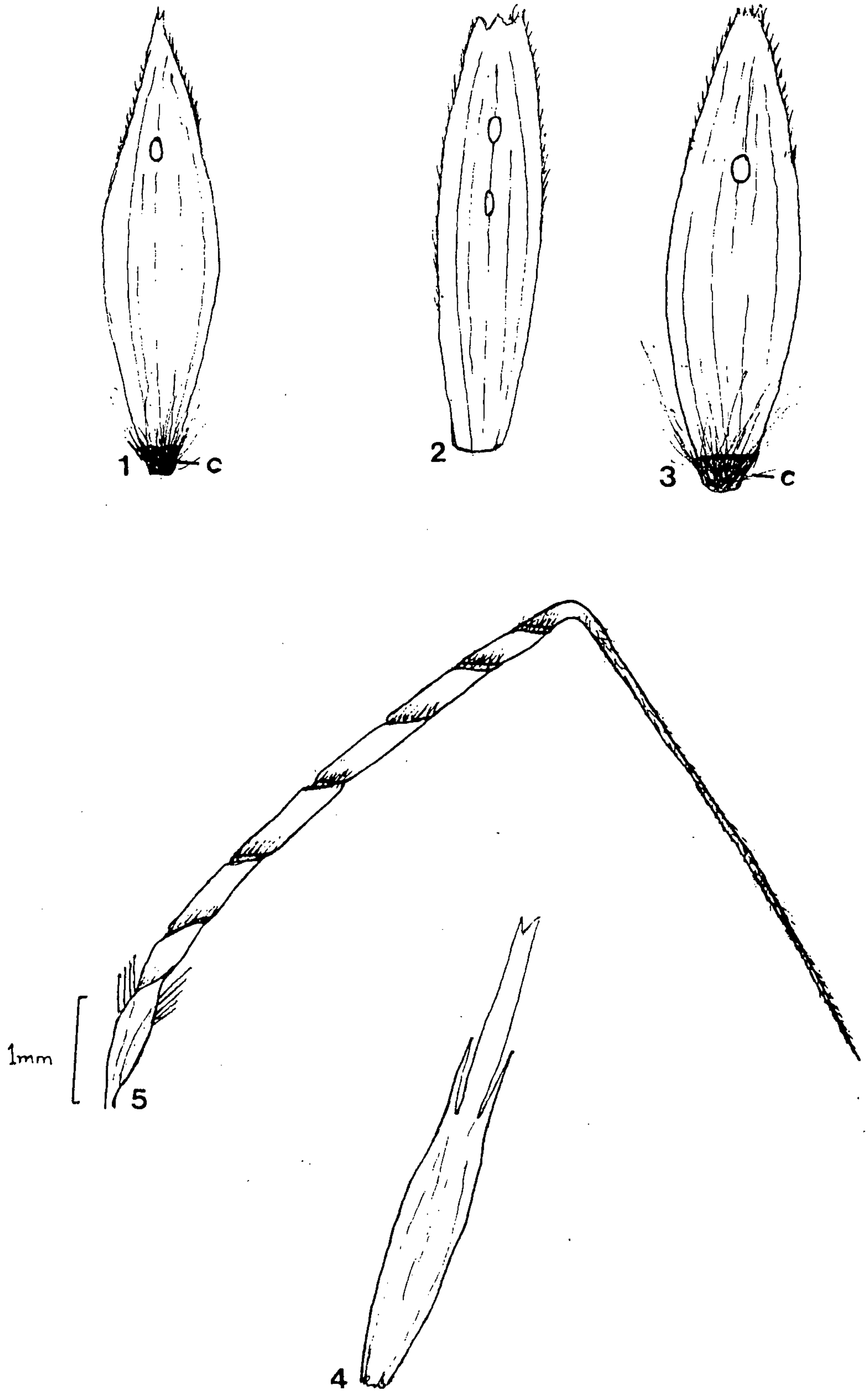


Figure 4.7 ***Bothriochloa kuntzeana.*** Sessile spikelet: 1. Lower glume (x20), c-callus. ***Bothriochloa insculpta.*** Pedicellate spikelet: 2. Upper glume (x20). Sessile spikelet: 3. Lower glume (x20), c-callus. ***Bothriochloa biloba.*** Sessile spikelet: 4. Upper lemma (x45), NB*-filiform lobes. ***Cleistachne sorghoides.*** 5. Awn.

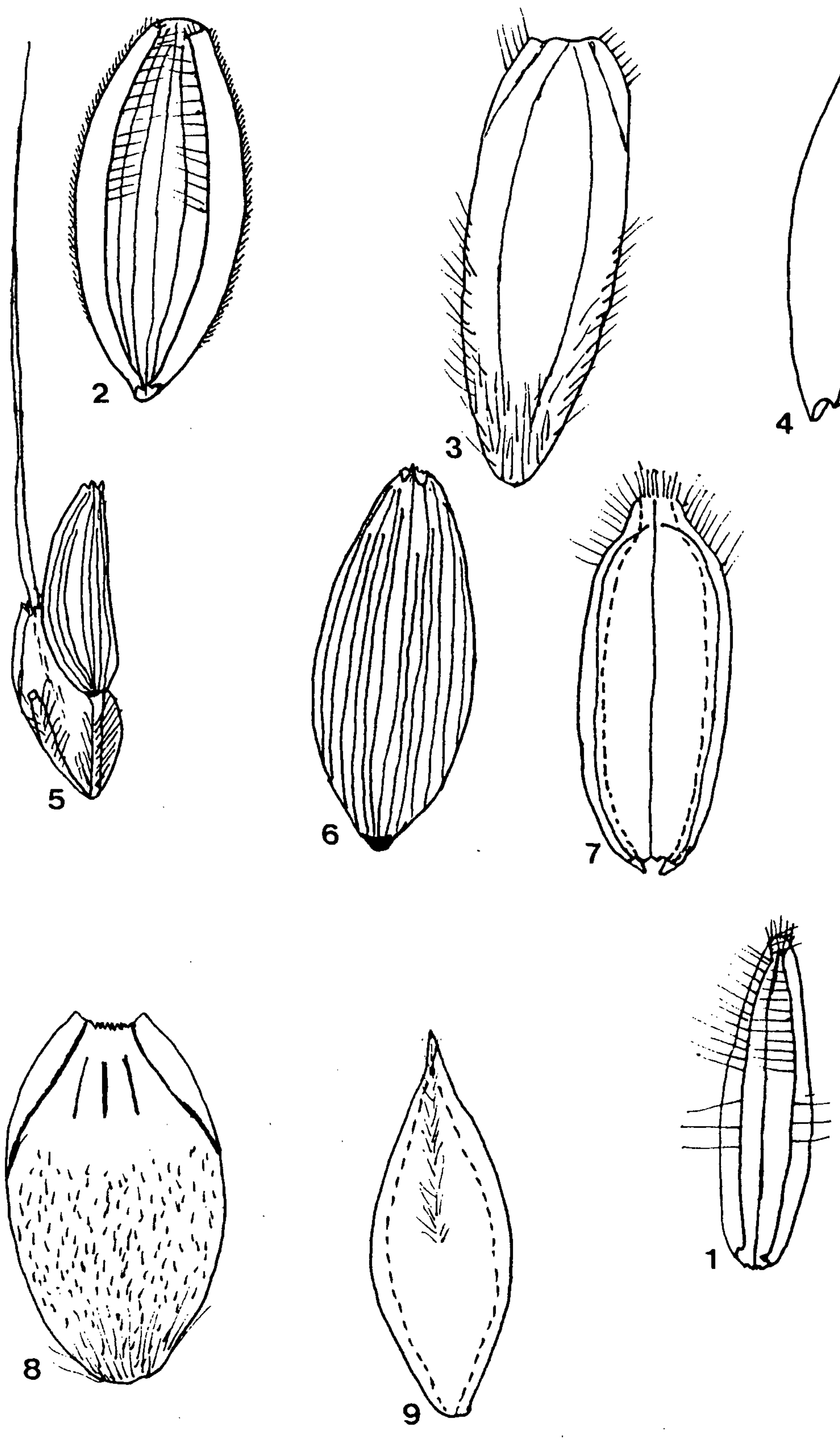


Figure 4.8 ***Euclasta oligantha*****.** Pedicellate spikelet: 1. Upper glume (x20). 2. Lower glume (x20). Sessile spikelet: 3. Lower glume (x40). 4. Upper glume (x30). ***Euclasta clarkei*****.** 5. Spikelet pair (x20). Pedicellate spikelet: 6. Lower glume (x45). 7. Upper glume (x45). Sessile spikelet : 8. Lower glume (x45). 9. Upper glume (x45).

Figure 4.9 ***Vetiveria nigritana***. 1. Spikelet pair (x15). Sessile spikelet: 2. Lower glume (x15). 3. Upper glume (x20). 4. Upper lemma (x20). 5. Ovary (x20). Pedicellate spikelet: 6. Lower glume (x20). 7. Upper glume (x20). ***Vetiveria zizanioides***. Sessile spikelet: 8. Upper lemma (x45).

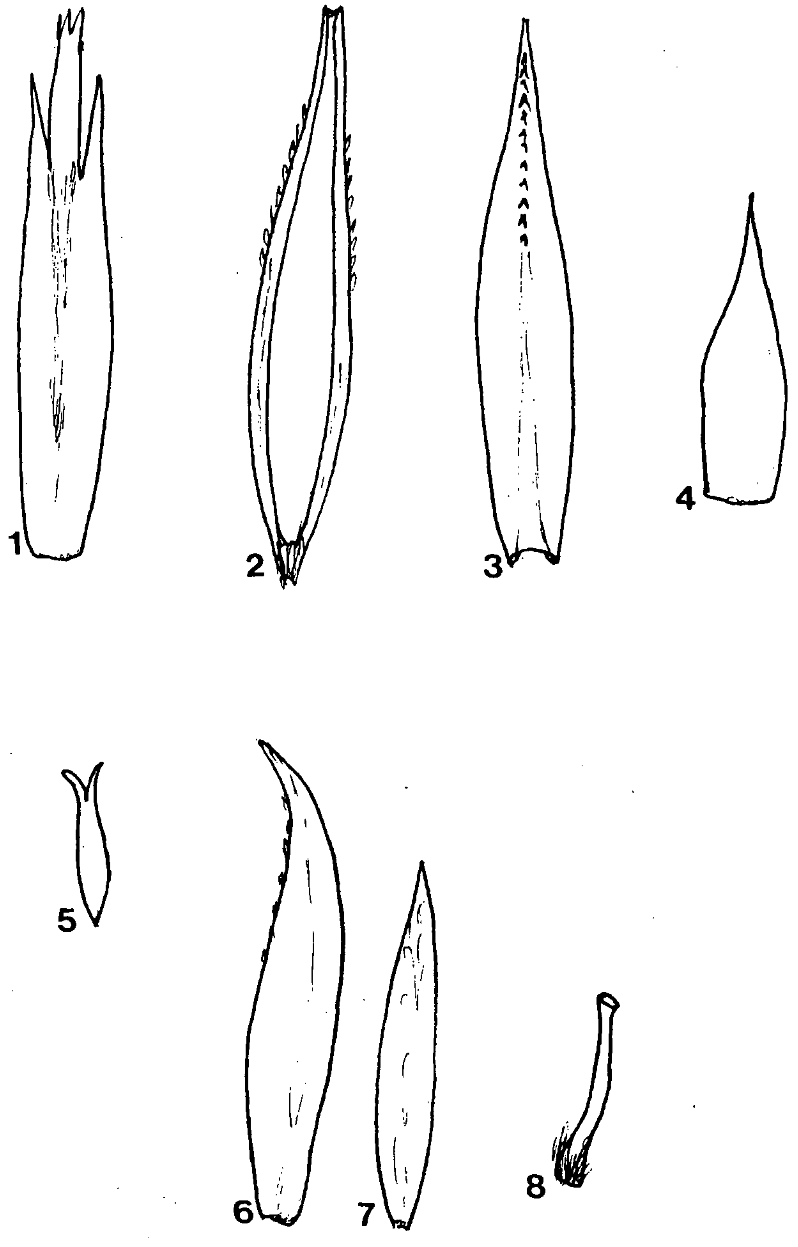


Figure 4.10 ***Hemisorghum venustum***. Sessile spikelet: 1. Bilobed upper lemma (x35). 2. Lower glume (x35). 3. Upper glume (x35). 4. Lower lemma (x35). 5. Caryopsis (x35). Pedicellate spikelet: 6. Lower glume (x35). 7. Upper glume (x35). 8. Pedicel (x35).

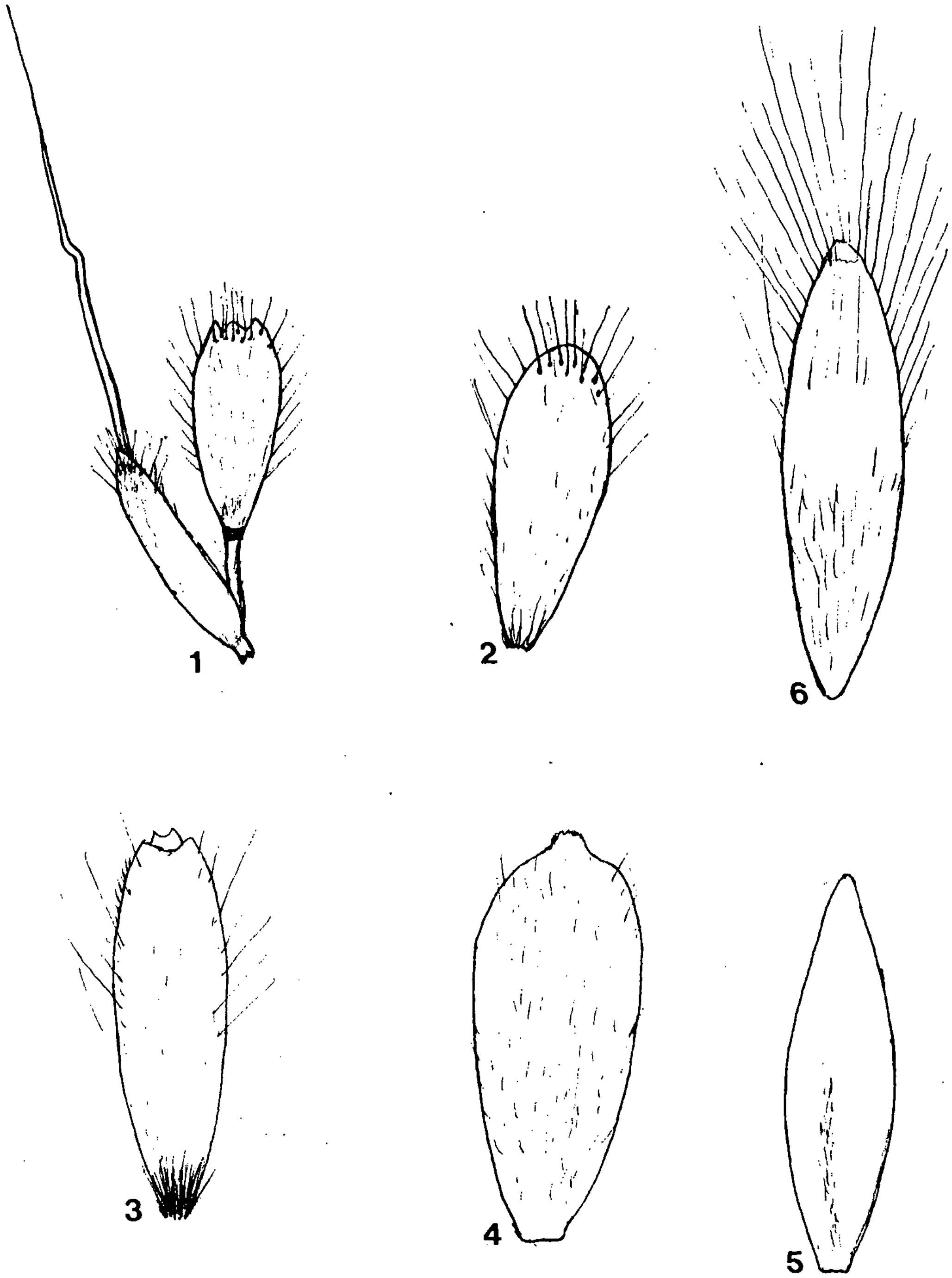


Figure 4.11 ***Dichanthium annulatum*** var. ***papillosum***. 1. Spikelet pair (x30). Sessile spikelet: 2. Lower glume (x30). ***Dichanthium annulatum*** var. ***annulatum***. Sessile spikelet: 3. Lower glume (x30). ***Dichanthium aristatum***. Sessile spikelet: 4. Lower glume (x30). 5. Upper glume (x30). ***Dichanthium sericeum***. Sessile spikelet: 6. Lower glume (x13).

Chapter 5. Micromorphological studies by Scanning Electron Microscope (SEM).

5.1. Introduction.

Features observable only with the electron microscope provide useful characters. The SEM provides an image of unequalled depth of field which is ideal for comparative studies. Even though the technique usually uncovers relatively few new characters, it has however enabled the rapid, recordable and comparative study of a great many micromorphological features, that have become realistic and practicable as standard taxonomic characters (Stace, 1989). This technique was used to glean for characters of the glume.

5.2. Materials and Methods.

Whole glumes from herbarium specimens were mounted on aluminium stubs using a double sided adhesive tape. These were positioned and duly labelled for identification purposes. For those specimens sticking out from the surface, a silver conductive paint (Electrodag 915, Acheson colloids, Plymouth) was used to create an electrical connection between the specimen and the stub surface. The specimens were then sputter-coated with gold and viewed using a Stereoscan S250 MK1 Scanning Electron Microscope (Leica UK Ltd, Cambridge, UK) at an accelerating voltage of 5-25kv. Electron micrographs were recorded on Ilford FP4 and Kodak TMAX 100 120 film.

5.3. Glume pit(s) in the grass genera *Bothriochloa* Kuntze and *Dichanthium* Willemet.

5.3.1. Introduction.

Some species of the genera *Bothriochloa* and *Dichanthium* show a tendency for pitting. Their species, in common with others of the subtribe, posses digitate or subdigitate inflorescence with spikelets borne in pairs, one pedicellate and the other sessile. The inflorescence consists of racemes with the spikelet pairs arranged distichously along the rachis, terminating in a triplet of two pedicellate spikelets and one sessile spikelet. Both the pedicellate and the sessile spikelets have two glumes, the lower and the upper. The pedicellate spikelet is either male or neuter (in which case it is represented by two empty glumes). The sessile spikelet has two florets: the lower is represented by an empty lemma; the upper is bisexual and fertile, thus being the only functional floret in the nodal group. The anther number ranges between 1 and 3.

5.3.2. Glume pits.

The lower glumes of some genera of *Andropogoneae* are crustaceous and are sculptured, grooved, wrinkled, pitted or provided with appendages for which it is hard to find a purpose. *Bothriochloa* and *Dichanthium* have some members characterised by the presence of a glandular depression or pit in the middle or upper portion of the lower glume of either the sessile spikelet and or the pedicellate one (Table 5.2). The significance of the glume pit has always been something of an enigma to people who have worked with these genera. It seems hardly reasonable for a feature so conspicuous and unusual to be without a function of some sort. Two other genera of the tribe *Andropogoneae* said to have glume pits are *Kerriochloa* C.E. Hubbard (subtribe *Ischaeminae*) and *Anadelphia* Hack. (subtribe *Anthistriinae*) (Clayton & Renvoize, 1986). Five other genera in the *Andropogoneae* (Table 5.1) have lower glumes of the sessile spikelet which can be described as lacunose with deep depressions (Figure 5.1, *H. granularis* and *O. exaltatus*). These are however not in any way similar to the glume pits of *Bothriochloa* and *Dichanthium*. These are just shallow superficial sculptures which do not have any corresponding markings on the inner side of the glume.

Table 5.1. *Andropogoneae* genera with pitted and lacunose lower glumes.

Genus	Subtribe	Description of lower glume of sessile spikelet
Bothriochloa Kuntze	*Sorghinae*	Two-keeled; convex to flattened on the back; with or without a conspicuous pit.
Dichanthium Willemet	*Sorghinae*	Two keeled; convex to flattened on the back; with or without a conspicuous pit.
Glyphochloa W. D. Clayton*	*Rottboelliinae*	Two-keeled; convex on the back; lacunose with deep depressions, or rugose, or tuberculate or prickly.
Hackelochloa Kuntze*	*Rottboelliinae*	Not two-keeled; convex on the back; lacunose with deep depressions.
Heteropholis C. E Hubbard*	*Rottboelliinae*	Not two-keeled; convex on the back; lacunose with deep depressions or rugose (transversely).
Kerriochloa C .E. Hubbard*	*Ischaeminae*	Not two-keeled; convex on the back; with a conspicuous pit; relatively smooth.
Ophiuros Gaertn.f.	*Rottboelliinae*	Not two-keeled; convex to flattened on the back; lacunose with deep depressions, or rugose (with a basal transverse groove).
Anadelphia Hack.*	*Anthistriinae*	Convex to flattened on the back; with a conspicuous pit (at the base, at least in *A. afzeliana* and *A. hamata*); relatively smooth.
Ratzeburgia Kunth.*	*Rottboelliinae*	Two-keeled; lacunose with deep depressions (5-6 rows of pits).

* - From Clayton & Renvoize (1986).

Table 5.2. *Bothriochloa* and *Dichanthium* species with glume pits.

Species	Pit on sessile spikelet (always single)	Pit on pedicellate spikelet (1 to 4 pits)
**Bothriochloa alta* (Hitchcock) Henrard	p	a
Bothriochloa macera S. T. Blake	p	a
**Bothriochloa barbinodis* (Lag.) Herter	p	a
Bothriochloa bladhii (Retz.) S.T. Blake	p	a
Bothriochloa decipiens (Hack.) C. E. Hubbard	p	a
**Bothriochloa edwardsiana* (Gould) L. Parodi	p	a
**Bothriochloa ewartiana* (Domin) C. E. Hubbard	p	a
Bothriochloa bladhii (Roxb.) A. Camus *subsp. glabra* Simon	p	a
**Bothriochloa hybrida* (Gould) Gould	p	a
Bothriochloa insculpta (Hochst.) A. Camus	p	p(1 to 4)
Bothriochloa kuntzeana (Hack.) Henrard	p	p
**Bothriochloa palmeri* (Nash) Pilger	p	a
Bothriochloa pertusa (Willd.) A. Camus	p	a
**Bothriochloa springfieldii* (Gould) L. Parodi	p	a
**Bothriochloa wrightii* (Hack.) Henrard	p	a
**Dichanthium armatum* Blatter & McCann	p	a
Dichanthium foveolatum (Delile) Roberty	p	a
Dichanthium micranthum T. A. Cope	p	a
**Dichanthium panchganiense* Blatter & McCann	p	p

*- The asterisk indicate that these species were not observed in this study but the information used was obtained from the literature.

p - present; a - absent

Figure 5.1. Glume surface characteristics.

A. *Hackelochloa porifera*, outer surface of glume. This shows the outer surface with lacunose deep depressions.

B. *Hackelochloa porifera*, inner surface of glume, smooth.

C. *Ophiuros exaltatus*, outer surface of glume with shallow depressions.

D. *Ophiuros exaltatus*, inner surface of glume, smooth.

5.3.3. Role of the glume pit in cleistogamy.

Heslop-Harrison (1961) carried out a study to find out the function of the glume pit in *Bothriochloa decipiens* (Hack.) C. E. Hubbard. *B. decipiens* has a single anther, which is an adaptation associated with cleistogamy. His main conclusion was that the glume pit played a role in the mechanism of cleistogamy (fertilisation in an unopened flower) in this species. Its function is that of an obturator, preventing the emergence of the single anther from the floret and ensuring its dehiscence in contact with the stigmas in all florets where the glumes do not open normally at anthesis. In a young floret, before pollination, the boss of the glume pit (on the inner side of the glume), depresses the lemma between the two branches of the stigma, lying just above the level of the tip of the immature anther. Should the glumes fail to open when anthesis would normally occur, emergence of the stigmas is prevented by their engagement upon the depressed lemma below the boss. As the filament of the stamen extends, the anther is then driven hard up against the boss, and internal dehiscence takes place at the tip in contact with the stigmas. This correlates quite well with the fact that in all pitted species, there is always a pit on the lower glume of the sessile fertile spikelet, hence its association with anthesis and pollination. This argument, however, loses credibility when considering the fact that glume pits do also occur on the lower glume of the pedicellate male spikelet.

This function of the glume pit depends on the opening of the glumes of the spikelet, which in turn is influenced by various environmental factors. Therefore should the glumes open at the maturation of the floret, normal chasmogamous anthesis is possible, since there is no barrier to the exsertion of either stigma or anther.

Also of significance is the depth of the glume pit, hence the extension of the complementary boss on the inner side of the glume. The glume pit varies in size , shape and depth in the species observed. It can be round and small, as in *Bothriochloa pertusa,* big and deep, as in *B. macera,* or slit-like and shallow, as in *B. kuntzeana.* One would therefore assume that the involvement of the glume pit in cleistogamy in the various situations would differ. Heslop-Harrison (1961) concluded that facultative cleistogamy was a common feature in tropical and subtropical *Andropogoneae*. There are some plants that are irregularly pitted on different plants or even different parts of the same panicle. Detailed studies are needed to determine whether there is any correlation between pit development, breeding behaviour and environmental control factors.

5.3.4. Use of the glume pit as a taxonomic character.

Gould (1959) used the glume pit as a marker character for tracing relationships of Old World and New World taxa of the genus *Bothriochloa*, and found it to be a reliable character when properly used. De Wet and Higgins (1963) however found it highly unreliable. Chippindall (1955) found it difficult to separate *B. insculpta* from *B. pertusa* on the basis of the presence of the glume pit. Both species always have a single pit on the lower glume of the sessile spikelet. *B. insculpta* has, in addition 1 to 4 pits on the pedicellate spikelet (Figure 5.2B). Also the lower glume of the sessile spikelet in *B. insculpta* is glabrous on the back while it is hairy in *B. pertusa*. There are however those specimens that have a single pit on both lower glumes (sessile and pedicellate (making them likely to be *B. insculpta*)), and have the lower glumes of the sessile spikelet hairy (making them *B. pertusa*). This illustrates the inadequacy of overweighting a single character. I found the glume pit, as a taxonomic character, quite limited, except when used at generic level. The occurrence of glume pits is variable in a single inflorescence and between specimens of the same species.

Figure 5.2. Glume surface characteristics.

A. *Bothriochloa insculpta*, lower glume of sessile spikelet with a single pit above the centre of the glume.

B. *Bothriochloa insculpta*, lower glume of pedicellate spikelet with four slit-like and shallow pits along the middle of the glume.

C. *Dichanthium micranthum*, lower glume of sessile spikelet with a shallow pit at the centre of the glume.

D. *Dichanthium foveolatum*, lower glume of sessile spikelet with a deep pit at the centre of the glume.

Figure 5.3. Glume surface characteristics.

A. *Bothriochloa pertusa*, lower glume of sessile spikelet with a deep pit just above the centre of the glume. Note the long hairs from the glume base and callus.

B. *Bothriochloa pertusa*, close up of glume pit.

C. *Bothriochloa edwardsiana*, lower glume of sessile spikelet, inner boss.

D. *Bothriochloa bladhii*, lower glume of sessile spikelet with a deep pit just above the centre of the glume.


1MM
7.0KV
00
022
S

A


40PM
7.0KV
09
040
S

B


400PM
7.5KV
05
005
S

C


400PM
7.0KV
01
025
S

D

Chapter 6. Anatomical investigation of the leaf blade.

6.1. Introduction.

Leaf anatomical data has been of considerable use in grass taxonomy. Structurally the grass leaf is a complex organ, exhibiting a wide range of anatomical features and providing valuable additional taxonomic information (Ellis, 1986). Leaf characters rank second to those of flowers and fruits in their use in taxonomic studies. They however are strictly comparable over a wider range (all vascular plants) than are those of floral organs. A diversity of cells and tissues, their arrangement and positions in the leaf blade, provide a pool of characters and character states of high potential. These cell patterns are characteristic of a species and often diagnostic of genera and tribes (Stebbins, 1956). These basic differences in leaf anatomy have facilitated a compilation of anatomical diagnosis (Renvoize, 1981; Watson, et al., 1985).

It was the pioneering work of Duval-Jouve (1875) that set the pace for the use of leaf anatomical characters in grass systematics. Later emphasis was mainly geared towards the structural and functional relationships of the grass leaf, particularly the correlation of C4 photosynthetic pathway with Kranz anatomy, and the C3 photosynthetic pathway with non-Kranz anatomy. This resulted in several new systems of higher classification of the Gramineae. Leaf anatomical data from the study has revealed that the grasses of the subtribe *Sorghinae* are of C4 physiology. Taxonomically useful leaf anatomical attributes of the Gramineae have been comprehensively defined and illustrated by several authors (Ellis, 1976, 1979; Clifford and Watson, 1977; Watson and Dallwitz, 1980) basing most of their interpretations on the work of Metcalfe (1960). Ellis (1976, 1979) has made a useful contribution by attempting to standardise and stabilise grass anatomical terminology so far employed by all previous authors (and see Rahman, 1988).

6.2. Materials and Methods.

Leaf blades from herbarium and living specimens (grown in greenhouses), were used for the anatomical investigations. Healthy looking leaves from recent collections were used. An attempt was made to sample at least one species from each genus. This was however not possible because of the unavailability of suitable representative material. The sample therefore consisted of the following species: *Chrysopogon fulvus*, *C. gryllus* subsp. *echinulatus*, *C. orientalis*, *Capillipedium parviflorum*, *Dichanthium micranthum*, *Sorghastrum friesii*, *Sorghum halepense*, *S. versicolor*, and *Vetiveria nemoralis*.

6.2.1. Preparation.

Leaves were softened by gently boiling them in water in a water bath until they reverted to their natural shape. This was checked every 5 minutes, and in most instances took 20 to 30 minutes The boiled leaves were then put in Formalin Acetic Alcohol (F.A.A.) solution in labelled 20ml vials for at least two days.

6.2.2. Rinsing.

Two to three segments of about 5mm long were cut from the middle part of the lamina using a pair of scissors. The remainder of the leaf was placed back in the F.A.A. vials to store indefinitely. The segments were then washed in cold water in separate labelled vials, with occasional shaking by hand. Several changes of water were made to remove the F.A.A.

6.2.3. Dehydration.

The dehydration procedure follows that of Johansen (1940). The rinsed segments were put through a graded series of alcohols as follows:

10% alcohol	1 1/2 hours
20% alcohol	1 1/2 hours
30% alcohol	1 1/2 hours
50% alcohol	1 1/2 hours
70% alcohol	2 hours
Johansen solution 1	2 hours
Johansen solution 2	2 hours
Johansen solution 3	2 hours
Johansen solution 4	2 hours
Johansen solution 5	2 hours
Tertiarybutylalcohol (TBA)	2 hours: followed by 2 changes - one overnight.

The time limits are only indications. The material was however not allowed to stay for too long in any of the alcohol solutions weaker than 50%, otherwise it could be left overnight at any of the other stages, and the series continued the following morning.

6.2.4. Infiltration.

The infiltration method used follows that of Purvis, Collier and Wallis (1964). After the last dehydration stage, the segments were put in a mixture of equal parts liquid paraffin and tertiarybutylalcohol (TBA) for 6 hours. A specimen bottle was then filled two thirds full of melted wax and allowed to solidify but not completely harden. The segments were then covered with the mixture of TBA and liquid paraffin. The bottle was then placed on the embedding bath and the segments left to infiltrate slowly as they sank down the wax. They were left for about 1 hour after they had sunk to the bottom of the bottle. Two changes of pure wax were then made before embedding.

6.2.5. Embedding.

Brass embedding frames and plates were used. The leaf segments were poured into the embedding frames, arranged properly with a hot needle, and the whole mass cooled quickly in an ice bath. It is necessary to cool the wax quickly because otherwise it crystallises: the blocks become full of fluffy white spots and patches, and this makes the wax difficult to microtome. Finished wax blocks were then labelled, and ready for sectioning.

6.2.6. Sectioning.

A rotary microtome (3880/A296) was used for cutting the sections. The blade was inclined at 16°, and sections of 15μm cut.

6.2.7. Mounting Ribbons.

The ribbons were placed on a drop of water on a slide smeared with glycerine albumen. More drops of water were added to have the ribbons floating freely. Excess water was drained off using absorbent tissue paper, leaving the ribbons flat on the slide, and these were positioned using a needle. The slide was then put on a slide warmer (20°C) for at least 2 days. Duplicate slides of each species were made.

6.2.8. De-waxing.

Slides were removed from the slide warmer, and taken through a de-waxing series as follows :

1. Xylene	30 minutes
2. Xylene	15 minutes
3. Xylene + absolute alcohol	10 minutes

4. Absolute alcohol	10 minutes
5. Absolute alcohol	10 minutes

The slides were then transferred to safranin and left for 24 hours

6.2.9. Staining.

The steps in staining follow on from the de-waxing series:

6. Safranin	24 hours
7. Absolute alcohol	5 minutes
8. Absolute alcohol	10 minutes
9. Absolute alcohol	10 minutes
10. Fast green	5-20 seconds
11. Absolute alcohol	10 seconds
12. Absolute alcohol	10 seconds
13. Absolute alcohol	5 seconds

6.2.10. Mounting.

Permanent slides were then prepared by mounting the sections in Euparal and covering them with Chance cover slips. The slides were then put on a slide warmer at 45°C for at least 2 days.

6.2.11. Cleaning slides.

After the Euparal had dried completely, any excess that had oozed out from underneath the cover slips, was scraped away with a razor blade. The slide was then wiped with a tissue paper soaked in absolute alcohol.

6.3. Evaluation of characters observed.

6.3.1. Outline of leaf lamina in transverse section.

The outline of the cross section of the leaves of most of the species observed for this exercise is V-shaped. The two lateral halves of the lamina fold adaxially towards each other with the midrib or keel forming the bottom of the V(Figures 6.1B, 6.2, 6.3 & 6.4A, B, C). There is however one species, *Sorghum halepense* (Figure 6.1A), which has an inrolled leaf and does not have a conspicuous midrib. The two leaf surfaces, abaxial and adaxial, can either have ribs and furrows or none at all. The ribs correspond to the leaf veins while the furrows are the spaces between the veins. The furrows are sometimes referred to as the intercostal zones. In instances where these occur, they are mostly found on the adaxial surface. There is somewhat a correlation between the presence of ribs and furrows with that of bulliform cells. The distribution of the bulliform cells is related to the manner in which the leaf is folded. The capacity for leaves with marked adaxial ribs to roll is a character that seems to have arisen as a response to ecological conditions, and for this reason leaves of this type are to be found in grasses between which there are no close taxonomic affinities (Metcalfe, 1960).

6.3.2. Epidermis.

The cells of the two epidermal layers differ. The adaxial epidermis is characteristically composed of bulliform cells and short cells, which are shallow above the strands of sub-epidermal sclerenchyma (where present). The abaxial epidermis consists mostly of short cells (tabular in shape), most of which have developed protrusions above the surface to form papillae (Figure 6.5D). All of the species observed had papillae. These were mostly found scattered randomly on the abaxial surface. They do occur on the adaxial surface but with less frequency as on the abaxial one. Macrohairs were observed on *Chrysopogon gryllus* subsp.

echinulatus (Figure 6.4D). Microhairs proved to be rather difficult to observe in these particular sections.

6.3.3. Bulliform cells.

The distribution and arrangement of bulliform cells in the leaf vary in the species observed. In ribbed species, e.g., *Sorghum versicolor*, these cells occupy the furrows (Figures 6.5B & 6.6) or the intercostal zones. Therefore the bulliform cells are found on the adaxial surface. Two bulliform cells' arrangements were recognised:

(i) Bulliform cells found only on the adaxial and or abaxial intercostal zones (furrows) and stopping at the ribs formed by 1st order vascular bundles, e.g., *Sorghum versicolor* (Figure 6.5B & 6.6). These therefore occur over the 2nd and 3rd order vascular bundles.

(ii) Bulliform cells occupying the whole adaxial and or abaxial surface, even over the 1st order vascular bundles over which they are shallow but nonetheless present (Figures 6.2A & 6.3). On *Vetiveria zizanioides*, the bulliform cells are found only at the bottom of the V, in the keel region on the adaxial surface.

The sizes and shapes of the bulliform cells also differ between the species. They can be large and inflated with short tangential walls than the inner lateral ones, e.g., *Chrysopogon orientalis* (Figure 6.5A). They can also be large, but have wavy walls, e.g. *Sorghum versicolor* (Figures 6.5B & 6.6). This happens to be the case in instances where the cells occur in furrows, and when the middle cell of the group is bigger than the remainder.

The significant function of bulliform cells has been argued over for years now. According to one view, the bulliform cells are concerned with the unrolling of developing leaves. Their sudden and rapid expansion during a certain stage of leaf development is assumed to bring about the unfolding of the blade (Esau, 1965). Another concept is that, by changes in turgor, these cells play a role in the hygroscopic opening and closing movements of mature leaves. The presence of these cells in grass leaves would therefore not necessarily indicate a close taxonomic affinity of the grasses concerned.

6.3.4. Vascular bundles.

There are three orders of vascular bundles. The 1st order vascular bundles form the ribs on the adaxial surface of the ribbed species. These alternate with groups of 2nd and 3rd order vascular bundles which are in the intercostal zones. The number and distribution of these were found to be inconsistent.

For species with V-shaped leaves, many vascular bundles are present in the keel and are all adaxially arranged. In such cases the median bundle is indistinguishable from the other 1st order vascular bundles in the rest of the leaf. Also three 1st order bundles and 3 to 4 other smaller bundles comprise the keel. The only exception was *Sorghum halepense* (Figure 6.1A), which has an inrolled lamina, there is no midrib or keel. The same level of positioning for vascular bundles of all orders was observed. All bundles are situated towards the abaxial surface of the blade. The 2nd and 3rd order vascular bundles have a complete bundle sheath, which is entirely parenchymatic and has chloroplasts (Figure 6.5A), while the sheath is incomplete for the 1st order vascular bundles. Sclerenchyma girders are abaxial. They occur on both the abaxial and adaxial sides of the vascular bundles less frequently (Figure 6.3B).

6.4. Discussion.

The degree of infolding or inrolling of the leaf varies with environmental conditions and thus is not of much value diagnostically. However, according to Ellis (1976), leaves of grasses that are fully expanded under optimum conditions invariably exhibit a characteristic type of involution in response to environmental stress. He suggests that it is therefore the nature, and not the degree of the infolding or inrolling that is of importantance taxonomically and diagnostically. Most of the species observed in this sample have a V-shaped leaf, which is a resultant appearance of infolding leaves. This is however not evident enough to support the use of the leaf outline in this sample as being of specific or generic value. The leaf outline has been observed to vary within species and genera, and therefore a sampling procedure should adequately reveal extremes of this variation.

The vascular bundles are usually arranged in a single row embedded at various positions in the mesophyll. The arrangement found in *Sorghinae* grasses, is for all the bundles to be positioned towards the abaxial surface of the blade. Ellis (1976) suggests that the positioning of the vascular bundles in the blade is a useful diagnostic character above genus level. The total number of vascular bundles in a section through a leaf blade is inconsistent. The number varies with the width of the leaf and hence can not be relied upon. The distribution patterns of bundles of different orders, and their variation, have been found to be important diagnostic characters. A formula can be used to describe the pattern of various orders but this will only be useful if a regular pattern of these is present. No pattern was observed in the present investigation. Therefore, no discernible conclusion could be reached for vascular bundle distribution and variation.

All the species observed have a single bundle sheath. Single sheaths are characteristic of panicoid grasses. Structural variations of bundle sheaths are important for diagnostic purposes. The typical single or outer sheath cells are either translucent, without chloroplasts, or they may contain green pigment in plastids similar to, or differing from chloroplasts of chlorenchyma of the mesophyll (Ellis, 1976). However, there is a need to standardise leaf sampling for this kind of character, because older leaves tend to have few or no plastids in bundle sheaths (Percival, 1929). Bundle sheaths of second order vascular bundles of *Chrysopogon orientalis* (Figure 6.5A) were found to contain chloroplasts.

For plants with C4 physiology (Kranz), two types can be distinguished (Brown, 1975, 1977):

(a) PS (Parenchyma Sheath) type. This type is characterised by chlorenchyma which is strongly radiate surrounding bundles of approximately equal size. Both bundle sheaths (inner and outer) are present, but only the outer (parenchyma) sheath forms starch;

(b) MS (Mestome Sheath) type. This type is characterised by irregular or weakly radiate chlorenchyma surrounding bundles of differing size. Only one bundle sheath is present, this forming starch and apparently derived from the mestome sheath (Clayton & Renvoize, 1986).

The *Sorghinae* species are of the MS type. C4 physiological set-up is an advantage in hot climates with some additional advantage if the climate is also dry, but is ineffective or disadvantageous in cool climates and shady habitats (Clayton & Renvoize, 1986). Most grass genera are consistently either C3 or C4, with only four known exceptional genera: *Alloteropsis*, *Eragrostis*, *Neurachne* and *Panicum* (Hattersley & Watson, 1992). Furthermore, most C4 genera are consistently of one biochemical type. There are three known biochemical variants of the C4 acid cycle in grasses. These are the NADP-ME, NAD-ME, and PCK types. The three variants differ in part according to the C4 acid predominantly transported from PCA (Primary Carbon Assimilation, in leaf mesophyll) to PCR (Photosynthetic Carbon Reduction, in leaf chlorenchyma) cells. In the NAD-ME and PCK types, aspartate is the predominant C4 acid that diffuses from PCA to PCR tissue, while in NADP-ME type, it is malate (Hattersley & Watson, 1992). Hattersley & Watson (1992) also indicate that members of the *Sorghinae*, and *Andropogoneae* in general, are of the NADP-ME biochemical type.

Sclerenchyma in the leaf is often associated with vascular bundles, midrib or keel and leaf margins. The sclerenchyma associated with the vascular bundles is in the form of subepidermal longitudinal bands following the course of each vascular bundle. The distribution of these can be correlated with ecological factors. Grasses from arid areas are thus characterised by well developed sclerenchyma tissue while many tropical grasses often have a high proportion of the smaller bundles not accompanied by sclerenchyma (Ellis, 1976). No conclusion can be reached concerning the sclerenchyma of the species in the present sample because of inconsistent ecological data.

Epidermal cells do not always by themselves exhibit any particularly important diagnostic characters. Their examination in section is of assistance in the interpretation of many epidermal structures as seen in surface view. These include the nature of the papillae, the attachment and structure of other epidermal appendages, the positioning of the stomata, or the cuticle form and function. These characters are important taxonomically for comparative studies for a whole range of species.

6.5. Conclusion.

Though it is appreciated that the transverse section of the leaf blade offers a pool of potential characters, I had the problem of not having adequate suitable material to exploit this aspect of taxonomic evidence. The little information that came from the sections made basically confirms results from past investigations (Clayton & Renvoize, 1986; Hattersley & Watson, 1992; Watson & Dallwitz, 1992), that the grasses of the *Sorghinae* are of C4 physiology. Chlorenchyma cells weakly radiate from the vascular bundles, and the cells of the bundle sheath have chloroplasts. A comparative analysis of the leaf blade for a more representative sample of the subtribe might yield useful taxonomic information. The work that was done on the available sample did not indicate any striking taxonomic differences in the leaf anatomy of the different genera. It was decided, reluctantly, not to extend the work but to concentrate on macromorphology.

The following is a legend to abbreviations used in Figures 6.1 - 6.6.

Ab	Abaxial surface
Ad	Adaxial surface
Bc	Bulliform cell(s)
Bs	Bundle sheath
Cc	Chlorenchyma
Cp	Chloroplasts
Cut	Cuticle
Le	Lower epidermal cell(s)
Mac	Macrohair
Mes	Mesophyll
Met	Metaxylem
Pap	Papillae
Ph	Phloem
Prot	Protoxylem
Sb	Silica body
Sc	Sclerenchyma
St	Stomata
Ue	Upper epidermal cell(s)
1st vb	First order vascular bundle
2nd vb	Second order vascular bundle
3rd vb	Third order vascular bundle

Figure 6.1. Transverse section of the leaf blade (Diagrammatic).

The sections show the leaf outline and the distribution and position(s) of the leaf tissues.

A. *Sorghum halepense* (x60).

B. *Vetiveria zizanioides* (x60).

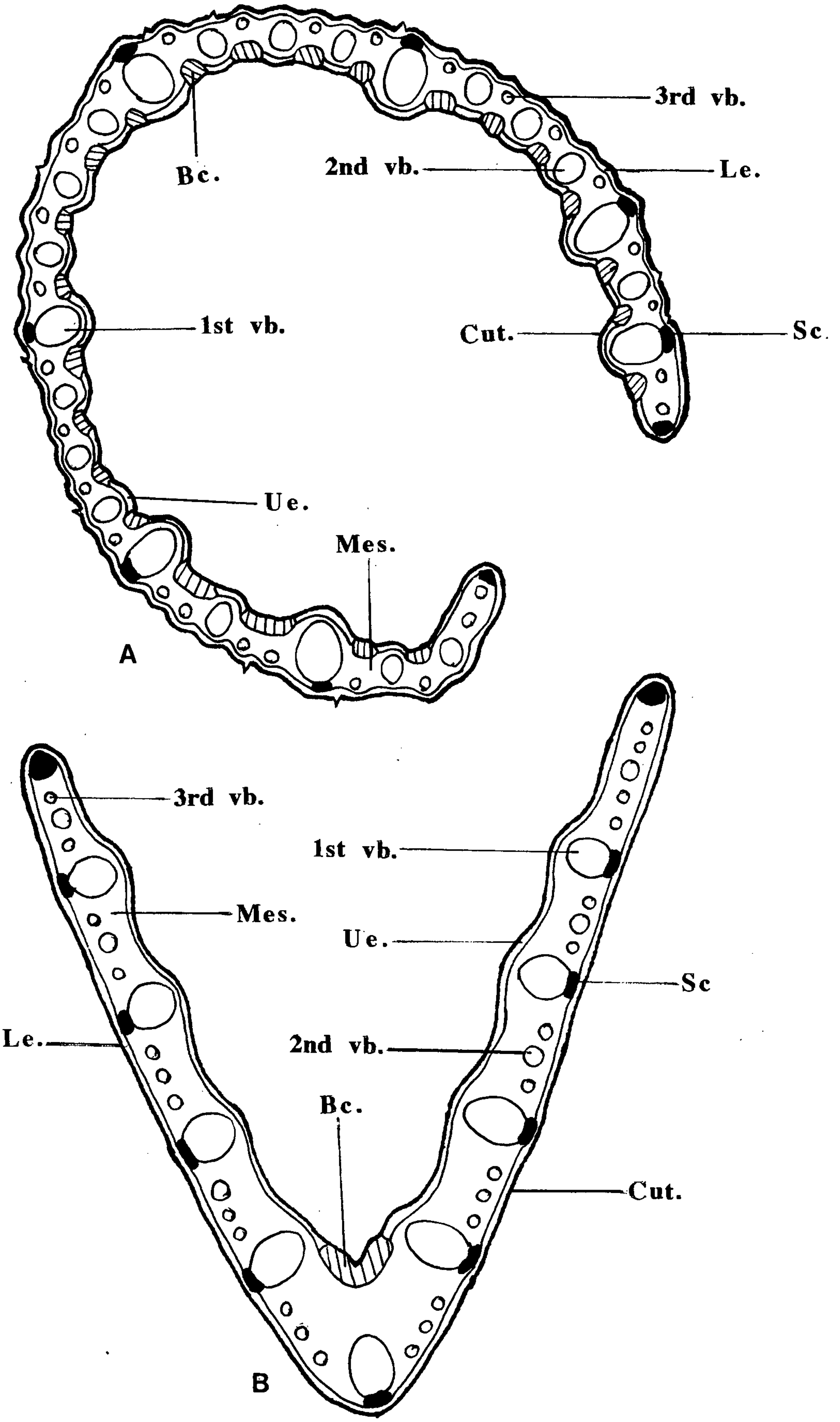

3rd vb.
Bc.
2nd vb.
Le.
1st vb.
Cut.
Sc.
Ue.
Mes.
A
3rd vb.
1st vb.
Mes.
Ue.
Sc
Le.
2nd vb.
Bc.
Cut.
B

Figure 6.1

Figure 6.2. Transverse section of the leaf blade (Diagrammatic).

The sections show the leaf outline and the distribution and position(s) of the leaf tissues.

A. *Chrysopogon fulvus* (x60).

B. *Chrysopogon gryllus* (x60).

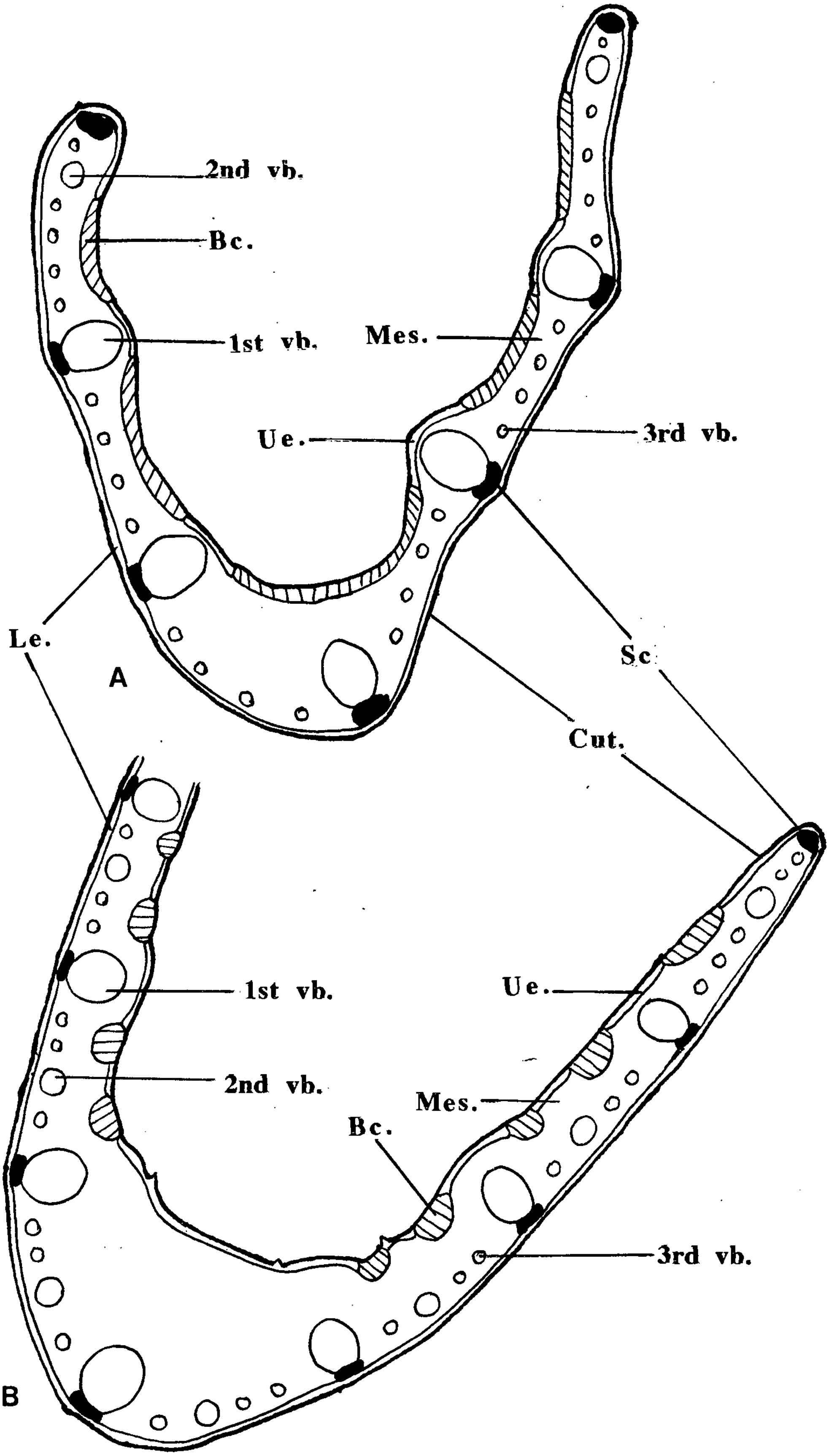

2nd vb.
Bc.
1st vb.
Mes.
Ue.
3rd vb.
Le.
A
Sc
Cut.
1st vb.
Ue.
2nd vb.
Mes.
Bc.
3rd vb.
B

Figure 6.2

Figure 6.3. Transverse section of the leaf blade (Diagrammatic).

The sections show the leaf outline and the distribution and position(s) of the leaf tissues.

A. *Bothriochloa ischaemum* (x60).

B. *Pseudosorghum fasciculare* (x60).

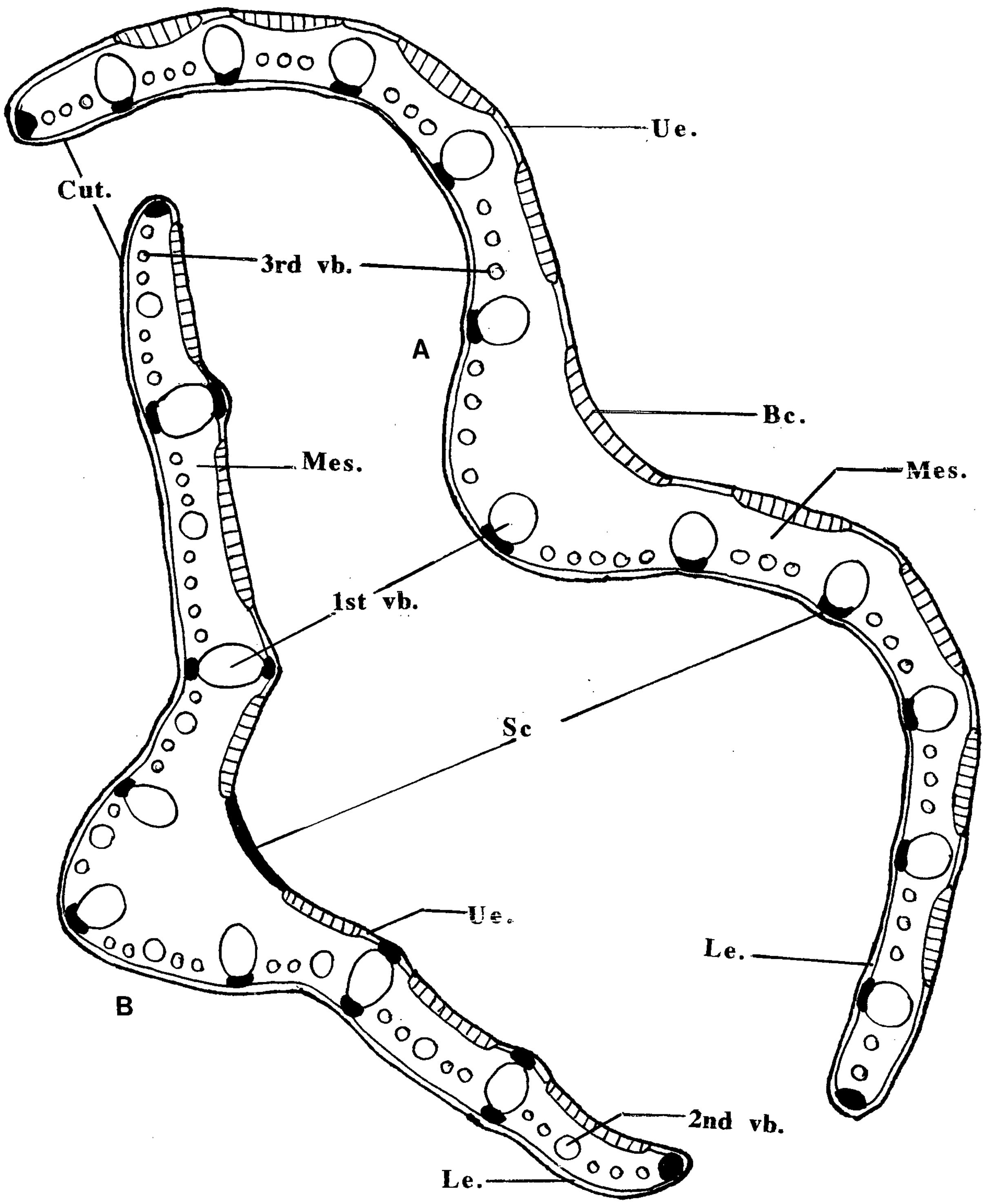


Figure 6.3

Figure 6.4.Transverse section of the leaf blade.

The keel:

A. *Chrysopogon gryllus* subsp. *gryllus* (x10).

B. *Bothriochloa ischaemum* (x10).

C. *Chrysopogon orientalis* (x10).

A macrohair:

D. *Chrysopogon gryllus* subsp. *echinulatus* (x40).

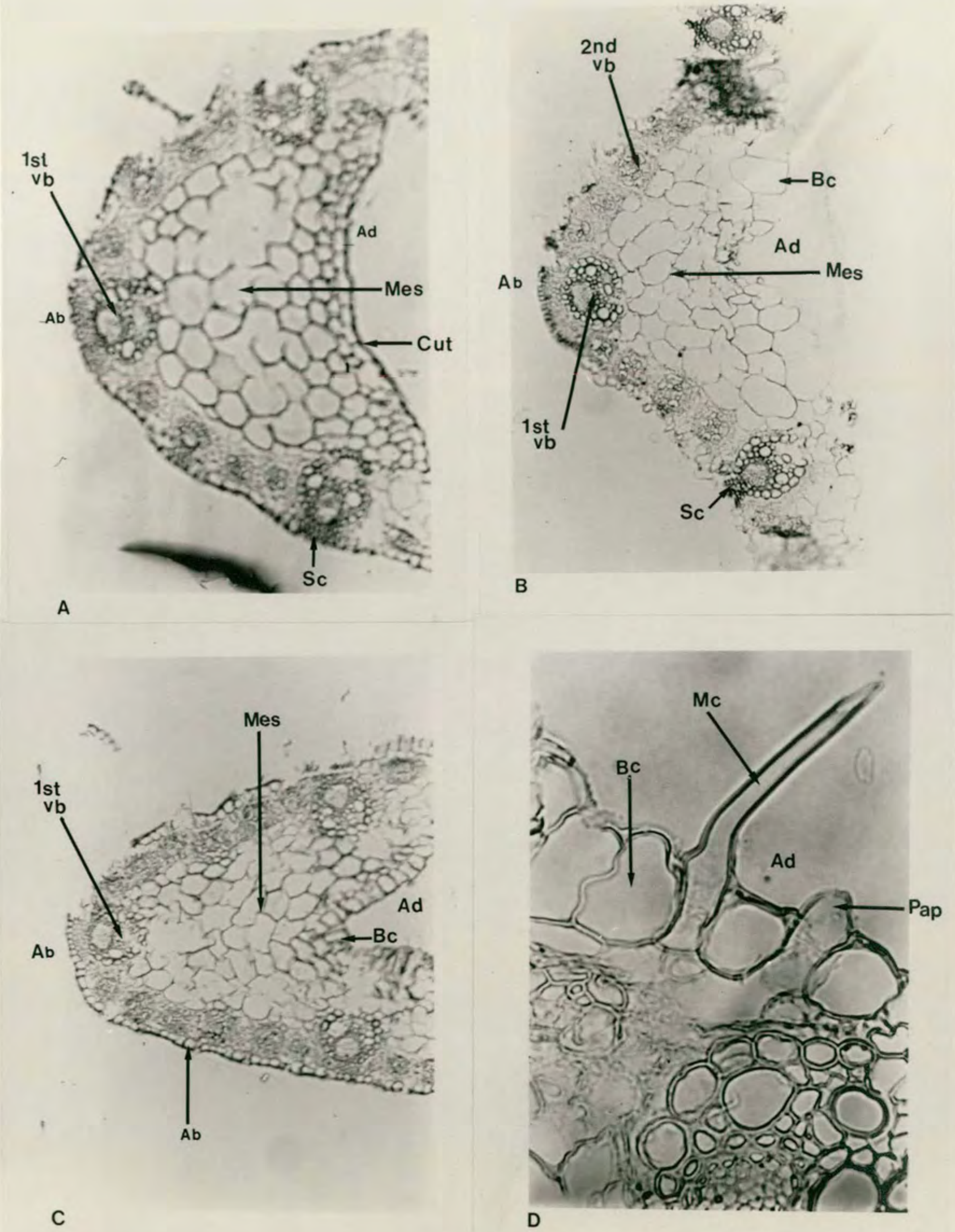

1st
vb
Ad
Mes
Ab
Cut
Sc
A
2nd
vb
Bc
Ad
Mes
Ab
1st
vb
Sc
B
Mes
1st
vb
Ad
Bc
Ab
Ab
C
Mc
Bc
Ad
Pap
D

Figure 6.4

Figure 6.5. Transverse section of the leaf blade.

Bulliform cells on adaxial epidermis: Note the different sizes and shapes of the cells.

A. *Chrysopogon orientalis* (x40). Also shown are the starch containing second order vascular bundles.

B. *Sorghum versicolor* (x40).

C. *Bothriochloa insculpta* (x40).

D. *Pseudodichanthium serrafalcoides* (x40): Note the silica body on top of the vascular bundle on the adaxial surface.

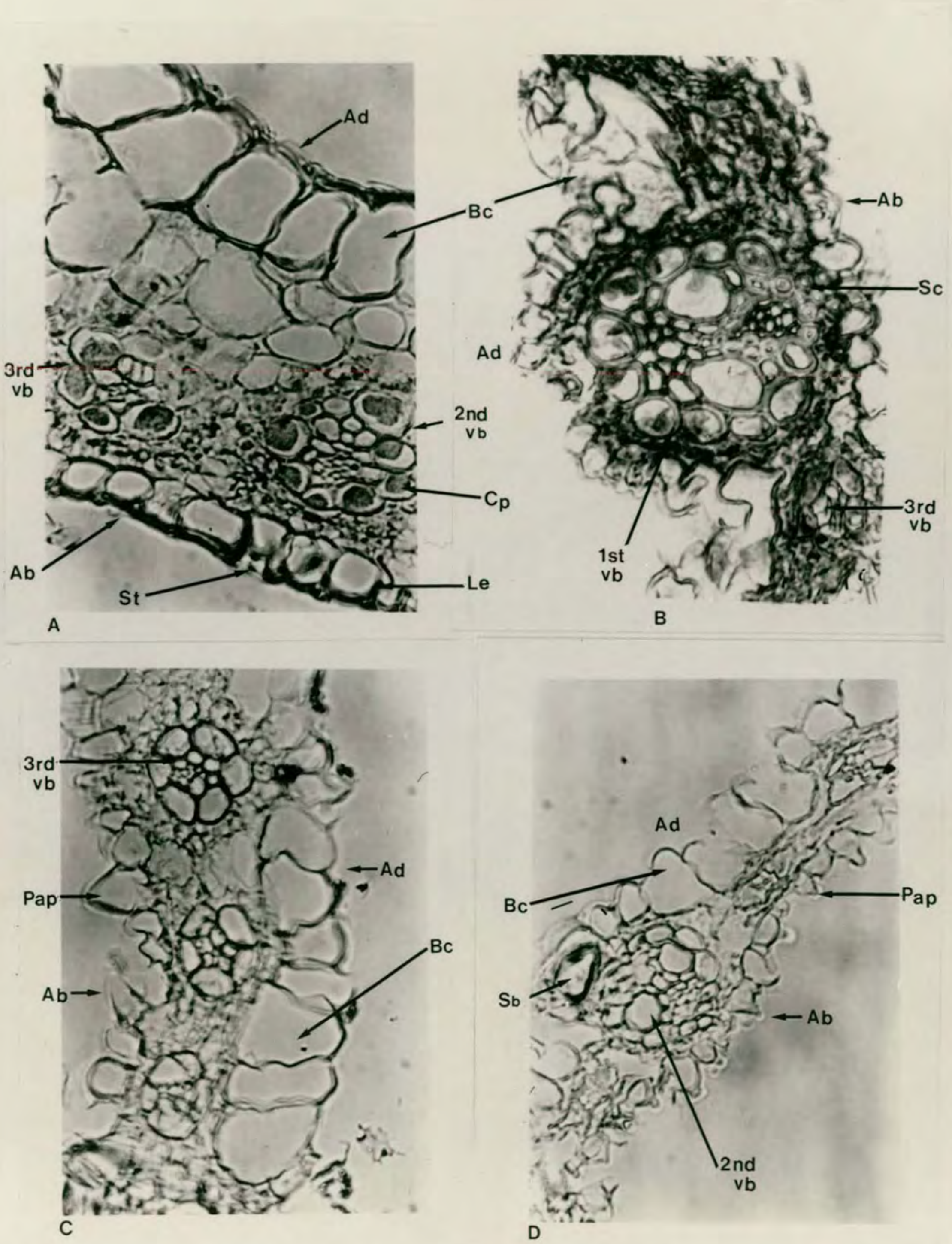

Ad
Bc
3rd vb
2nd vb
Cp
Ab
St
Le
A
Ab
Sc
Ad
3rd vb
1st vb
B
3rd vb
Ad
Pap
Ab
Bc
C
Ad
Bc
Pap
Sb
Ab
2nd vb
D

Figure 6.5

Figure 6.6. *Sorghum versicolor* (x1000). Transverse section of the leaf blade through a First order vascular bundle showing anatomical details.

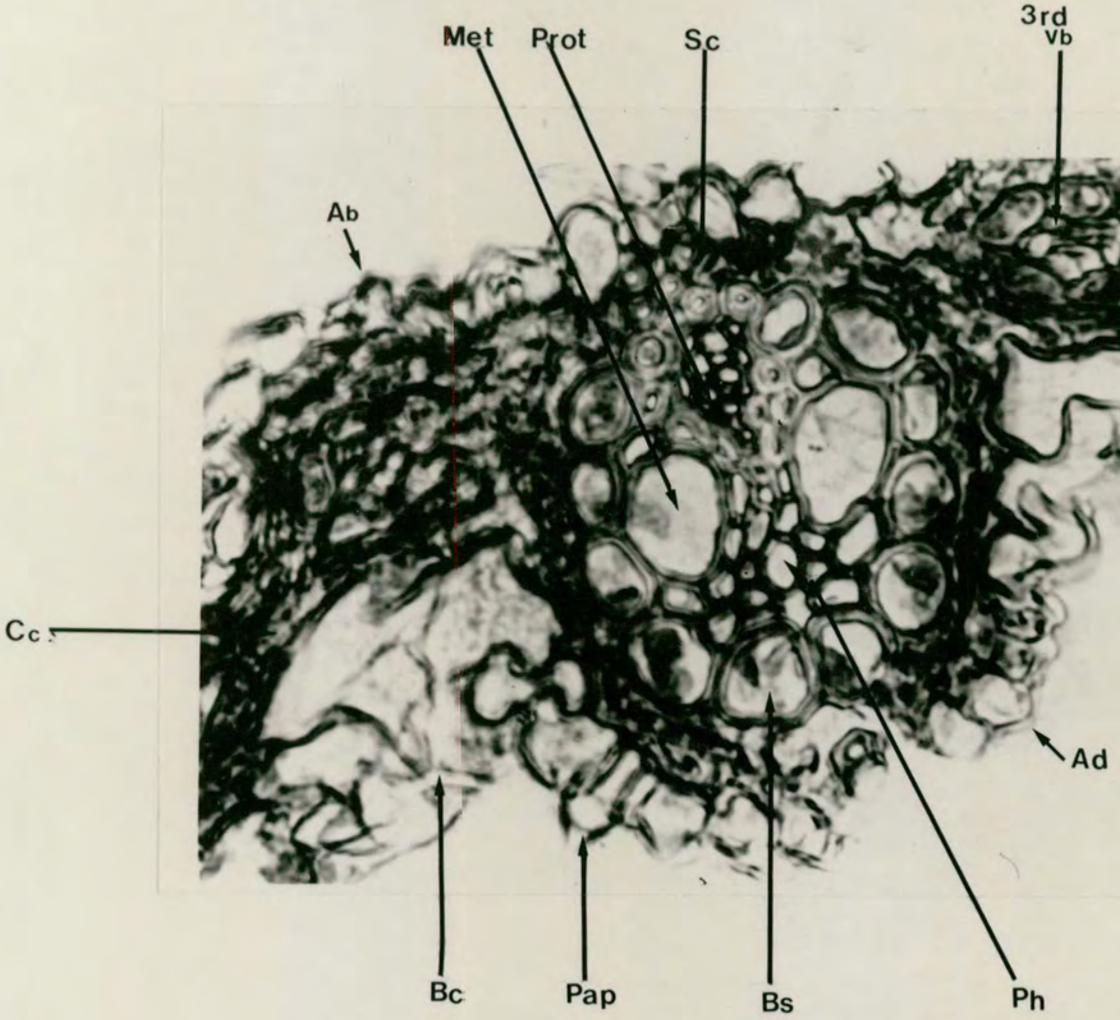


Figure 6.6

Chapter 7. Numeric analysis.

7.1. Introduction.

Modern classifications have their roots in ancient folk taxonomies. These were basically utilitarian in nature and did not serve any special-purpose classifications. They permitted communication about organisms among those individuals who already understood the nature and recognised the features of the organisms being discussed. Classification systems that developed were mainly building on these as additional information became available. These classifications were artificial and established sets of classes on the basis of weighted predetermined characters. Examples include classifications of Cesalpino, Tournefort, Bauhin, and Linnaeus, they differ only in the author's choice of differentiating characters. These were subjective and gave too much weight and hence were biased towards certain characters. It was in the writings and schemes of the de Jussieus, Adanson, de Candolle, and Bentham and Hooker, that the principle of using a multitude of characters for the description of classes gained ground and some credibility. *A priori* interpretation of important characters, the essentialism of Linnaeus, was replaced by *a posteriori* determination (Estes & Tyrl, 1986). Classifications then became a reflection of natural phenomena. Darwin's *The Origin of Species* and a more complete understanding of the theory of natural selection made the most striking impact of evolutionary thought on plant taxonomy, if little practical change followed in systematics. The works of Huxley, Anderson, Stebbins, Clausen, and Grant, provided the intellectual and procedural bases for a new approach (Estes & Tyrl, 1986). The naturalness of taxa could therefore not only be interpreted in terms of overall similarities (phenetic) made possible by the use of a lot of characters, but also from their evolutionary history (phylogeny). Sporne (1948, 1949) and Stebbins (1950, 1951) and in a series of other related papers devised and advocated the use of what Sporne called an advancement index, which was a statistic reflecting the advancement and primitiveness of angiosperm families. Families could, therefore, on the basis of certain characters, be ordered to reflect an evolutionary hierarchy. Views, however, differed on what was to be considered primitive and advanced. Mistakes were undoubtedly made.

The application of experimental techniques to generate and evaluate data resulted in a significant increase in the information upon which classifications could be based. Interpretation of variational patterns therefore became more difficult. Fortunately, there was a corresponding development of techniques for numerical analysis that allowed for simultaneous examination of large numbers of characters. Computers provided an entirely new means of information storage and retrieval and turned the interest of both mathematicians and philosophers towards the problems of classification. The most influential book was undoubtedly that by Sokal & Sneath (1963, and also Sneath & Sokal, 1973), which established numerical taxonomy as an important branch of classification theory and practice. Numerical analysis, though initially associated with phenetics, has also found widespread use in phylogenetic systematics. Computer programmes have been designed which can handle both kinds of data and produce dendograms.

7.2. Phenetics.

The theory of phenetic analysis asserts that natural classifications should be based on overall similarity. This method is critical of character weighting and emphasis on phylogeny in classification. The central thrust of phenetic methods in taxonomy is the objective examination of a suite of characters from an array of individuals in order to determine patterns of variation for both the characters and the organisms. Historically, characters were almost exclusively morphological, but the data base has been expanded to include features from any field of comparative botanical study, such as anatomy, biochemistry, and physiology. These techniques are therefore based on the analysis of the phenotype, which provides an estimate of genetic similarity.

Two general approaches to deriving phenetic estimate of genetic similarity have been used, neural analysis and numerical analysis (Estes & Tyrl, 1986). Neural analysis is the ability to formulate mental groupings on the basis of the totality of features of the examined specimens. It is to some extent dependent on the experience and capability of the individual scientist and hence subjective in that sense. Numerical analysis involves the use of computer-based systems to compare individuals and groups (Operational taxonomic units, OTU's) on the basis of numerous characters and to express the results in more easily interpreted diagrams. Patterns of variation based on scores and even hundreds of characters are compressed with varying degrees of distortion and loss of information into two dimensional branching diagrams (phenograms) that serve as simplified models of overall similarity. In a phenogram, the branching pattern along the vertical axis represents the degree of phenetic relationship (or similarity). The advantages of numerical analysis are that the comparative operations are clearly and rigorously defined and are, therefore, repeatable; complex multidimensional patterns are reduced to easily interpreted diagrams; classifications based on overall similarity exhibit predictive potential; and the resultant classifications are based on observations of the organisms and not on inferred evolutionary lineage. Numerical analysis, however, provides a phenogram that summarises phenetic relationships, it does not provide a classification system. It is therefore for the taxonomist still, to make decisions concerning the circumscription, rank attribution and relationships of any taxa he decides to recognise.

7.2.1. Procedure.

In this study, phenetic similarities were set out at two levels of OTU's. Firstly, they were analysed at species level. This was to see where 'bridging' species between genera would appear in the dendograms. 'Bridging' species are those species whose taxonomic positioning could be with either of the genera involved. Secondly, the similarities were set out at generic level. This was to see whether the genera formed any recognisable clusters within the subtribe. At species level two tests were carried out. Firstly, a totality of all characters were used, i.e., all those characters which were observed and have been accumulated from both herbarium specimens and living plants (Figure 7.1). Secondly, *a posteriori* weighting of characters was carried out and only those characters considered morphologically diagnostic were used (Figure 7.2). Similarly, all characters that could be used to delineate the genera of the subtribe were used to seek phenetic similarities between the genera (Figure 7.3). I did not perform any *a posteriori* weighting in the case of the genera because doing that would reduce the genus definition to something very similar to a species, and hence not be an all-inclusive category.

(i) Character coding: The coding system used in this exercise was DELTA (DEscription Language for TAxonomy) (see Appendix 11.3). This is an official international data standard approved by the Taxonomic Database Working Group. A PANKEY program package was used to perfect the data matrix and produce a similarity coefficient matrix. PANKEY is a computer-based package of programmes that provide specialised tools for diagnosis or identification in biology or medicine (Pankhurst, 1991). The programme accepts variable or polymorphic characters, which means that the OTU can be coded for all its possible character states. One other feature of PANKEY is to generate a matrix of similarity coefficients. It is this matrix of similarity coefficients that is then used for cluster analysis by other statistical packages.

(ii) Cluster analysis: The statistical package used for producing dendograms was NTSYS (Numerical Taxonomy and Multivariate Analysis System) Version 1.70. The matrix of similarity coefficients produced by PANKEY was fed onto NTSYS. The clustering method used was UPGMA (Unweighted Pair-Groups Method using Arithmetic averages). This method produced well-resolved phenograms.

(iii) Results: The dendograms which were produced are as follows:

[NB* - The scales at the top and bottom of the phenograms indicate phenon levels, the percentages of similarity. Therefore the lower the phenon level, the less similar the species or genera]

Test 1: The results of this test are shown in Figure 7.1. The species separate into two main groups at 56.9% similarity. The first group (I) consists of *Asthenochloa* and *Cleistachne* species. This group is characterised by the absence of pedicellate spikelets. The group then divides again at 63.9% similarity. The basis of this separation is the total suppression of the pedicel and pedicellate spikelet in *Cleistachne*. The second group (II) consists of all those species that have pedicels and or pedicellate spikelets. This second group then divides into two (III & IV) at 60.4% similarity on the basis of inflorescence type. Group III consists of all species with either a branched paniculate inflorescence (V) or those with racemose inflorescence (VI) (see Chapter 4 for definitions). Group IV consists of species with simple (unbranched) paniculate inflorescences.

In the whole of the phenogram, species of the same genus cluster at the same position except those of the genera *Bothriochloa*, *Capillipedium* and *Dichanthium*. The species of these genera are interspersed amongst each other and do not form any recognisable clusters. Also the species of the genus *Pseudosorghum* peculiarly clusters with *Euclasta* species.

Test 2: This phenogram (Figure 7.2) was constructed using only those characters that I considered to be diagnostic of the species of the subtribe. The phenogram looks very similar to Figure 7.1. The groups are the same. The only differences are in the phenon levels at which the groups separate and the order of species in the clusters. The phenon levels are lower here. The whole group begins to resolve at 50.9%. Group I separates from the rest at 57.9%. Group II divides at 58.8%. This shows that by removing those characters common to all taxa, makes the taxa less similar. The lower the phenon level at which taxa separate, the less similar the taxa.

Test 3: A totality of all characters were used to construct a phenogram at generic level (Figure 7.3). The subtribe primarily divides into two generic groups (I & II).

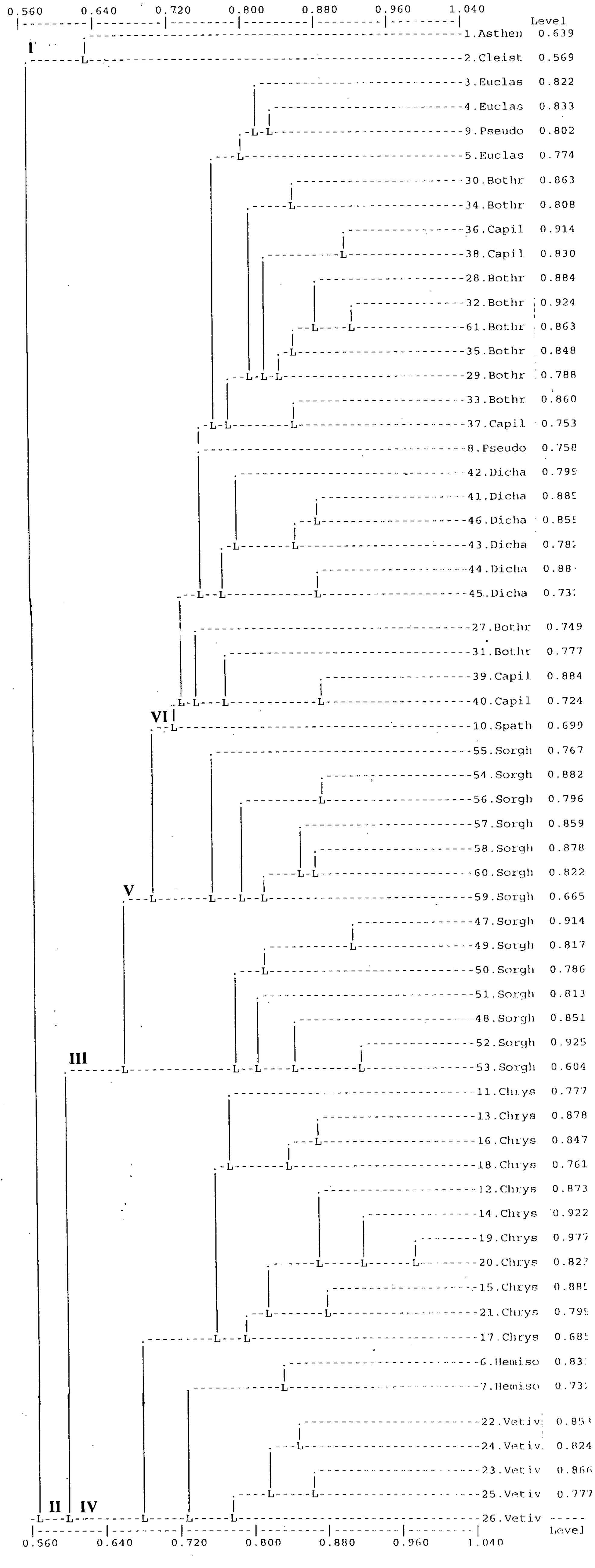
These groups neither correspond to those in Figures 7.1 & 7.2 nor to those I proposed for the subtribe, the *Bothriochloastrae* and *Sorghastrae* (see Chapter 3). *Cleistachne* (II) separates from the other genera at the 38% phenon level. This separation is on the basis of the absence of the pedicellate spikelet. *Asthenochloa* (III) subdivides from the rest of group I at 41% similarity, on the basis of the absence of the pedicellate spikelet and the rudimentary pedicel. Group IV consists of those genera with pedicellate spikelets. This phenogram shows a clear picture of generic associations. The following clusters are recognisable: *Bothriochloa*, *Capillipedium*, *Dichanthium* and *Pseudosorghum*; *Sorghum-Sorghastrum*; *Vetiveria*, *Chrysopogon* and *Hemisorghum*; *Euclasta*, *Pseudodichanthium* and *Spathia*. Similarly, here the genus *Pseudosorghum* clusters with members of the *Bothriochloastrae* and not the *Sorghastrae* as I suggested in generic delimitation of the subtribe (Chapter 3). The generic clusters in the phenogram however reflect morphological similarities and overlaps I referred to in Chapter 3.

7.2.2. Conclusion.

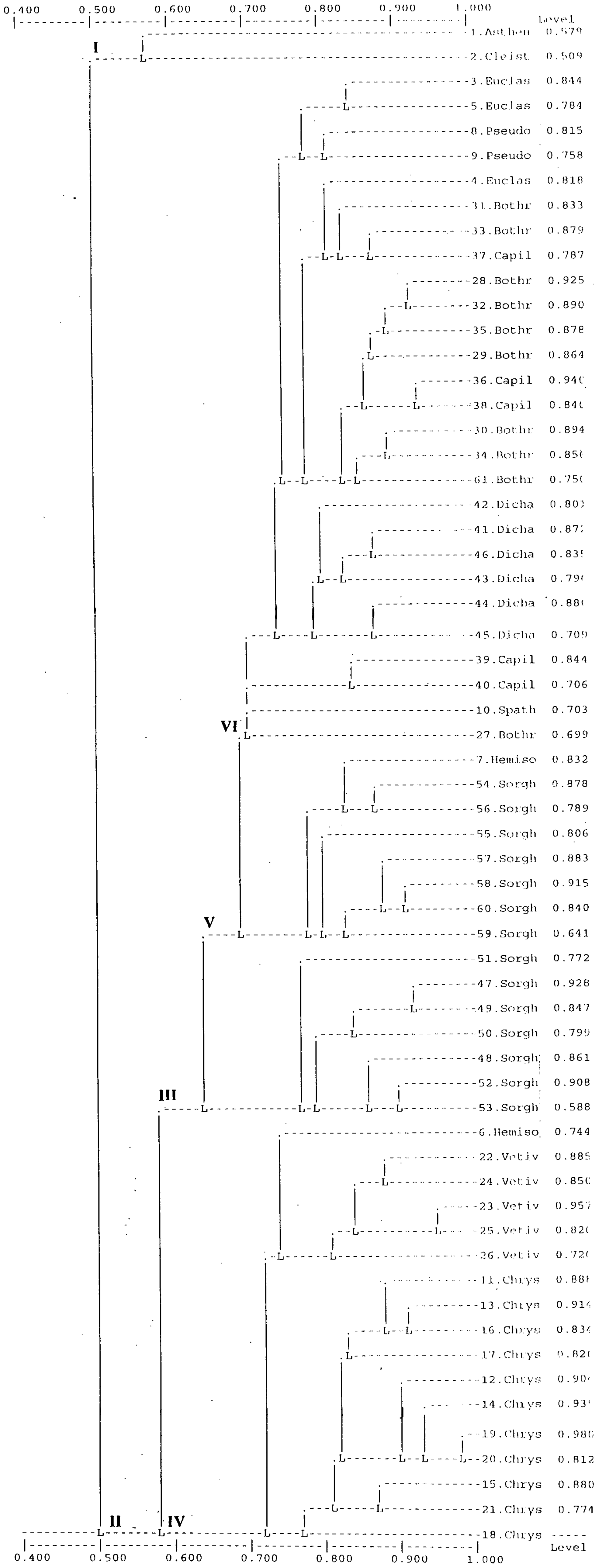
This exercise has been very useful in identifying species complexes (Figures 7.1 & 7.2) and generic groups (Figure 7.3). There are species complexes in the *Sorghinae* which consist of morphologically similar species. These always separate at high phenon levels, e.g., *Chrysopogon fallax*, *C. latifolius* and *C. pallidus*; *Dichanthium micranthum* and *D. foveolatum*, etc.

At generic level, the two main groups do not correspond to my *Bothriochloastrae* and *Sorghastrae* (see Chapter 3). Some of the generic associations that come out of the clustering however correspond to those I suggested in my discussion on generic delimitation in the subtribe (Chapter 3), e.g., *Bothriochloa*, *Capillipedium* and *Dichanthium*; *Chrysopogon* and *Vetiveria*, etc.

Figure 7.1. Phenogram of 61 OTU's when 64 characters are used, based on UPGMA cluster analysis (see text for details).



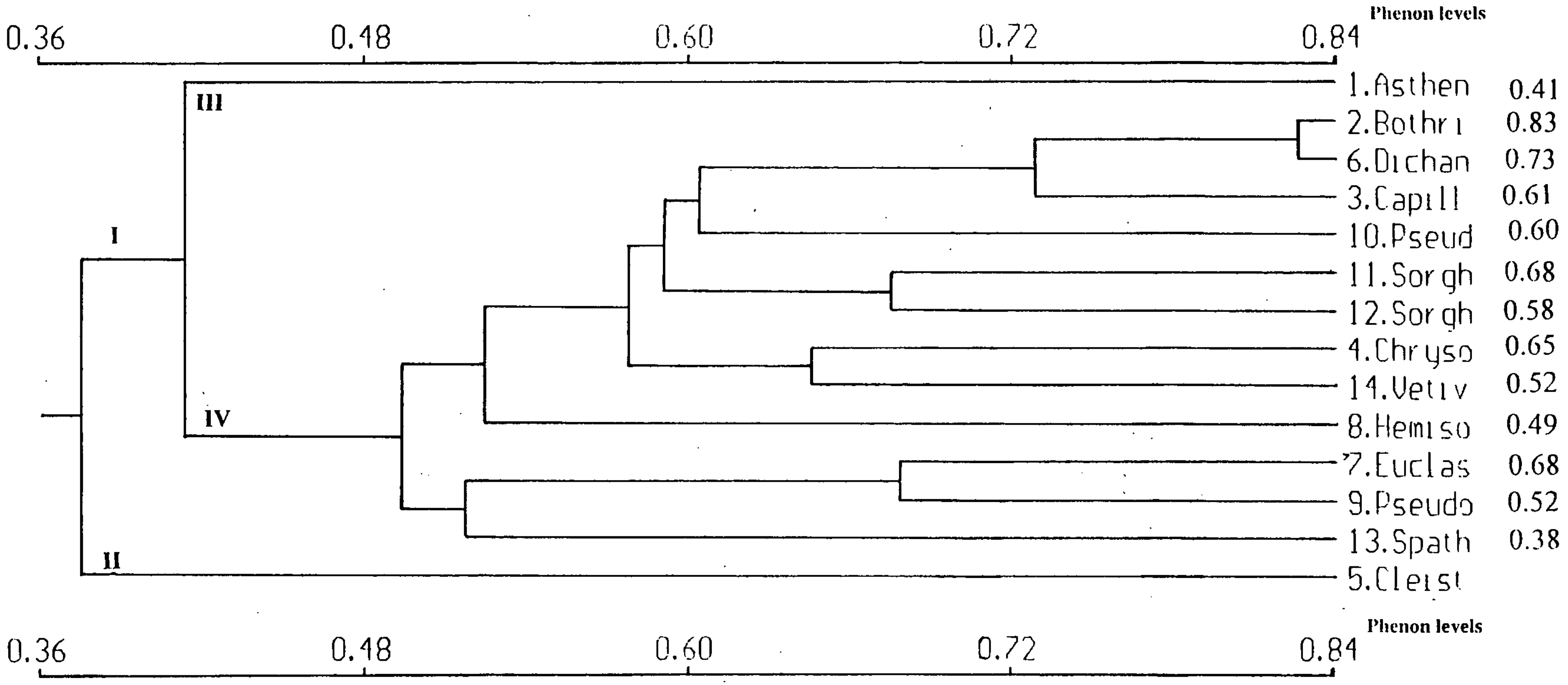
#1. *Asthenochloa tenera*
#2. *Cleistachne sorghoides*
#3. *Euclasta clarkei*
#4. *Euclasta condylotricha*
#5. *Euclasta oligantha*
#6. *Hemisorghum mekongense*
#7. *Hemisorghum venustum*
#8. *Pseudodichanthium serrafalcoides*
#9. *Pseudosorghum fasciculare*
#10. *Spathia neurosa*
#11. *Chrysopogon aciculatus*
#12. *Chrysopogon aucheri*
#13. *Chrysopogon fallax*
#14. *Chrysopogon fulvus*
#15. *Chrysopogon gryllus*
#16. *Chrysopogon latifolius*
#17. *Chrysopogon orientalis*
#18. *Chrysopogon pallidus*
#19. *Chrysopogon plumulosus*
#20. *Chrysopogon serrulatus*
#21. *Chrysopogon sylvaticus*/
#22. *Vetiveria elongata*
#23. *Vetiveria filipes*
#24. *Vetiveria fulvibarbis*
#25. *Vetiveria nigritana*
#26. *Vetiveria zizanioides*
#27. *Bothriochloa biloba*
#28. *Bothriochloa decipiens*
#29. *Bothriochloa insculpta*
#30. *Bothriochloa ischaemum*
#31. *Bothriochloa kuntzeana*
#32. *Bothriochloa macera*
#33. *Bothriochloa pertusa*
#34. *Bothriochloa radicans*
#35. *Bothriochloa saccharoides*
#36. *Capillipedium assimile*
#37. *Capillipedium filiculme*
#38. *Capillipedium huegelii*
#39. *Capillipedium parviflorum*
#40. *Capillipedium spicigerum*
#41. *Dichanthium annulatum*
#42. *Dichanthium aristatum*
#43. *Dichanthium caricosum*
#44. *Dichanthium foveolatum*
#45. *Dichanthium micranthum*
#46. *Dichanthium sericeum*
#47. *Sorghastrum elliottii*
#48. *Sorghastrum fuscescens*
#49. *Sorghastrum incompletum* var. *bipennatum*
#50. *Sorghastrum minarum*
#51. *Sorghastrum nutans*
#52. *Sorghastrum pogonostachyum*
#53. *Sorghastrum setosum*
#54. *Sorghum arundinaceum*
#55. *Sorghum halepense*
#56. *Sorghum macrospermum*
#57. *Sorghum nitidum*
#58. *Sorghum versicolor*
#59. *Sorghum plumosum*
#60. *Sorghum stipoideum*
#61. *Bothriochloa bladhii*



#1. *Asthenochloa tenera*
#2. *Cleistachne sorghoides*
#3. *Euclasta clarkei*
#4. *Euclasta condylotricha*
#5. *Euclasta oligantha*
#6. *Hemisorghum mekongense*
#7. *Hemisorghum venustum*
#8. *Pseudodichanthium serrafalcoides*
#9. *Pseudosorghum fasciculare*
#10. *Spathia neurosa*
#11. *Chrysopogon aciculatus*
#12. *Chrysopogon aucheri*
#13. *Chrysopogon fallax*
#14. *Chrysopogon fulvus*
#15. *Chrysopogon gryllus*
#16. *Chrysopogon latifolius*
#17. *Chrysopogon orientalis*
#18. *Chrysopogon pallidus*
#19. *Chrysopogon plumulosus*
#20. *Chrysopogon serrulatus*
#21. *Chrysopogon sylvaticus/*
#22. *Vetiveria elongata*
#23. *Vetiveria filipes*
#24. *Vetiveria fulvibarbis*
#25. *Vetiveria nigritana*
#26. *Vetiveria zizanioides*
#27. *Bothriochloa biloba*
#28. *Bothriochloa decipiens*
#29. *Bothriochloa insculpta*
#30. *Bothriochloa ischaenum*
#31. *Bothriochloa kuntzeana*
#32. *Bothriochloa macera*
#33. *Bothriochloa pertusa*
#34. *Bothriochloa radicans*
#35. *Bothriochloa saccharoides*
#36. *Capillipedium assimile*
#37. *Capillipedium filiculme*
#38. *Capillipedium huegelii*
#39. *Capillipedium parviflorum*
#40. *Capillipedium spicigerum*
#41. *Dichanthium annulatum*
#42. *Dichanthium aristatum*
#43. *Dichanthium caricosum*
#44. *Dichanthium foveolatum*
#45. *Dichanthium micranthum*
#46. *Dichanthium sericeum*
#47. *Sorghastrum elliottii*
#48. *Sorghastrum fuscescens*
#49. *Sorghastrum incompletum* var. *bipennatum*
#50. *Sorghastrum minarum*
#51. *Sorghastrum nutans*
#52. *Sorghastrum pogonostachyum*
#53. *Sorghastrum setosum*
#54. *Sorghum arundinaceum*
#55. *Sorghum halepense*
#56. *Sorghum macrospermum*
#57. *Sorghum nitidum*
#58. *Sorghum versicolor*
#59. *Sorghum plumosum*
#60. *Sorghum stipoideum*
#61. *Bothriochloa bladhii*

Figure 7.2. Phenogram of 61 OTU's when 44 characters are used, based on UPGMA cluster analysis (see text for details).

Figure 7.3. Phenogram of 14 OTU's based on UPGMA cluster analysis (see text for details). 1. Asthenochloa. 2. Bothriochloa. 3. Capillipedium. 4. Chrysopogon. 5. Cleistachne. 6. Dichanthium. 7. Euclasta. 8. Hemisorghum. 9. Pseudodichanthium. 10. Pseudosorghum. 11. Sorghastrum. 12. Sorghum. 13. Spathia. 14. Vetiveria.



7.3. Phylogenetics.

The theory of phylogenetic systematics asserts that evolution by descent is the causative factor that has produced the diversity among modern plants and permits the construction of a hierarchical classification. It is therefore the evolutionary histories of taxa that are of primary interest for systematic investigation and the derived data and their interpretation form the framework of the classification system. Furthermore, the taxa in the system must be monophyletic. Evolutionary divergence, lineage, and branching may be used in the circumscription of taxa, and overall resemblance that might result from parallel or convergent evolution is not considered. Pheneticists and phylogeneticists may use the same comparative techniques and the same data sets. The basic distinction between the two groups rests on a philosophical foundation, that is, whether in principle similarity or phylogeny should be most significant in the formulation of a classification.

The core concept of phylogenetic systematics is the use of derived or apomorphic characters to reconstruct common ancestry relationships and the grouping of taxa based on common ancestry. It is essential for the phylogenetic methods that an ancestral type, either a hypothetical ancestor or a relatively putative primitive taxon, be recognised. Analysis progresses easily if there is fossil evidence, if the groups are already well known from a phenetic vantage point, and if the adaptive significance of the various character states is known. Evolution may still be perceived even when only extant taxa are available to study. Correlation of characters may provide a reasonable estimate of likely primitive and advanced states.

At about the same time as the birth of numerical taxonomy, Hennig (1966), proposed a new approach to determine evolutionary branching patterns, an approach also readily adaptable to computer technology. This approach is termed cladistics. Cladistics is basically a methodology that attempts to analyse phylogenetic data objectively (and hence to produce phylogenetic classification), in a manner parallel to that in which taxometrics seeks to introduce objectivity into phenetics and phenetic classification (Stace, 1989). Despite this similarity, the two approaches and their respective proponents are largely in conflict. Cladistics focuses exclusively on inferred branching patterns of evolutionary lineages. In this approach the classification must be retrieved directly from the cladogram, a two-dimensional depiction of the branch points, each taxon must be monophyletic as recognised by patterns of shared derived characters, and sister groups must be accorded equal rank in the hierarchical system. In a cladogram the branching pattern along the vertical axis represents ancestry in time (or evolutionary advancement). A number of cladograms are possible for the same set of organisms and data. The cladogram with the fewest character state changes, that is, the most parsimonious, would then have to be chosen. Cladistic methods are not the only ones to adopt the principle of parsimony, for the latter has been used by phenetic taxonomists, who attempt to relate extant OTU's without hypothesising *a priori* any ancestor or directions of evolutionary change.

For cladistic classification, the only characters which can be used are those which are the outcome of evolutionary history, i.e., derived characters. Other characters are irrelevant. Unfortunately, there is no method, statistical or otherwise, that can be used to choose the right characters, and these therefore are chosen subjectively by the taxonomist. The next problem is to decide the polarity of the characters, that is, which character states are primitive and which are advanced. If suitable fossils were always available for study, polarity could be decided without any doubt, but this is practically never the case. Differences have therefore always ensued between different workers when it comes to this aspect of cladistics.

A lot of debate has always been around since Hennig's proposals on the cladistic theory. There are different opinions on what cladograms should be interpreted to represent (see section 7.3.2). Most phylogeneticists argue that cladistic methods should be used to come up with classifications that supposedly reflect evolutionary relationships between taxa studied. However, one school of thought, that of the so called 'pattern cladists', use cladistic methods without assuming that they should be used to create classifications. These contend that cladistics should be used merely to unravel the pattern of variation rather than detect the true phylogeny. They believe that the pattern is nearly always close to the genealogy, and sometimes coincident with it, but there is no certainty that it is the same. It is generally assumed that when a hypothesis has been put forward about evolution of a group, this will then be used to create a classification, this is not necessarily so. The onus is, therefore, still on the taxonomic to impose his own interpretation on the outcome of cladistic analysis.

Cladistic analyses of the grasses is a recent phenomenon. Linder & Ferguson (1985) and Campbell & Kellogg (1987) concluded that the grass family is linked with six small families of the Southern Hemisphere (*Anarthriaceae*, *Centrolepidaceae*, *Ecdeiocoleaceae*, *Flagellariaceae*, *Joinvilelaceae* and *Restionaceae*). These conclusions are far from novel.

7.3.1. Some concepts associated with cladistics.

Cladistics has as its basis three concepts: apomorphy, monophyly, and parsimony. An **apomorphy** is a derived character. If this character is shared by more than one taxon it is called a **synapomorphy**. An apomorphy that is found only in a particular taxon is called an **autapomorphy**. Every apomorphous character is paired with the character from which it is derived, the **plesiomorphous** character (primitive or ancestral character). Cladistic methods basically view evolution as an ordered, divergent, step-wise transformation of characters from plesiomorphous to apomorphous states.

If all organisms in a branching genealogical tree have the same single ancestor, and all the descendants are included, then the group of organisms is said to be **monophyletic**. On a cladogram, this translates into any group that includes all taxa that share at least one synapomorphy. A monophyletic group of taxa is called a **clade**. Non-monophyletic groups are of two types: (i) When a group of organisms all have the same common ancestor, but not all the descendants are included, then the group is **paraphyletic** (also called a **grade**); and (ii) if a group of organisms includes two or more complete branches from different parts of a tree, but does not include the common ancestor, then the group is said to be **polyphyletic**. A diagrammatic representation of monophyly, paraphyly and polyphyly is shown in Figure 7.4. The horizontal, solid black lines indicate the 'taxa' belonging to the particular group.

The process of assigning status of apomorphy to a character is called determining **polarity**. Using an **outgroup** (or outgroups) is the most common way of determining which characters are apomorphic (Funk, 1995). Characters found in the outgroup as well as in some of the taxa in the **ingroup** (the group being studied) are considered to be plesiomorphous. Those characters found only in some of the taxa of the ingroup but are absent in the rest of the ingroup and in the outgroup are considered apomorphous. An outgroup can be, but is not necessarily, the taxon most closely related to the ingroup, the **sister** group.

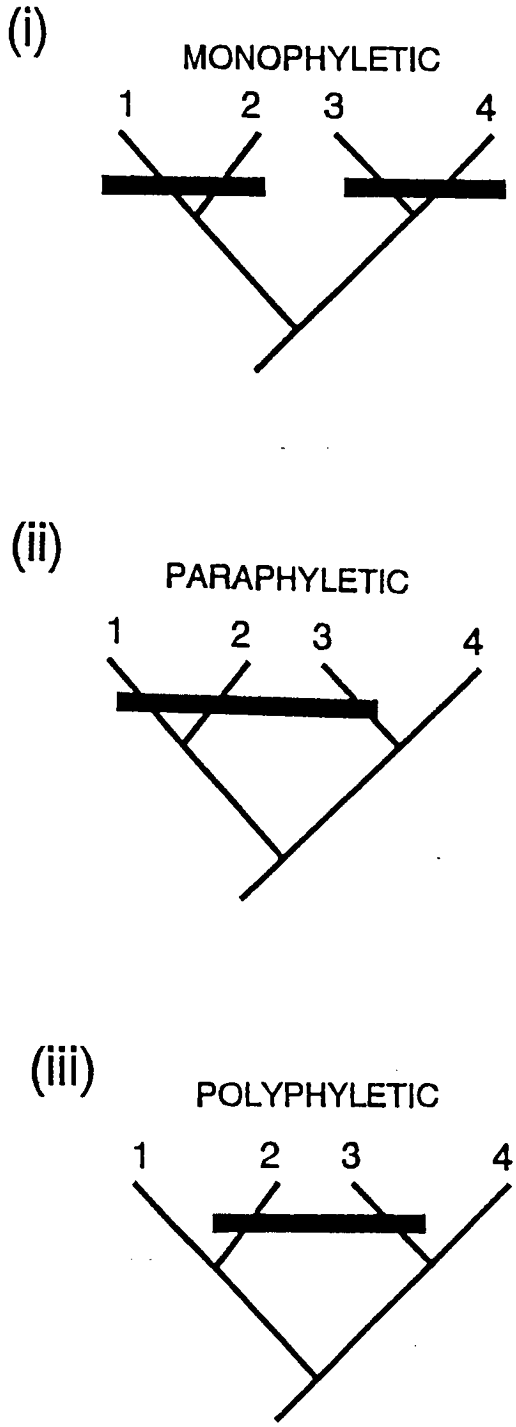


Figure 7.4. A diagrammatic representation of the concepts of monophyly, paraphyly and polyphyly.

7.3.2. Cladogram interpretation and evaluation.

Cladograms are statements about the distribution of shared characters. There are various measures used to evaluate the 'robustness' of a cladogram. The simplest measure is the **tree length**. This indicates the number of character state changes required to explain the character state changes possessed by each terminal taxon on the tree. The **consistency index** (CI) measures the amount of homoplasy (extra steps) in a character. A CI value of 1 indicates that a character has no homoplasy. The messier the data on the tree, and the greater the amount of homoplasy, the more CI approaches 0. The other commonly used statistic is the **retention index** (RI) which measures the amount of implied synapomorphy in the data matrix that is retained as synapomorphy on the tree, i.e., ratio of the apparent synapomorphy to actual synapomorphy. Similarly, high homoplasy in characters is indicated by values near 0. The CI and RI are usually combined to form what is called a **rescaled consistency index** (RC). The RC excludes characters that do not contribute to the 'fit' of the tree by excluding autapomorphic characters as well as those showing total homoplasy (Funk, 1995). As with CI and RI, RC ranges from 0 to 1, with higher RC values indicating that characters in the data set are congruent with each other and the tree. These indices can be used for each individual character as well as for the cladogram as a whole.

Another approach to estimating the value of a particular cladogram with respect to the data is by using the technique of **bootstrapping**. This technique involves randomly sampling the original data set with replacement to create a series of 'bootstrap' replicates of the same size as the original data set. New matrices and their corresponding trees are produced. In each of these trees, percentages of occurrence of particular monophyletic groups are recorded. These percentages of occurrences (usually out of 100) that a particular monophyletic group appears among the trees of the sample data sets can be considered an index of support for that monophyletic group.

Cladistic analysis more often generates many equally parsimonious trees. Therefore, consensus techniques are usually used. Consensus techniques summarise sets of trees into a single topology. Two types of consensus techniques are common in the literature: (I) **Strict consensus** - depicts only monophyletic groups retained in all trees; and (ii) **Majority rule consensus** - shows the branching sequences that are found in most of the trees and depicts monophyletic groups that are present in a specified percentage of trees (usually 50%). Both these consensus techniques have the potential of producing unresolved branching patterns, **polytomies**. Although consensus trees are useful in identifying the areas of agreement and conflict among competing trees, unless a consensus tree is identical to one of the equally parsimonious trees, it can not be used to study character evolution (Funk, 1995).

As mentioned earlier, cladograms can be interpreted to represent various assumptions. According to Maddison & Maddison (1992) they can represent:

1. *The hypothesised phylogenetic history, with lines representing lineages descending through time and branch points representing speciation events.* Two taxa placed next to one another on separate terminal branches means that they share a common ancestor unique to them, and neither is the ancestor of the other. If one had been an ancestor, it would have been placed directly at an internal node of the cladogram.

2. *The relative recency of common ancestry of the observed taxa.* Taxa placed together in a clade share a common ancestor not shared by other taxa outside the clade. However, though these taxa are placed in terminal position on the cladogram, the internode leading to the terminal node might or might not have existed in nature.

3. *The hierarchical distribution of shared, derived, homologous character states (synapomorphies).* This interpretation asserts that taxa forming a clade do not necessarily represent a group of taxa sharing uniquely a common ancestor, but rather a group of taxa united by concordant synapomorphies. The cladogram is therefore a summary of evolutionary changes in characters.

4. *The hierarchical distribution of shared characteristics.* Placing taxa in the same clade does not necessarily mean that they share an evolutionary innovation, but rather

that they share a similarity. This interpretation makes no claims about evolution. This interpretation is contradictory because cladograms thus produced are based on the use of polarised characters, a necessary first step to cladistic analysis. Distribution of shared characters would best be represented by phenograms.

7.3.3. Procedure.

(i) Character coding: The first thing that was done was to polarise characters. (Appendix 11.4). Plesiomorphic characters are indicated as 0 while apomorphic ones have values higher than 0 (1, 2, & 3; see Table 7.1). Unlike the phenetic analysis (see section 7.2.1), only representative species (type species) of the 14 genera of the subtribe were used. Also, most characters from phenetic analysis were discarded because they could not be satisfactorily polarised or polarising them made no sense. Therefore, only 26 characters were chosen. The genus *Saccharum* (in subtribe *Saccharinae*) is supposedly closely related to the genera of the *Sorghinae*, hence the species, *S. officinarum*, was chosen as an outgroup.

(ii) Results and analysis: The statistical packages used for producing cladograms were MacClade (Maddison & Maddison, 1992) and PAUP (Phylogenetic Analysis Using Parsimony) (Swofford, 1993). These packages are relatively user-friendly and (in theory) wholly compatible. MacClade was used for data input and tree examination/interpretation. PAUP was used for the actual algorithmic analysis that generates trees and tree summary data. Thus, in order to obtain optimal results, one must flip backwards and forwards between the two packages.

Four cladograms were produced, each with the following tree statistics: Tree length: 172; CI: 0.67; RC: 0.44; and RI: 0.65. A Majority rule consensus of these trees was computed (Figure 7.5). The numbers on branches are the percentages of occurrence of the particular clades in the original four trees. For instance, on the *Asthenochloa tenera/Cleistachne sorghoides* branch, the 100% means that this clade is present in all the four original trees. There are two unresolved branches, polytomies, in the tree. The first is represented by the *Pseudosorghum fasciculare* branch. The second is *Spathia neurosa* and the two clades above it containing *Euclasta condylotricha* and *Bothriochloa bladhii*, and *Pseudodichanthium serrafalcoides* and *Dichanthium annulatum*. This cladogram is very different from the phenogram produced for the same set of genera (see Figure 7.3). I have not used the cladogram to study character evolution because it does not look like any of the four original trees.

newsorghinae2.1		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1	Asthenochloa tenera	0	0	0	0	1	1	0	0	?	0	0	2	2	1	?	1	0	0	0	0	0	1	1	1	0	1
2	Cleistachne sorghoides	1	?	0	0	0	0	0	0	?	0	0	3	3	1	?	2	0	1	0	0	0	0	0	0	0	1
3	Euclasta condylotricha	1	?	0	0	1	1	1	?	0	0	1	2	1	0	1	0	0	0	0	0	0	0	0	0	1	1
4	Pseudodichanthium serrafalcoide	1	?	0	0	1	0	1	?	2	0	0	2	1	0	1	0	0	0	0	1	0	0	1	0	1	1
5	Pseudosorghum fasciculare	1	?	0	0	1	0	0	0	?	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1	1
6	Spathia neurosa	1	?	1	0	1	1	2	?	1	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	1	1
7	Chrysopogon gryllus	0	0	0	0	1	1	0	1	?	1	0	0	0	0	?	0	1	0	0	0	0	1	0	0	1	1
8	Vetiveria zizanioides	0	0	0	0	1	1	0	1	?	0	0	2	1	0	0	0	0	0	0	0	0	0	1	0	1	1
9	Bothriochloa bladhii	0	0	0	0	0	1	1	?	0	0	1	2	1	?	0	0	0	0	0	0	1	0	1	0	1	1
10	Capillipedium parviflorum	0	0	0	0	1	1	0	0	?	1	1	0	0	0	?	0	0	0	0	0	0	1	1	0	1	1
11	Dichanthium annulatum	0	1	0	0	1	0	1	?	1	0	0	2	1	0	1	0	0	0	0	0	0	0	1	0	1	1
12	Sorghastrum nutans	0	1	0	1	1	0	0	0	?	1	0	0	0	1	?	0	0	0	0	0	0	0	1	0	1	1
13	Sorghum arundinaceum	1	?	0	0	1	1	0	0	?	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1	1
14	Hemisorghum mekongense	0	0	0	0	0	1	0	1	?	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0
15	Saccharum officinarum	0	1	0	0	0	1	0	0	?	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1

Table 7.1. A matrix of species and characters used in cladistic analysis.

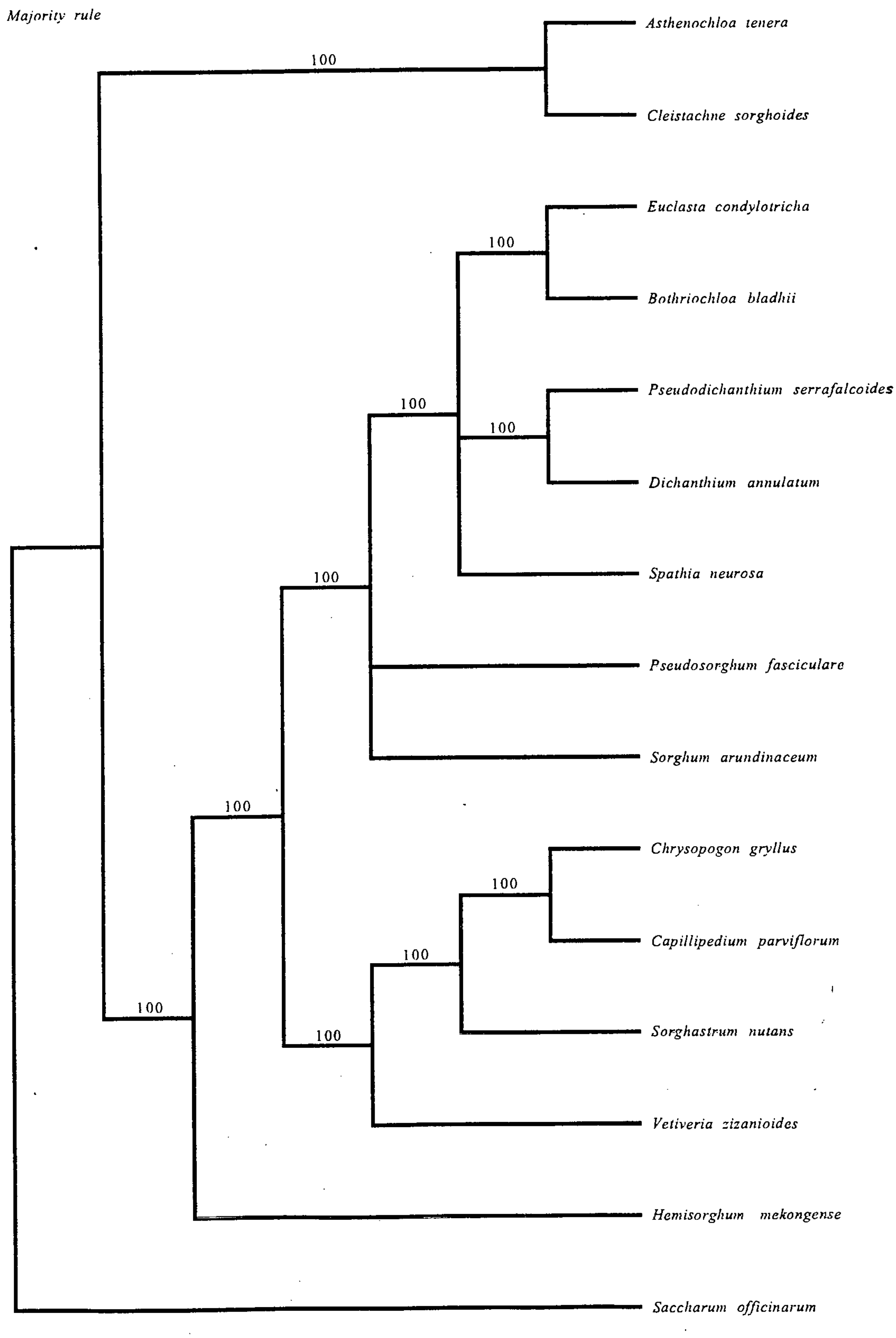


Figure 7.5. A Majority rule consensus cladogram of reperesentative *Sorghinae* species.

7.4. General Discussion.

The two approaches, phenetics and cladistics, are two basic taxonomic philosophies at extremes of a continuum. One extreme is that the categories of any classification should be based on genetic similarity and dissimilarity, and the other contends that the categories should reflect phylogenetic relationships (Estes & Tyrl, 1986). Even though plausible arguments can be advanced for the significance of both approaches, Pankhurst (1991) though advocating experimentation with both methods, notes that '...the phenetic methods involve few subjective decisions, do not involve any major approximations, and have effective algorithms. On the other hand, the cladistic methods are much more ambitious, involve many subjective decisions and several major approximations, and do not have generally effective algorithms'. In general, a phylogenetic classification will be better at showing the supposed ancestral relationships, and a phenetic classification will better represent the characters of current day organisms. However, if evolution proceeds at a constant rate and in a strictly divergent fashion, a correct phenogram will indeed appear exactly the same as a correct cladogram, and a highly competent taxonomist might subjectively produce the same pattern (Stace, 1989). When 'actual' phylogeny is not known, as in most angiosperms (and certainly in grasses), phenetic approaches to classification may often produce as plausible a 'phylogenetic' classification as any, and one that has excellent predictive value (Hattersley & Watson, 1992).

There are a number of points I could raise from the experience of using phenetic and cladistic methods in the present study. Cladistic methods are very sensitive to characters used. The resolution is far much improved if very good few characters are used, i.e., those characters that truly influence the 'fit' of the cladogram. If a lot of useless characters are used, they tend to create 'noise' and cladograms yielded are unresolved and uninformative. Also, reducing the number of taxa to only a few representative ones seemed to help. In contrast, for phenetic methods, the more characters one uses, the more resolved are the phenograms. These methods allow for terminal taxa to have polymorphic characters, i.e., one can code for more than one state of a character in a taxon. This can also be done in cladistic methods. There is however a practical problem of the algorithms not coping well with these characters and this leads to the production of erroneous cladograms. I was able to produce phenograms at generic level because I could code for all the characters in the species sampled. The same could have been done for cladistic analysis but this would have resulted in a large portion of the matrix consisting of polymorphic characters because character variations in other species of the genera would have had to be included. I however used a sample of representative species. Also, it is almost impossible to produce a single cladogram that one can use to study character evolution, which means that one ends up having to compute consensus trees.

Neither of the exercises, phenetic and cladistic, produced dendograms which exhibited similar generic groups to the ones I proposed for the taxa of the *Sorghinae*. Phenograms nevertheless indicated some species complexes and some generic associations I suggested in my intuitive delimitation of the genera of the *Sorghinae* (see Chapter 3). Though worthwhile in terms of generating understanding of method and philosophy, the exercises did not sway my intuitive understanding of the group sufficiently to suggest any alternative classifications based on them. I simply do not trust their outcomes. Between them, I incline to the certainty of similarity analysis rather than the greater dubiety of phylogenetic assumption, as a basis for classification.

Chapter 8. Taxonomic descriptions.

8.1. Introduction.

The order in which the genera have been arranged is not intended to suggest any evolutionary sequence. The sequence is a reflection, to some extent, of phenetic relationships between the different genera. The species are arranged likewise under each genus. On average, five (5) specimens were closely observed for each species, but in cases where the specimens showed considerable variation, more specimens were used to cover this variation. Type specimens, either seen or not, are listed separately. Sometimes only type localities are indicated due to scanty information, and only in a few species was I unable to record information pertaining to types. I was however hesitant to suggest any new types because I felt that the types might exist somewhere but I was not able to trace them within the time that I had to finish the research. Typification would have to be done at a later date.

The taxonomic descriptions that follow represent the species throughout the whole of their morphological variations and ecological ranges. Any outstanding characteristics are outlined, otherwise it is those characters found in the keys that should be considered diagnostic. Taxonomic affinities are also discussed briefly. Additional information (if available), e.g. chromosome numbers, which is not a result from the present study, is included and sources of origin quoted.

Information on habitat and distribution was obtained mainly from the herbarium sheets, unless otherwise stated. The specimens studied are arranged alphabetically by country. Under each country, they are then arranged alphabetically by author in the order: location, altitude, date of collection, collector, collector(s) number, and, in parenthesis, the herbarium from which the material consulted came. It will be obvious in some cases that not all the information was available on the herbarium sheets.

8.2. ***Sorghinae*** Bluff, Nees & Schauer, Comp. Fl. Germ. ed. 2, 1: 46 (1836).

Synonym: *Bothriochloinae* Keng, in Sinensia 10: 282 (1939).

Inflorescence terminal or rarely axillary, of single or digitate or paniculate racemes, the latter often in whorls; racemes with fragile rachis and slender internodes, sometimes reduced to triads or single spikelets, occasionally with homogamous pairs. Spikelets paired, dissimilar, seldom plumose. Sessile spikelet bisexual, usually dorsally compressed, the callus usually obtuse with cupuliform or truncate articulation but the latter sometimes oblique (always so when callus pungent); lower glume usually firm, more or less convex on the back and abruptly rounded on the flanks (except *Hemisorghum*); lower floret reduced to a barren lemma; upper lemma linear to oblong, entire or bilobed, usually with a glabrous awn. Pedicellate spikelet male, neuter, or (rarely) bisexual, sometimes much reduced, rarely with a small callus.

Genera 14.

A key to the genera of the *Sorghinae*:

Spikelets in racemes which are not interrupted by spathes, or solitary at ends of branches; the racemes collected into whorled panicles; joints and pedicels terete, i.e. not furrowed:

  Spikelets solitary at the ends of branches; pedicellate spikelets absent, or represented by barren pedicels:

    Pedicels entirely absent. 1. ***Cleistachne***

    Pedicels present:

      Pedicel well developed. 2. ***Sorghastrum***

      Pedicel reduced to a minute axis hidden by callus hairs. 3. ***Asthenochloa***

  Spikelets in pairs or threes; pedicellate spikelets present but often more or less reduced:

Spikelets dorsally compressed:

Racemes up to 30cm long, tardily disarticulating, with scabrid rachis nodes and pedicels; spikelets awnless; lower glume 2-keeled for its whole length; lodicules glabrous.

4. ***Hemisorghum***

Racemes very much less than 30cm long, readily disarticulating; rachis nodes and pedicels ciliate; lower glumes 2-keeled near the tip; lodicules glabrous or ciliate:

Lower glume of sessile spikelet convex, rounded on the sides; lodicules hairy. 5. ***Sorghum***

Lower glume of sessile spikelet flat, with narrowly inflexed margins; lodicules glabrous.

6. ***Pseudosorghum***

Spikelets laterally compressed:

Spikelets in groups each consisting of a sessile and two more or less reduced pedicellate spikelets; lower glume smooth, not tuberculate. 7. ***Chrysopogon***

Spikelets with many pairs of spikelets arranged in whorled racemes; lower glume tuberculate. 8. ***Vetiveria***

Spikelets in racemes which are interrupted by spathes, or the espatheate racemes digitate or in pairs or solitary and terminal, sometimes the joints and or pedicels with a translucent median furrow:

Margins of the lower glumes inturned and rounded at the sides, at the most keeled upwards; awn usually hairy; lower glume of the sessile spikelet keeled and broadly winged, glabrous.

9. ***Pseudodichanthium***

Margins of the lower glume of the sessile spikelets sharply infolded, 2-keeled; awn glabrous; lower glume of sessile spikelet not broadly winged, hairy or glabrous:

Spikelets arranged in false racemes terminating the branches and branchlets of a true panicle; pedicels with a median translucent furrow. 10. ***Capillipedium***

Spikelets arranged in false racemes which are either solitary and terminal or subsessile, arranged along a central axis but not at the tips of capillary branches:

Racemes solitary at the ends of branches supported by spathes, but sessile spikelets not overlapping. 11. ***Spathia***

Racemes several to many, if solitary then the sessile spikelets imbricate; spathes absent:

Joints and pedicels with a translucent longitudinal furrow; all spikelets, both sessile and pedicellate, in the racemes, dissimilar:

All pairs of spikelets heterogamous, rarely homogamous; racemes ascending; glumes sometimes pitted. 12. ***Bothriochloa***

The lowest 1-3 pairs of spikelets homogamous; racemes nodding; glumes never pitted. 13. ***Euclasta***

Joints and pedicels without a translucent furrow; lowest 1-3 pairs of spikelets homogamous; all spikelets in the racemes more or less alike, with obtuse apices. 14. ***Dichanthium***

8.2.1. *Cleistachne* Benth., in Hook. Ic. Pl. 14: t 1379 (1882). The type species is *Cleistachne sorghoides* Benth.

Coarse annual. Inflorescence a panicle, its primary branches bearing racemes at regular intervals along their length, each raceme reduced to a single sessile spikelet (whose apparent pedicel is homologous to the raceme peduncle); spikelets solitary, sessile; female fertile florets one; upper lemma stipiform; lodicules 2, ciliate; pedicellate spikelet and pedicel completely suppressed.

Species 1.

Cleistachne sorghoides[*] Benth., in Hook. Ic. Pl. 14: t 1379 (1882).-Hack., In DC., Monogr. Phan. 6: 653 (1889).-Stapf, in Prain, Flora of Trop. Africa IX: 154 (1917).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 8 (1954).-Chipindall, in Meredith, The grasses and pastures of South Africa: 468 (1955).-Bogdan, A revised list of Kenya grasses: 56 (1958).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 33 (1958).-Bor, Grasses of Burma Ceylon India & Pakistan: 119 (1960).-Napper, Grasses of Tanganyika: 98 (1965).-Hood, A guide to the grasses of Zambia: 58 (1967).-Clayton, in Polhill, Flora of Tropical East Africa, Gramineae (3): 734 (1982).-Gibbs Russell et al, Grasses of Southern Africa: 87 (1991).

Tall, erect, stilt-rooted annual up to 3m tall. Culms slender, culm nodes and internodes glabrous. Leaf blades linear-lanceolate, variable in width but often expanded to greater than 2cm wide, hairy on both surfaces, but less so on the abaxial

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[*] **oides** is a Greek suffix meaning **like** or **resembling**, alluding to the resemblance of the species to those of the genus *Sorghum*.

surface, with prominent midribs; leaf sheaths hairy or glabrous, when hairy, the hairs just upward of the horizontal; leaf ligule an unfringed membrane.

Inflorescence a very compact panicle; racemes markedly reduced to single sessile spikelets (the raceme peduncle equivalent to the spikelet pedicel); peduncles and rachis internodes covered with hair; spikelet colour variable but ranges from straw coloured to chestnut brown. Spikelets oblong; lower and upper glumes the same size, slightly coriaceous; lower glume minutely truncate, finely 7-nerved, covered with uniform short and dense hairs; upper glume glabrous below, hispid towards the apex, clasped lengthwise by the lower; callus obscure, shortly bearded. Florets 2: lower floret empty, lemma hyaline, oblong, ciliate, 2-nerved; upper floret bisexual, lemma hyaline, ciliate on margins, finely 3-nerved, awned; awn 5-8 times the length of the lemma, geniculate, with a twisted column hairy along the spiral and a serrate distal bristle; palea shorter than the lodicules; lodicules 2, ciliate; anthers not seen; caryopsis obovate oblong, truncate, brown. Pedicellate spikelet and pedicel absent.

Chromosome number: 2n = 36 (Garber 1950; Celarier, 1959).

Diagnostic characters and affinities: This is one species in which controversy has arisen as to whether it is one species or three. Specimens seen showed variation in the pubescence of the leaf sheath, simplicity (i.e. whether open or compact) of the inflorescence and its overall colour. In detail (i.e. standard characters of the spikelet) the specimens are the same. I therefore do not think that it would suffice to create two or more species based on the variable characters mentioned above. It is quite unknown as to the degree to which these variations may be partly due to environmental variation.

Habitat: Grassland or savannah woodland.

Type: Mozambique, Shupanga, *Kirk* (K!).

Representative specimens:

Malawi: Dedza District, Mau-Livulezi Forest, 09.iv.1964, *Adlard* 607 (MAL); Southern Region, Chiradzulu, altitude 1250m, 1970, *Brummitt & Banda* 9831 (K);

Southern region, Zomba District, lower slopes of Zomba Plateau, above Salisbury bridge, Zomba, altitude 1140m, 26.iv.1980, *Brummitt, Masiye & Tawakali* 15560 (MAL); Lilongwe District, Agricultural Research Station, 07.iv.1951, *Jackson* 457 (MAL).

Mozambique: Niassa District, altitude 1000m, 23. iii. 1964, *Torre & Paiva* 11359 (K).

Zambia: Dambo, 06.vi.1931, *Fraser* 14 (K).

Zimbabwe: Salisbury (Harare), Teviotdale, 20.iii.1965, *Bingham* 1429 (BM); Melsetter District, Muchira river, Tarka Forest Reserve, altitude 1100m, iii.1971, *Goldsmith* 12/71 (BM); Gokwe District, 19.iii.1984, *Mahlangu* 981 (K); Salisbury (Harare), Henderson Research Station, 10.iii.1964, *West* 4743 (BM); Banket District, 15.iv.1947, *Wild* 1891 (K).

Distribution: Tropical Africa and India.

8.2.2. ***Sorghastrum*** Nash, in Britton, Fl. North. United States: 71 (1901). The type species is *Sorghastrum nutans* (L.) Nash.

Synonyms: *Poranthera* Raf., in Bull. Bot. Geneve 1: 221 (1830); *Dipogon* Steud., Nom. Bot. ed. 2, 1: 518 (1840).

Annuals or perennials. Inflorescence a panicle, the subdivided primary branches bearing short racemes, these sometimes reduced to triads. Sessile spikelet callus obtuse or pungent (with involucral hairs in *S. pogonostachyum*); lower glume coriaceous, convex, keeled at the tip; upper glume broadly convex; upper lemma mostly entire, sometimes bilobed, awned; lodicules glabrous. Pedicellate spikelet usually reduced to a barren pedicel, but present and bisexual in *S. fuscescens* and *S. pogonostachyum.*

Species ± 16.

A key to taxa sampled:

Pedicellate spikelet bisexual, some pedicels barren:

Culm nodes glabrous; racemes up to 7-jointed; spikelet surrounded by an involucre of silvery hairs to ¾ the length of the sessile spikelet; awn 4mm long; upper lemma entire. 1. ***pogonostachyum***

Culm nodes hairy; racemes 3-15-jointed; callus with a short beard of hairs only; awn 25mm long; upper lemma bilobed. 2. ***fuscescens***

Pedicellate spikelet absent, all pedicels barren:

Racemes single-jointed:

Plants annual; sessile spikelet 4-5.5mm long; upper lemma entire; awn 25-40mm long, glabrous. 3. ***incompletum*** var. ***bipennatum***

Plants perennial; sessile spikelet 6.5-10mm long; upper lemma bilobed; awn 25-70mm long, glabrous or hairy:

Sessile spikelet 6.5mm long; lower glume of sessile spikelet hairy on the back; awn 25-35mm long, glabrous. 4. ***elliottii***

Sessile spikelet 10mm long; lower glume of sessile spikelet glabrous; awn greater than 35 (-70)mm long, hairy along the spiral. 5. ***minarum***

Racemes 2-many-jointed:

Culm nodes glabrous; raceme peduncles glabrous; sessile spikelet 4mm long; upper lemma with entire margins, awned or awnless. 6. ***setosum***

Culm nodes hairy; not with the above combination of characters:

Nodal hairs a conspicuous ring; raceme peduncles hairy; sessile spikelet 6-8mm long. 7. ***nutans***

Nodal hairs inconspicuous, short and velvety; raceme peduncles glabrous; sessile spikelet 4-7(-8)mm long:

Leaf sheaths not produced into auricles; spikelets 5-7(-8)mm long; awns 3-8(-10)mm long, straight or bent and twisted. 8. ***friesii***

Leaf sheaths with auricles; spikelets 4-7(-8)mm long; awns 8-16mm long, never straight, always bent and twisted. 9. ***stipoides***

1. ***Sorghastrum pogonostachyum**** (Stapf) Chippind. & Pole Evans, in Bot. Surv. S. Afr., Mem.: 247 (1948).

Synonyms: *Sorghum pogonostachyum* Stapf, in Prain, Flor. Trop. Afr. IX: 144 (1917); *Mischanthidium gracilius* Napper, in Kirkia 3: 120 (1963).

Perennial grass with a creeping rhizome, sending up a small tuft of culms from base. Culms about 1m tall; culm nodes glabrous. Leaf blades narrow, glabrous, smooth except at the slightly rough tips; leaf sheaths firm, tight, glabrous, smooth, striate; ligule short, stout, scarious, pubescent.

Inflorescence a narrow panicle up to 15cm long; racemes loose, containing spikelet pairs i.e. both sessile and pedicellate spikelets. Sessile spikelet lanceolate; lower glume chartaceous, sparsely pilose on the back, 5.5mm long; upper glume glabrous; callus short, round, with hairs 4mm long. Florets 2: lower floret empty, lemma oblong, ciliate on the margins; upper floret bisexual, lemma entire, 3-nerved, awned from the tip; awn bristle-like, 4mm long; epaleate; lodicules 2, minute, fleshy; anthers

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* **pogon**, beard, and **stachyum**, from stachy, which means 'relating to a spike, the epithet therefore alludes to the haity spikelets.

3, 3mm long; ovary oblong. Pedicellate spikelet lanceolate, also with two florets of which the upper is bisexual; anthers 3, 3mm long, pedicels pilose, some barren while others bear the bisexual pedicellate spikelets.

Diagnostic characters and affinities: Many, if not most, of the pedicels bear perfect spikelets.

Habitat: Wet places, especially along water courses.

Type: Angola, country of the Ganguellas and Ambuellas, *Gossweiler* 2225 (K!).

Representative specimens:

Malawi: Madzimarera Dambo, Dzalamanyao, 04.xii.1951, *Jackson* 693 (K).

Zambia: Chisinga Ranch near Lurungi Upland Dambo system, altitude 4600ft, 17.ix.1961, *Astle* 901 (K); Luwingu District, Lunte river dambo, 38km east of Luwingu, 10.ii.1962, *Robinson* 4939 (K); Central Province, Chakwenga Headwaters, 100-129 km east of Lusaka, 27.x.1963, *Robinson* 5770 (K; PRE); Mkushi District, Mkushi river dambo, 27.x.1967, *Simon & Williamson* 1222 (PRE).

Distribution: South Central and Eastern Africa.

2. ***Sorghastrum fuscescens*** (Pilger) Clayton, in Kew Bull. 30(3): 509 (1975).

Synonyms: *Miscanthidium fuscescens* Pilger, in Notizdbl. Bot. Bart. Berlin II: 806 (1933).

Tufted perennial of up to 2m tall. Culm nodes shortly hairy. Leaf blades linear, 10-60cm long, 2-7mm wide, densely and coarsely pubescent; leaf sheaths also pubescent; ligule a short unfringed membrane.

Inflorescence a panicle of about 20-30cm long; the internodes of the main inflorescence axis pilose in the upper third, the rest glabrous, the joints pilose; racemes loose, 3-10cm long, with 3-15 spikelet pairs; raceme peduncles pilose on the upper third of their length; raceme internodes and pedicels pilose along their whole lengths; both pedicellate and sessile spikelets alike with a brown developed brown awn. Sessile spikelet 6mm long, lanceolate; lower glume coriaceous, pilose on the back, lanceolate, 5.5mm long, brown; upper glume keeled in the middle, pilose on the keel only, the rest of the body glabrous, slightly longer than the lower glume, 6mm long, ciliate on the margins. Florets 2: lower floret empty, lemma ovate, ciliate on the margins; upper floret bisexual, lemma bilobed, ciliate on the margins, awned; awn 25mm long, bigeniculate, glabrous; lodicules 2, opaque, fleshy; epaleate; callus 1mm long, rounded with short hair; anthers 3, 4mm long; ovary oblong. Pedicellate spikelet similar to the sessile, also with a bisexual upper floret; glumes coriaceous; anthers 2 or 3, 4mm long; pedicels pilose, some barren while others bear the spikelet.

Diagnostic characters and affinities: Many, if not most, of the pedicels bear perfect spikelets. This species together with *S. pogonostachyum* differ from other members of *Sorghastrum* in this respect, but conform in most other characters.

Habitat: Grassy hillsides and lake margins.

Type: Tanzania, Njombe District, Msima, *Schleiben* 1010 (K!).

Representative specimens:

Malawi: Linthipe Dedza river, 10.iii.1951, *Jackson* 426 (K).

Tanzania: Iringa Province: Njombe, altitude 6000ft, 1931, *Emson* 129 (K); Mufundi, Brooke Bond Tea Estate, about 15km south of Mafinga, 5km north of Ngwazi House in dry marsh, 08°30'S 35°10'E, altitude 1820m, 12.xi.1988, *Gereau & Lovett* 2454 (K).

Zambia: Mporokoso District, near Muzombwe, western side of Mweru-we-Ntipe, altitude 3500ft, 15.iv.1961, *Phipps & Vessey-Fitzgerald* 3218 (BM); Arbecom District, Kawimbe, altitude 5600ft, 26.iii.1959, *Webster* A239 (K).

Distribution: South Central and Eastern Africa.

3. ***Sorghastrum incompletum*** (Presl.) Nash var. ***bipennatum*** (Hackel) Davila, Systematic revision of the genus *Sorghastrum* (1988).

Synonyms: *Andropogon bipennatus* Hackel, Androp. Nov. Fl. 68(8): 142 (1883); *Sorghum bipennatum* (Hackel) Kuntze, Re. Gen. Pl. 2: 791 (1891), based on *Andropogon bipennatus* Hackel; *Sorghum bipennatum* (Hackel) Stapf, Fl. Trop. Afr. IX: 144 (1917), based on *Andropogon bipennatus* Hackel; *Sorghastrum bipennatum* (Hackel) Pilger, in Notizdbl. Bot. Gart. Berlin XIV: 96 (1938).

A weak annual up to 1.5m tall (rarely more than 2m), often decumbent and rooting at the nodes below and with short stilt roots. Culms unbranched; culm nodes with short shiny hairs. Leaf blades up to 30cm long, linear-lanceolate, 3-10mm wide; leaf sheaths striate; ligule a tough membrane.

Inflorescence a loose, narrowly lanceolate panicle; raceme peduncles capillary, glabrous; racemes reduced to a single sessile spikelet, always accompanied by 2 barren pedicels; spikelets golden in colour, narrowly ovate, 4-5.5mm long, with a rounded base; lower glume coriaceous, dark brown, ovate, pilose with white hairs on the back, 5.5mm long; upper glume smooth on the back, also dark brown, boat-shaped. Florets 2: lower floret empty, lemma hyaline, ciliate along margins; upper floret bisexual, lemma entire, awned; awn 40mm long, smooth, scabrid along the spiral, bigeniculate; palea present, single-nerved, small; lodicules 2, fleshy; no anthers seen; ovary ovate. Pedicellate spikelet absent; pedicels 2, 4mm long, barren, pilose with white hairs.

Chromosome number: 2n = 20 (Olorde, 1975).

Diagnostic characters and affinities: Has a looser and darker panicle compared to var. *incompletum*. Also has longer awns.

Habitat: Wooded grasslands.

Type: Suda, Seriba Ghattas, *Schweinfurth* 2486 (K!).

Representative specimens:

Malawi: Dedza District, Mua-Livulezi forest, 09.iv.1964, *Adlard* 607 (SRGH); Lilongwe District, Kampini, 17.iv.1950, *Jackson* 761 (MAL); Zomba, Naisi road, altitude 3500ft, 14.v.1949, *Wiehe* N/106 (K).

Mozambique: Malema District, 09.iv.1962, *Lemos & Marrime* 330 (PRE, K); Cabo Delgado Province, Montepuez area, 21.iv.1984, *Timberlake* 3408 (SRGH); Cabo Delgado, Montepuez, 09.iv.1964, *Torre & Paiva* 11.833 (K).

Zambia: Chipata District (no exact location given), 17.iii.1970, *Abel* 182 (SRGH); Luangwa valley, Mfuwe Camp, altitude 2000ft, 01.iv.1966, *Astle* 4765 (K).

Zimbabwe: Gokwe District (no exact location given), 15.iii.1984, *Mahlangu* 975 (SRGH, K).

Distribution: African variety of *Sorghastrum incompletum*: tropical areas of Africa; Sudano-Zambesian and Guineo-Congo regions.

4. ***Sorghastrum elliottii*** (Mohr) Nash, Nor. Amer. Flor. 17: 13 (1912).-Britton & Brown, Ill. Fl. (ed.2)i: 120, fig. 275 (1913).-Silveus, Texas Grasses: 743, 745 (1933).-Hitchcock, Man. Grasses U. S. (ed.1): 753, fig. 1672, fig. 1673 (1935).-Blomquist, Grasses N. Carolina: 205, fig. 229 (1948).-Allen, Grasses of Louisiana: 110 (1975).-Davila, Systematic revision of the genus *Sorghastrum* (1988).

Synonyms: *Chrysopogon elliottii* Mohr., Bull. Torrey Club 24: 21 (1897); *Andropogon nutans* Elliot, Bot. S. C. and Ga. 1: 144 (1816); *Sorghum nutans* Chapman, Fl. S. U. S.: 5853 (1883); *Sorghum nutans* ssp. *linneanum* Hackel, Fl. Bras. 2: 276 (1883); *Andropogon nutans* var. *linneanus* (Hackel) Hackel, in DC., Monogr. Phan 6: 531 (1889); *Chrysopogon nutans* var. *linneanus* (Hackel) Mohr., Bull. Torrey Club 24: 21 (1897), based on *Sorghum nutans* ssp. *linneanum* Hackel; *Andropogon linneanus* (Hackel) Scribner & Kearney, Bull. Us. Dep. Agr. Agrost. 24: 40 (1901), based on *Andropogon nutans* var. *linneanus* (Hackel) Hackel;

Sorghastrum linneanum (Hackel) Nash, in Small, Fl. S. E. U.S.: 66 (1903), based on *Sorghum nutans* Chapman; *Sorghastrum apalachicolense* Hall, Sida 9(4): 302 (1982).

Perennial grass with fibrous roots. Culms single or tufted, mostly 80-180cm tall, erect; culm nodes hidden by leaf sheaths. Leaf blades 40 cm long or less, mostly 3-8mm wide, striate, glabrous, scabrous (rough); leaf sheaths smooth and glabrous; ligule firm, membranous, truncate or variously lobed, 2-4mm long, thickened laterally to form stiff sheath auricles.

Inflorescence a narrow, loosely and sparsely flowered panicle 15-25cm long; racemes consisting of single sessile spikelets accompanied by 2 hairy pedicels; raceme peduncles glabrous or sparingly pilose towards the apex. Sessile spikelets deep chestnut brown, about 6.5mm long; lower glume hirsute with yellowish-brown or cream white hairs on the back, lanceolate, 9-nerved, 6.5mm long; upper glume lanceolate, 6mm long, shortly mucronate, carinate, the back mostly glabrous, 5-nerved, sparsely ciliate on the incurved inner margins; callus short and blunt with yellowish-brown or cream white hairs. Florets 2: lower floret empty, lemma broadly ovate, 4.5mm long, 2-nerved, ciliate along the margins; upper floret bisexual, lemma bidentate (bilobed), awned from the sinus; awn 35mm long, dark brown and twisted, the column geniculate, several times longer than the spikelet; lodicules 2, small, fleshy, highly vascularised; anthers 3, 2.2mm long; caryopsis obovate; pedicels 4.5mm long, with yellowish brown hairs up to 2mm long.

Chromosome number(s): 2n = 20 (Brown, 1950; Garber, 1950).

Habitat: In sandy soils and in or along margins of woodlands.

Type: Nash (North American Flora 17 (1912)) indicates the type locality to be South Carolina, USA. Despite an exhaustive search for this type, I was not able to track it.

Representative specimens:

United States of America:

Alabama: Lawrence County, 8.8 miles south of Meulton, 23.ix.1970, *Kral* 41261 (BM).

Georgia: Elbert County, north side of Broad river at Anthony Shoals, 14½ miles south-east of Elberton, 01.xi.1949, *Duncan* 10574 (BM).

North Carolina: Mecklenburg County, 7 miles west of Huntersville along the Catwaba river, 02.xi.1958, *Ahles & Duke* 50115 (E).

South Carolina: McCormick County, 6 miles south-west of McCormick, 18.ix.1949, *Duncan* 10394 (BM).

Texas: Smith County, Amigo, 19.ix.1945, *Moore* 1041 (E, BM).

Virginia: Sussex County, State Game Sanctuary, north-west of Newville, 18.ix.1945, *Fernald & Long* 14895 (BM).

Distribution: South-eastern and eastern USA.

5. ***Sorghastrum minarum*** (Nees) Hitchcock, Contr. U. S. Nat. Herb. 24: 501 (1927).- Davila, Systematic revision of the genus *Sorghastrum* (1988).

Synonyms: *Trachypogon minarum* Nees, Agrost. Bras.: 349 (1829); *Andropogon minarum* (Nees) Kunth, Rev. Gram. 1: 507 (1830), based on *Trachypogon minarum* Nees; *Stipa penniglumis* Trin., Mem. Acad. St. Petersb. 1: 77 (1833); *Chrysopogon minarum* (Nees) Bentham, Linn. Soc. 9: 73 (1881), based on *Trachypogon minarum* Nees; *Sorghum minarum* (Nees) Hackel, Fl. Bras. 2: 276: (1883), based on *Trachypogon minarum* Nees.

A slender erect perennial to about 1.5m tall. Culms rooting from the lower nodes; culm nodes hidden by sheaths, with short velvety hairs where exposed. Leaf blades flat, mostly glabrous, infrequently with short tubercle-based hairs on the upper surface, up to 35cm long and 10mm wide, linear-lanceolate and becoming attenuate;

leaf sheaths longer than the internodes, striate, glabrous, drawn into a stiff membranous ligule of about 10mm long.

Inflorescence a profusely divided panicle 10-25cm long, compact with long awned spikelets giving it a characteristic facies; main inflorescence axis and raceme peduncles glabrous. Sessile spikelets 10mm long, narrowly lanceolate; lower glume glabrous except towards the base and on the side keels, opaque, 7.5mm long, narrowly lanceolate with a truncate apex; upper glume 7mm long, narrowly lanceolate, with a single sharp keel on the back and pointed cilia at the apex. Florets 2: lower floret empty, lemma ovate, 3-nerved and ciliate on the margins, hyaline; upper floret bisexual, lemma awned, bidentate; awn 7cm long, chestnut brown, bigeniculate, with hairs 2mm long along the spiral, tightly twisted; epaleate; lodicules 2, fleshy; callus sharp, with long whitish hairs, 3mm long; no anthers seen; caryopsis obovate pedicels 2, hairy, 3.5mm long.

Chromosome number(s): 2n = 20 (Pereira, 1982 & 1986).

Habitat: Plains and open grasslands.

Type: Type not found. Type locality not known.

Representative specimens:

Argentina: Posadas, Loreto, Yabebiriz, 31.i.1908, *Ekman* 563 (BM); Province Corrientes, 24.ii.1951, *Pederson* 1033 (E).

Brazil: (no location given), 14.iv.1909, *Dusén* 7962 (E).

Paraguay: Cordillera de Altos, Cerro Choice, 23.i.1903, *Fiebrig* 779 (E); Zwischen Rio Apa und Rio Aquidaban, i.1909, *Fiebrig* 5089 (BM); Cordillera de Ville-Rica, i.1905, *Hassler* 8774 (BM); in regione lacus Ypacaray, i.1913, *Hassler* 12480 (E, BM); Prope Sapucay, ix.1913, *Hassler* 13025 (E, BM).

Distribution: South America, in Argentina, Paraguay, Bolivia and Brazil.

6. ***Sorghastrum setosum***[*] (Griseb.) Hitchcock, Contr. U. S. Nat. Herb. 12(6): 195 (1909).-Hitchcock, Manual of the grasses of the West Indies: 409 (1936).-Davila, Systematic revision of the genus *Sorghastrum* (1988).

Synonyms: *Andropogon setosus* Griseb., Cat. Pl. Cuba: 235 (1866); *Sorghum parviflorum* Desv., Hamilton Prodr. Pl. Ind. Occ. 12 (1825); *Trachypogon stipoides* (HBK) Nees, Fl. Bras.: 351 (1829); *Andropogon francavillamus* Fourn., Mex. Pl. 2: 56 (1881); *Andropogon agrostoides* Speg., Anal. Soc. Genc. Argent. 16: 36 (1883); *Sorghum nutans* ssp. *micranthum* var. *submuticus* Hackel, Fl. Bras. 2(3): 275 (1883), based on *Andropogon setosus* Griseb; *Andropogon nutans* var. *submuticus* (Hackel) Hackel, in DC., Monogr. Phan. 6: 529 (1889), based on *Andropogon setosus* Griseb; *Andropogon nutans* var. *agrostoides* (Speg.) Hackel, in DC., Monogr. Phan 6: 529 (1889), based on *Andropogon agrostoides* Speg.; *Sorghastrum francavillanum* (Fourn.) Hitchcock, Contr, U. S. Nat. Herb. 12(6): 195 (1909), based on *Andropogon francavillanum* Fourn; *Sorghastrum agrostoides* (Speg.) Hitchcock, Bot. Gaz. 51: 300 (1911), based on *Andropogon agrostoides* Speg.; *Sorghastrum parviflorum* (Desv.) Hitchcock & Chase, Contr. U. S. Nat. Herb. 18: 287 (1917), based on *Sorghum parviflorum* Desv.; *Sorghastrum stipoides* (HBK) Nash ssp. *agrostoides* (Speg.) Ros., Arr. & Iz., Gramineas Uruguayas: 201 (1970), based on *Andropogon stipoides* HBK and *Andropogon agrostoides* Speg.

A tall tufted perennial grass. Culms up to 1.5m tall, glaucous, bluish green; culm nodes glabrous, upper portion of culm internodes tinged pinkish-red. Leaf blades long, up to 50cm long, 7mm wide, involute or flat, striate, glabrous; leaf sheaths glabrous, striate, rarely hirsute at the apex; ligule a membrane 2mm long.

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[*] **setosu(s)m**, setose, bristly, i.e., beset with scattered ascending stiff hairs.

Inflorescence a panicle 20cm long, oblong to oblong-linear; racemes 1-5-jointed; raceme peduncles glabrous; rachis internodes pilose; sessile spikelets accompanied by pilose pedicels (every sessile spikelet with a pedicel and the terminal with two pedicels); pedicels about ½-¾ the length of the spikelet; spikelet yellowish-brown in colour; lower glume pilose on the back with very fine and uniformly distributed hairs, 3.5mm long, ovate; upper glume glabrous on the back, shiny, narrowly ovate-lanceolate or boat-shaped, 4mm long. Florets 2: lower floret empty, lemma ovate, same length as lower glume, 2-nerved; upper floret bisexual, lemma entire, 3-nerved, awnless; lodicules 2, fleshy; anthers 3, 2mm long; ovary obovate, tiny; pedicels barren, 3mm long.

Chromosome number(s): 2n = 20 (Saura, 1944; Carnahan & Hill, 1961; Davidse & Pohl, 1972 & 1974; Pereira, 1986).

Diagnostic characters and affinities: This species can be either awned or awnless. Most specimens seen were however awnless. *Pedersen* 1003 is the only awned form, with an imperfect awn about 3mm long, the exserted portion not longer than the spikelet.

Habitat: In wet seasonally flooded areas.

Type: Type locality, Cuba.

Representative specimens:

Argentina: (both without locality), 07.ii.1951, *Pedersen* 1003 & 27.iii.1957, 4522 (E).

Brazil: Território Federal de Roraima, Municipio de Boa Vista, Reserva Ecológica De Maraca, 61°50'W 3°35'N, 28.iii.1987, *Lewis* 1584 (E); Territory of Roraima, SEMA Ecological Reserve, Ilha de Maraca, Roraima, 3°22'N 61°25'W, Santa Rosa area, about 4km north-east of Station buildings, 30.i.1988, *Ratter, Milliken, Ramos & Mota* R6172 (E).

Guatemala: Sacate, 25.viii.1971, *Ortíz* 1868 (BM).

Jamaica: St. Andrew, Greenwich Bridle road, altitude 3000ft, 06.vii.1960, *Adams* 7496 (BM); Bermuda Mt., Port Royal Mtns., altitude 2300ft, 13.vii.1913, *Harris* 11635 (BM); Hall's Delight, St. Andrew, altitude 1000ft, 22.vii.1916, *Harris* 12394 (BM).

Distribution: Tropical and subtropical regions of the Americas.

7. ***Sorghastrum nutans****[*] (L.) Nash, in Small, Fl. Southeast U. S.: 66 (1903).-Nash, in North Amer. Fl. 17: 129 (1912).-Britton & Brown, Ill. Fl. (ed.2)i: 120 (1913).-Deam, Grasses of Indiana: 327 (1929).-Silveus, Texas Grasses: 742, 744 (1933).-Hitchcock, Man. Grasses U. S. (ed.1): 752 (1935) and (ed.2): 777 (1951).-Kearney & Peebles, Fl. Pl. & Ferns Ariz.: 153 (1942) and Ariz. Pl.: 143 (1951).-Blomquist, Grasses N. Carol.: 205, 228, 247 (1948).-Fernald, Gray's Man. (ed.8): 234, 333 (1950).-Fasset, Grasses of Wisconsin: 94, 350 (1951).-Gould, The grasses of Texas: 577 (1975).-Davila, Systematic revision of the genus *Sorghastrum* (1988).

Synonyms: *Andropogon nutans* L. Sp. Pl. ed. 1: 1045 (1753); *Andropogon avenaceus* Michx., Fl. Bor. Amer. 1: 58 (1803); *Andropogon ciliatus* Ell., Bot. S. C. & G. 1: 144 (1816); *Sorghum nutans* (L.) A. Gray, Man.: 617 (1848); *Sorghum avenaceum* Chapm., Fl. South U. S.: 583 (1860); *Chrysopogon nutans* (L.) Benth., in J. Linn. Soc. Bot. 19: 73 (1881); *Chrysopogon avenaceus* (Michx.) Benth., in J. Linn. Soc. Bot. 19: 73 (1881); *Sorghum nutans* subsp. *avenaceum* (Michx.) Hack., in Mart., Fl. Bras. 2: 3, 274 (1883); *Sorghum nutans* subsp. *linnaeanum* Hack., in Mart., Fl. Bras. 2: 276 (1883); *Andropogon albescens* Fourn., Mex. Pl. 2: 56 (1886); *Andropogon confertus* Trin. ex Fourn., Mex. Pl. 2: 55 (1886); *Andropogon nutans* var. *avenaceus* (Michx.) Hack., in DC., Monogr. Phan. 6: 539 (1889); *Chrysopogon nutans* var. *avenaceus* Cov. et Brann., Rept. Geol. Surv. Ark. 4: 234 (1891); *Poranthera nutans*

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[*] **nutans**, nodding (direction), inclining very much from the perpendicular so that the apex is directed downwards, alluding to the inflorescence which is said to be nodding in the living state.

Raf. ex Jacks., Ind. Kew 2: 606 (1894); *Poranthera ciliata* Raf. ex Jacks., Ind. Kew 2: 606 (1894); *Chrysopogon nutans* var. *linnaeanus* Mohr., in Bull. Torr. Bot. Club 24: 21 (1897); *Sorghastrum avenaceum* (Michx.) Nash, in Britton, Man. Fl. N. U. States: 71 (1901); *Andropogon linnaeanus* (Hack.) Scribn. et Kearn. in Scribn. et Ball., in Bull. U. S. Dept. Agric., Div. Agrost. 24: 40 (1901); *Sorghastrum linnaeanum* (Hack.) Nash, in Small, Fl. Southeast U. S.: 66 (1903); *Holcus nutans* (L.) O. Kuntze. ex Stuck., in Ann. Mus. Nac. Buenos Aires 11: 48 (1904); *Holcus nutans* var. *avenaceus* Hack. ex Stuck., in Ann. Mus. Nac. Buenos Aires 11: 48 (1904); *Chalcoelytrum nutans* (L.) Lunell, in Amer. Midl. Nat. 4: 212 (1915).

A perennial grass. Culms erect from short scaly rhizomes, 80cm to 2m tall; culm nodes hispid with stiff short hairs. Leaf blades long, linear, flat, mostly 5-10mm wide (rarely more than 15mm wide), tapering to a narrow base and an attenuate apex, glabrous, scabrous; leaf sheaths glabrous or the lower ones infrequently slightly hispid, continued at the apex as a stiff membranous ligule; ligule 2-5mm long, usually developed marginally as thickened, pointed sheath auricles.

Inflorescence a contracted panicle 15-30cm long; uppermost branchlets, inflorescence joints, raceme peduncles and pedicels all hispid with silvery hairs; racemes 2-5-jointed. Spikelets 6-8mm long, the glumes light brown or straw coloured; lower glume flat or slightly concave on the back, hirsute, narrowly ovate, 7mm long; upper glume 7mm long, convex on the back, glabrous. Florets 2: lower floret empty, lemma broadly ovate, emarginate, ciliate along the margins; upper floret bisexual, lemma awned, entire, ciliate along margins; awn 15mm long, geniculate, with a tightly twisted column; epaleate; only filament remains seen; caryopsis narrowly obovate; pedicel hairy, 4mm long.

Chromosome number(s): 2n = 20 (Carnahan & Hill, 1961); 40 (Church, 1929; Brown, 1950; Bowden, 1960); 80 (Gould, 1968).

Diagnostic characters and affinities: Inflorescence is said to be nodding in the living state, hence the name *nutans*.

Habitat: Important range forage species and indicator of range in good condition (Gould, 1975); prairie grass of North America.

Uses: Native pasture species.

Type: Type locality, Virginia, USA.

Representative specimens:

United States of America:

Indiana: Wells County (no exact location), 15.ix.1901, *Deam s.n.* (E).

Kansas: Douglas County, Lawrence, ix.1892, *Stevens* 102 (E).

Missouri: Jefferson County, Seckman, 04.ix.1972, *Christ s.n.* (E).

New Mexico: Sierra County, south of the Black Range, 24.viii.1904, *Metcalfe* 1242 (E).

North Carolina: Iredell County, Catwaba river, 24.xi.1958, *Ahles & Haesloop* 51874 (E).

Texas: Smith County, Amigo, 07.xi.1945, *Moore* 1049 (E).

Distribution: Central and East USA, Mexico, introduced to India.

8. ***Sorghastrum friesii*** (Pilg.) Pilg., Notizbl. Bot. Gart. Berlin XIV: 96 (1938).

Synonyms: *Andropogon friesii* Pilger, in R. E. Fries, Erg. Schwed. Rhod.-Kongo Exped. 1911-1912 I: 195 (1916); *Sorghum micratherum* Stapf, in Prain, Flor. Trop. Afr. 9: 142 (1917), based on *Andropogon nutans* var. *angolense* Rendle, Cat. Afr. Pl. Welw. 2(1): 152 (1899); *Sorghum friesii* (Pilger) Hubbard, in Kew Bull. Misc. Inf.: 109 (1934), based on *Andropogon friesii* Pilger.

Tufted, shortly rhizomatous perennial. Culms up to 120cm tall, often rooting from the lower nodes; culm nodes many (crowded) in the lower part, with inconspicuous velvety hairs; culm internodes terete, hollow. Leaf blades glabrous, to 20cm long and 2-6mm wide, linear to linear-lanceolate, usually reflexed, leaf base expanded; leaf sheaths non-auriculate, glabrous; ligule an unfringed membrane, 0.5-1.5mm long.

Inflorescence a loose open panicle; primary branches divided; raceme peduncles glabrous, sometimes hairy towards the apex; racemes (2-)4-7-jointed; rachis internodes and pedicels hairy. Sessile spikelet 5-7(-8)mm long, lanceolate; callus obtuse, bearded; glumes papery; lower glume hirsute on the back, slightly depressed longitudinally; upper glume glabrous, boat-shaped. Florets 2: lower floret represented by a hyaline lemma, lemma ovate, 5mm long, finely 2-nerved, ciliate on the upper margins, apex emarginate; upper floret bisexual, lemma bilobed, 4mm long, lobes glabrous, awned; awn 3-8(-10)mm long, straight, glabrous; epaleate; lodicules 2, tiny, fleshy, glabrous; anthers 3, 4-5mm long; ovary oblong; pedicel 5mm long, shorter than the sessile spikelet, hairy, curved towards the base.

Habitat: Typically favours wet areas such as swamps, road drains and stream banks. Often on poor sandy soils.

Type: Type not seen. Type locality not known.

Representative specimens:

Botswana: Ngamiland, Boro flood plain, altitude 940m, *Biggs* M517 (SRGH); 11km south of Gumare on road to Nokaneng, 18.iii.1976, *Ellis* 2680 (K); Boro river at Buffalo fence north of Maun, altitude 920m, 28.ii.1987, *Long & Rae* 464 (E); Lediba at Matsaudi aga Mmatalelo Island, 30.iii.1973, *Smith* 503 (K); Floodplain near Kwara Bochai river, 02.vi.1973, *Smith* 562 (E); Xudum Drainage, Okavango, altitude 3300ft, 15.iii.1961, *Vessey-Fitzgerald* 3241 (BM); Okavango river, 19km north of Shakawe on Botswana (Bechuanaland) border, 16.iii.1965, *Wild & Drummond* 7091 (BM); Kwando, James Camp, 18°22'S 23°32'E, 11.iv.1975, *Williamson* 16 (K).

Namibia: Rundu, Dcatsingu, Kavango, altitude 1060m, 13.iii.1986, *Potgieter* 352 (E).

Zambia: Mushwishi Agricultural Station, Broken Hill, altitude 3800ft, 08.xii.1953, *Hinds* 175 (K); roadside at Munshiwemba, 17.i.1942, *Stohr* 744 (PRE); Abercorn District, Saisi river (near Jericho), 27.ii.1958, *Vesey-Fitzgerald* 1547 (K).

Zimbabwe: Gwelo District, G.T.C. sand, altitude 4600ft, 10.iii.1967, *Biegel* 1989 (BM); Gokwe District, about ½mile north of Gokwe, 11.ii.1963, *Bingham* 484 (SRGH); Victoria District, 30.iii.1973, *Chiparawasha* 665 (K); Shangani, Gwampa vlei at Tunke pan, Gwampa Forest Reserve, altitude 3000ft, ii.1956, *Goldsmith* 31/56 (K); Sipolilo, Nyamunyeche Estate, Karoi vlei, 07.ii.1979, *Nyariri* 673 (PRE); Matobo District, Mtsheleli Dam, altitude 4400ft, 20.ii.1965, *Simon* 160 (BM).

Distribution: A southern African species.

9. ***Sorghastrum stipoides*** (Kunth) Nash, in N. Amer. Fl. 17: 129 (1912).-Clayton & Renvoize, in Polhill, Fl. Trop. E. Afr. Gramineae Part 3: 732, fig. 169 (1982).

Synonyms: *Andropogon stipoides* Kunth, in H.B.K., Nov. Gen. Sp. 1: 189 (1816); *Andropogon trichopus* Stapf, in Kew Bull. 1897: 287 (1897); *Sorghum trichopus* (Stapf) Stapf, in Fl. Trop. Afr. 9: 141 (1917); *Sorghum rigidifolium* Stapf, in Fl. Trop. Afr. 9: 143 (1917); *Sorghastrum trichopus* (Stapf) Pilg., in Engl. & Prantl, Pflanzenfam., edn 2, 14e: 142 (1940); Clayton, in Hepper, Fl. West Trop. Afr., edn2, 3: 468 (1972); *Sorghastrum rigidifolium* (Stapf) Chippindall & Pole Evans, in Mem. Bot. Surv. S. Afr. 22: 247 (1948), Chippindall, in Meredith, Grasses and pastures of South Africa: 468 (1955).

A robust tufted perennial up to 1.5m tall with a hard creeping rhizome. Culms erect, usually unbranched, the internodes glabrous, nodes with a ring of inconspicuous adpressed white hairs. Leaf blades usually glabrous, 15-45cm long and 3-6mm wide, usually inrolled, rigid and conspicuously narrowed towards the base; leaf sheaths auriculate; ligule an unfringed membrane, 1.5-4mm long.

Inflorescence a linear-lanceolate panicle, about 20cm long, primary branches subverticillate, with capillary peduncles; racemes 1-4-jointed; rachis internodes violet-hirsute. Spikelets all alike, lanceolate, 4-7(-8)mm long, the laterals each accompanied by a single densely violet-hirsute pedicel, the terminal on each raceme by two such pedicels; callus rounded, hirsute; lower glume 7mm long, coriaceous, tawny, green-nerved, pale violet-hirsute, broadly convex across the back, emarginate; upper glume about same length as lower glume, paler, glabrous proximally, shortly hirsute distally, emarginate. Florets 2: lower floret reduced to a hyaline lemma; upper floret bisexual, with a linear bilobed lemma, ciliate on the margins; awn geniculate, flattened distally, 8-16mm long, glabrous; palea hyaline, minute; lodicules 2, fleshy, glabrous; anthers 3; caryopsis oblong.

Habitat: Low lying areas subject to flooding.

Type: Colombia, Popayan to Almaguer, near Rio Putes, at the foot of Mt. Socobon, *Humboldt & Bonpland* (P, K).

Representative specimens:

Malawi: Zomba, near Tongani, 20.iv.1950, *BW* N/492 (MAL); Karonga, Mwemtete Dambo, 26.vi.1951, *Jackson* 552 (K); Mposa Dambo, 13.v.1952, *Jackson* 814 (K); Nkhotakota District, Katimbira village, T.A. Kanyenda, 13.v.1986, *Patel & Kwatha* 3194 (MAL).

Mozambique: Sul do Save, Maputo, 20.ii.1952, *Mrye & Carvalho* 1148 (K); Mahotas, Marracuene, xii.1945, *Pimenta* 52565 (PRE, SRGH); Beira District, Cheringoma Coastal Area, Zuni Drainage, 5km west of Nyamaruza Camp, v.1973, *Tinley* 2842 (K).

South Africa: Transvaal: White river, 'Pull Scar, altitude 3300ft, 05.v.1929, *Mogg s.n.* (K); Pilgrimsrest District, 09.ii.1961, *Strey* 3592 (K).

Zambia: Mbala District, Uninji pans, altitude 5000ft, 16.v.1968, *Sanane s.n.* (K); Abercorn District, wet pasture near Lunzuo river bridge, 20 miles from Abercorn, altitude 5000ft, 5.iv.1959, *Webster* A283 (K).

Distribution: Tropical America and Tropical Africa.

8.2.3. ***Asthenochloa*** Büse, in Miq., Pl. Jungh.: 367 (1854).-Backer & Brink, Flora of Java: 602 (1968). The type species is *Asthenochloa tenera* Büse.

Synonym: *Garnotiella* Stapf, in Hook. Ic. Pl. 25: t 2494 (1896).

Decumbent perennial. Inflorescence a branched panicle; ultimate branchlets pedicel-like; spikelets sessile, accompanied by a minute pedicel (rudiment of pedicellate spikelet) scarcely visible among callus hairs; spikelets very small (2mm long); callus obtuse; lower glume herbaceous, broadly convex; upper glume laterally compressed, navicular-keeled, acutely acuminate or with a short awn (mucronate); lower floret suppressed; lower lemma and palea wanting; upper floret bisexual; upper lemma shortly bilobed, awned; lodicules absent; anthers 2; caryopsis oblong. Pedicellate spikelet reduced to a tiny barren pedicel concealed in the callus beard.

Species 1.

Asthenochloa tenera Büse, in Miq., Pl. Jungh.: 368 (1854).-Backer & Brink, Flora of Java: 602 (1968).

Synonym: *Garnotiella philippinensis* Stapf, in Hook. Ic. Pl. 25: t 2494 (1896).

A perennial grass. Culms slender, erect or ascending, weak, sparingly branched, terete, glabrous. Leaf blades narrowly lanceolate, with strongly narrowed base and acute tip, glabrous on both sides with scabrous margins, the margins pilose underneath; leaf sheaths glabrous, striate; ligule short, ciliate.

Inflorescence a branched panicle, oblong, 4-10cm long; ultimate branchlets pedicel-like, with a cupuliform pilose apex, bearing a minute pedicel (rudiment of pedicellate spikelet) scarcely visible among callus hairs, 1 sessile spikelet. Spikelet with 2 florets, one empty and the other bisexual, with a geniculate awn; glumes thinly herbaceous, subequal; lower glume as long as the spikelet or somewhat shorter, with an emarginate apex, on either side of the back with 2 very slender nerves; upper glume as long as spikelet, navicular-keeled, with broad hyaline margins embracing floret, acutely acuminate or with short awn (mucronate), 3-nerved; upper lemma small, thinly membranous, acutely 2-lobed, with a rather long, geniculate awn from sinus; awn column twisted, bristle straight and serrated; palea and lodicules absent; anthers 2, linear; ovary glabrous; styles 2, free, rather long; stigma feathery; caryopsis oblong. Pedicellate spikelet absent.

Diagnostic characters and affinities: The main characteristic feature is the completely suppressed pedicellate spikelet represented by a minute rudimentary pedicel hidden by the callus hairs.

Habitat: Shaded places, steep banks of terraces, and of roads, dry river beds.

Type: Philippines, Miagao, Province Ilo-ilo, iii.1886, *Vidal* 3994 (K!).

Representative specimens:

Java: altitude 200-600m, 19.iv.1920, *Backer* 30773 (K); Lombok, altitude 1185-1265m, 31.v.1909, *Elbert* 1601 (K); Timor, ii - iv.1929, *Walsh* 58 (BM).

Philippines: Province of Benguet, Luzon, Buea river, x - xi.1905, *Merrill* 4322 (K); Miagao, Province Ilo-ilo, iii.1886, *Vidal* 3994 (K).

Distribution: Java and The Philippines.

8.2.4. *Hemisorghum* C. E. Hubbard, in Bor, Grasses Burma Ceylon India & Pak.: 686 (1960). The type species is *Hemisorghum mekongense* (A. Camus) C. E. Hubbard.

Tufted perennials. Inflorescence a panicle, its primary branches subdivided, bearing long loose racemes with glabrous or scabrid rachis internodes. Sessile spikelet callus obtuse; lower glume thinly coriaceous, flattened on the back, glabrous, 2-keeled for most of its length, the margins becoming sharply inflexed towards the base; upper lemma awned or awnless; lodicules glabrous. Pedicellate spikelet smaller than the sessile and neuter.

Species 2.

A key to the species:

Sessile spikelet awnless; leaf blades broad (up to 45mm); panicle axis and raceme peduncles relatively thick. 1. ***mekongense***

Sessile spikelet awned; leaves narrow (up to 10mm); panicle axis and raceme peduncles filiform. 2. ***venustum***

1. ***Hemisorghum mekongense*** (A. Camus) C.E. Hubbard, in Bor, Grasses Burma Ceylon India & Pak.: 687 (1960).

Synonyms: *Sorghum halepense* (L.) Pers. var. *mekongense* A. Camus, in Bull. Mus. Hist. Nat. Paris 25: 497 (1919); *Sorghum mekongense* (A. Camus) A. Camus, in Lecomte, Fl. Indo-Chine 7: 323 (1922).-Rhind, Grasses Burma: 65 (1945); Schmidt, in Agron. Tropicale 13: 212 (1958).

Tufted perennial. Culms tall, stout, erect, solid, terete, simple or sparingly branched. Leaf blades lanceolate, broad, 25-45mm wide, flat; ligule very short, truncate, densely short ciliate.

Inflorescence a large, loose panicle with numerous verticillate branches; racemes few-to-several-noded. Sessile spikelet bisexual, awnless; glumes dissimilar; lower glume lanceolate, obtuse, flat or slightly convex on the back in the lower part, 2-keeled, with narrow inflexed margins; upper glume lanceolate, acute, rounded on the back below the middle, with membranous ciliate margins. Florets 2: lower floret barren, lemma slightly shorter than the glumes, lanceolate-oblong, palea absent; upper floret bisexual, lemma oblong-lanceolate or narrowly ovate, entire or shortly bilobed, finely 1-nerved, with the nerve sometimes produced as a minute mucro between the lobes; palea present, as long as the lemma, similar in texture, linear-oblong, nerveless; lodicules very small, glabrous; anthers 3, 3mm long; ovary ovate. Pedicellate spikelet neuter, linear to narrowly lanceolate, smaller than the sessile; lower glume linear to narrowly lanceolate, 2-keeled, scabrid on the keels; upper glume slightly shorter to much shorter than the lower, narrowly lanceolate-oblong, keeled on the back towards the apex, membranous; lower lemma much reduced or absent; epaleate.

Diagnostic characters and affinities: Awnless spikelets, very broad leaves, robust plant and erect, a large panicle. Both panicle axis and raceme peduncles comparatively thicker, non-linear and shorter, making the inflorescence much compact than that of *H. venustum.*

Habitat: Along river banks.

Type: Laos, Mekong, Paklai, Muong mai, *Lakône* (whereabouts uncertain).

Representative specimens:

Burma: Mergui District, Tenasserui river, 03.v.1932, *Maung Po Khant* 13417 (4 sheets, K).

Thailand: Palanam Sifaram, altitude 1200m, 06.v.1932, *Kerr* 21356 (4 sheets, K).

Distribution: South Burma to Indo-China.

2. ***Hemisorghum venustum*** (Thw.) W. D. Clayton, in Kew Bull. 27(3): 448 (1972).

Synonyms: *Andropogon venustus* Thw., Enum. Pl. Zeyl.: 367 (1864); *Vetiveria venusta* (Thw.) Willis, Rev. Cat. Pl. Ceylon: 110 (1911); *Bothriochloa venusta* (Thw.) A. Camus, in Ann. Soc. Linn. Lyon n.s 76: 165 (1931); *Capillipedium venustum* (Thw.) Bor, Grasses Burma Ceylon India & Pak.: 113 (1960).

Perennial. Tufted grass, 1.2m tall; basal sheaths complicate and imbricate. Culms unbranched; culm nodes glabrous; culm internodes terete. Leaf blades mostly folded, up to 50cm long and 10mm wide; sheaths keeled, glabrous; ligule a ciliate membrane.

Inflorescence paniculate; panicles drooping; pedicels solid; both pedicels and rachis internodes are glabrous. Sessile spikelet bisexual, larger than the pedicellate one; lower glume 4.5mm long, glabrous, ovate-lanceolate, flat on the back, 2-keeled for most of its length; upper glume 4mm long, with a single keel, spinulose along upper half of keel, hyaline in most of its body. Florets 2: lower floret empty (barren), lower lemma hyaline, drawn to a narrow apex; upper floret bisexual, lemma narrowly elliptic with a bilobed apex, awned; awn about 10mm long, glabrous; anthers 3, 2.5mm long; ovary oblanceolate. Pedicellate spikelet neuter; lower glume 4mm long, lanceolate, glabrous; upper glume 3.5mm long, strongly carinate; upper lemma oblong, 2.5mm long; epaleate; pedicel glabrous, non-linear with a cupuliform apex.

Diagnostic characters and affinities: Awned spikelets, awn bristle-like, tussock forming grass. This species has been moved from genus to genus. It is often placed in *Capillipedium* but does not fit there because that genus has pedicels with a translucent longitudinal groove, and the upper lemma is entire and stipiform. It has also been put in *Vetiveria* but this genus has laterally compressed spikelets with lower glume rounded on the back. Finally it is sometimes placed in *Sorghum*, but *Sorghum* itself has a plump, broadly convex lower glume, 2-keeled only near the tip, ciliate pedicels and rachis internodes and ciliate lodicules.

Habitat: Roadsides and shallow soils of river banks.

Type: Sri-Lanka, Central Province, Rambodde, altitude 4000ft, *Thwaites* 2875 (BM! K!).

Representative specimens:

India: Bababuden Hills District, altitude 6500ft, 29.xii.1893, *Talbot* 3267 (K).

Sri-Lanka: road between Hakgala and Nuwara Eluja, altitude 5400ft, 27.xii.1950, *Ballard* 1264 (K); Markeluja, Moray Estate, 27.x.1993, *Clayton & Jagosekera* 6088

(K); Uva Province, Sita Eluja, lower Patna valley, 29.iii.1968, *Tetsuo, Kayama & Samarakoon* 13542 (K); Nuwara Eluja District, between Hakgala Botanical Garden and Nuwara Eluja, 14.xi.1968, *Wirawan* 754A (K).

Distribution: Southern India and Sri-Lanka.

8.2.5. *Sorghum* Moench, Meth.: 207 (1794) nom conserv; Hubbard, in Hook. Ic. Pl. 34: t 3364 (1938); Garber, in Univ. California Publ. Bot. 23: 283-361 (1950); Snowden, in J. Linn. Soc. Bot. 55: 191-260 (1955); Celarier, in Cytologia 23: 395-418 (1959); Ivanyukovich & Doronina, in Trudy Prikl. Bot. Genet. Selek. 69: 18-27 (1980). The type species is *Sorghum bicolor* (L.) Moench.

Synonyms: *Blumenchia* Koel., Decs. Gram.: 28 (1802); *Sarga* Ewart & White, in Proc. Roy. Soc. Victoria 23: 296 (1911).

Annuals or perennials, tufted or sometimes rhizomatous, mostly robust. Inflorescence a large panicle, its primary branches simple or subdivided, bearing short dense racemes with hairy internodes. Sessile spikelet dorsally compressed; callus obtuse or pungent; lower glume cartilaginous, convex, rounded on the flanks but becoming 2-keeled near the tip, usually hairy; upper lemma awnless, or bilobed and awned; lodicules ciliate. Pedicellate spikelet male or neuter, or reduced to a lower glume.

Species ± 20.

A key to taxa sampled:

Nodes glabrous or pubescent:

Racemes tough or tardily disarticulating; grain large, commonly exposed by the gaping glume; annuals; cultivated. 1. ***bicolor***

Racemes fragile; grain enclosed by the glumes; perennials or annuals; weeds or wild:

Perennial with abundant creeping rhizomes; sessile spikelet epaleate; lodicules ciliate; weed. 2. ***halepense***

Annual, rhizomes absent; palea 2mm long; lodicules glabrous; wild. 3. ***arundinaceum***

Nodes bearded:

Plants annual:

Racemes 3-7-jointed; spikelets variously coloured; sessile spikelet 5-7mm long; callus short and blunt; awn 25-40mm long, glabrous. 4. ***versicolor***

Racemes mostly single-jointed; spikelets a plain colour; sessile spikelet 10-18mm long; callus long and pungent; awn 60(-155)mm long, hairy on the spiral. 5. ***stipoideum***

Plants perennial:

Racemes 3-5-jointed; sessile spikelet 4mm long, epaleate; awned or awnless. 6. ***nitidum***

Racemes 1-6-jointed; sessile spikelet 8mm long; palea present; awn 60(-100)mm long, hairy on the spiral. 7. ***plumosum***

1. ***Sorghum halepense*** (L.) Pers., Syn. Pl. 1: 101 (1805).-Bor, Flora of Assam 5: 352 (1940).-Sturgeon, A revised list of the grasses of Southern Rhodesia Part IV: 6 (1954).-Chippindal, in Meredith (ed.), The grasses and pastures of South Africa: 460 (1955).-Clayton, in Hepper (ed.), Fl. West Trop. Afr. ed.2(3): 467 (1972).-Gould, The grasses of Texas: 575 (1975).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 252 (1982).-Gibbs Russell et al, Grasses of Southern Africa: 320 (1990).-Cope & Hosni, A key to Egyptian grasses: 54 (1991).-Simon, A key to Australian grasses: 158 (1993).

Synonyms: *Holcus halepensis* L., Sp. Pl. ed. 1: 1047 (1753); *Andropogon arundinaceus* Scop., Fl. Cam. ed. 2(ii): 274 (1772); *Milium halepense* (L.) Cav., Descr. Pl.: 306 (1802); *Blumenbachia halepensis* (L.) Koel., Descr. Gram.: 29 (1802); *Andropogon halepensis* (L.) Brot., Fl. Lusit. I: 89 (1804); *Andropogon Sorghum* (L.) Brot. subsp. *halepensis* (L.) Hack. var. *halepensis* (L.) Hack. subvar. *genuinus* Hack., in DC., Monogr. Phan. 6: 502 (1889); *Andropogon halepensis* (L.) Brot. var. *genuinus* (Hack.) Stapf, in Hook., Fl. Brit. Ind. 7: 183 (1896); *Andropogon halepensis* (L.) Brot. *typicus* Asch. et Graebn., Syn. Mitteleur. Fl. II Abt. I: 47 (1898); *Sorghum miliaceum* (Roxb.) Snowden, in J. Linn. Soc. (Bot.) 55: 205 (1955); *Sorghum miliaceum* var. *parvispiculum* Snowden, in J. Linn. Soc. (Bot.) 55: 209 (1955).

Perennial with abundant creeping rhizomes. Culms slender to robust, mostly simple but sometimes branched, 0.5-3.5m tall, up to 2cm wide; culm nodes exposed, glabrous. Leaf blades linear, narrowed to a point at the apex, 20-90cm long, 0.5-4cm wide; leaf sheaths glabrous; ligule an unfringed membrane.

Inflorescence a panicle; lower primary branches naked for about 2-5cm, glabrous; racemes 1 to 5-jointed; rachis internodes and pedicels slender, densely ciliate with whitish hairs, hairs up to 1mm long. Sessile spikelet elliptic, 4-6.5mm long, almost glabrous to densely hairy, awned or awnless; glumes coriaceous; lower glume 2-keeled, keel wings ending in minute teeth, forming with the pointed apex a 3-toothed tip, hairy on the back, dorsally compressed, broadly lanceolate; upper glume sparsely hairy on the back, boat-shaped; callus short and blunt, shortly bearded. Florets 2: lower floret empty, lemma lanceolate, ciliate; upper floret bisexual, lemma bilobed, ciliate, awned or awnless; awn (when present) 12mm long, glabrous, untwisted; epaleate; lodicules 2, fleshy, ciliate on the apical corners; anthers not seen; ovary ovate, small. Pedicellate spikelet male, narrower than the sessile, 5.5mm long; glumes papery; lower glume lanceolate, ciliate on the lateral keels, glabrous, 5.5mm long; upper glume sharply carinate, glabrous, 5.5mm long; lower lemma broadly lanceolate, ciliate on the margins, with a truncate apex, 4mm long; upper lemma ovate, ciliate on margins, 3mm long; lodicules 2, fleshy, glabrous; anthers 3, 2.5mm long; pedicels hairy on the margins.

Chromosome number(s): 2n = 20, 40 (Faruqi, Quraish & Halai, 1979).

Diagnostic characters and affinities: The distinguishing features of this species are the abundant slender wide-spreading rhizomes, narrow leaf blades, and the somewhat small contracted panicles. A frequent variation of the spikelets is the presence or absence of an awn to the upper lemma. The majority of the plants have awned spikelets, but sometimes in specimens of the same gathering and number, the spikelets of one panicle are awned and those of the other awnless. It is also not uncommon to find most of the spikelets in a panicle awnless but accompanied by a few that are distinctly awned. It is on this basis that some authors have recognised two forms or varieties, *S. halepense* subsp. *halepense* (the typical awned form), and *S. halepense* subsp. *muticus* (the awnless form).

Habitat: In moist areas on river banks, in clay soils and wet sandy soils.

Uses: Cultivated fodder.

Type: Type locality, Syria.

Representative specimens:

Australia: Queensland, Proserpicie, *Michael* 1415 (E); Q.A.C - Gatton road, 30.x.1970, *TS* 5291 (E).

Cyprus: Perapedhi, altitude 3500ft, 13.vii.1940, *Davis* 1851 (E).

Russia: Caucasus, District Abkhasia, Sukhumi, altitude 3m, 12.vi.1956, *Davis* 33683 (E).

Saudi Arabia: Jabal Fayja, 100km north-east of Jigan, altitude 5100ft, 02.viii.1982, *Collenette* 3711 (E); Saudia City compound, Jiddah, altitude 20ft, 27.ix.1983, *Collenette* 4583 (E).

Turkey: Province Tunceli, Ovacik, altitude 1400m, 21.vii.1957, *Davis & Hedge* D.31493 (E).

USA: North Carolina, Mecklenburg County, between Newell road and R.R tracks, 0.4 mile north of Newell Post Office, Newell road, 21.x.1966, *Williams & Matthews s.n.* (E).

Distribution: Tropics of Old and New Worlds.

2. ***Sorghum arundinaceum*** (Desv.) Stapf, in Prain, Fl. Trop. Afr. IX: 114 (1917).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 6 (1954).-Clayton, in Hepper (ed.), Fl. West Trop. Afr. ed.2(3): 467 (1972).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 727 (1982).-Lowe, Flora of Nigeria, Grasses: 277 (1989).-Cope & Hosni, A key to Egyptian grasses: 54 (1991).

Synonyms: *Andropogon arundinaceus* Willd, Sp. Pl. 4: 906 (1805); *Rhaphis arundinacea* Desv., Opusc.: 69 (1831); *Andropogon sorghum* var. *effusus* Hack., in DC., Monogr. Phan. 6: 503 (1889); *Andropogon sorghum effusus* Piper, in Proc. Biol. Soc. Wash. 28: 35 (1915); *Sorghum verticilliflorum* (Steud.) Stapf, in Prain, Flor. Trop. Afr. IX: 114 (1917); *Sorghum stapfii* (Hook.f.) Fischer, in Gamble, F.P.I. 10: 1735 (1934); *Sorghum pugionifolium* Snowden, in J. Linn. Soc. (Bot.) 5: 240 (1955).

Short-lived perennial or an annual. Culms 0.3-4m tall, often robust, branched; culm nodes mostly glabrous, sometimes pubescent. Leaf blades variable, often large, 5-75cm long, 5-7mm wide, flat, broadly lanceolate, glabrous on both surfaces, with a prominent whitish midrib, tapering to a fine point; leaf sheaths glabrous, not keeled; leaf ligule a fringed membrane, edged with a fringe of fine hairs and hairy on the back.

Inflorescence a broadly spreading panicle, 10-60cm long; main inflorescence axis angular, glabrous; primary branches divided, pubescent at the nodes; raceme peduncles glabrous; racemes 2-7-jointed; rachis internodes and pedicels hairy. Sessile spikelet (4-)7(-9)mm long, lanceolate to narrowly ovate; glumes coriaceous; lower glume white pubescent, sometimes tomentose or fulvously pubescent, slightly depressed longitudinally on the back; upper glume glabrescent or with sparse hairs on the back. Florets 2: lower floret empty, lemma lanceolate, 5.5mm long, ciliate on the margins; epaleate; upper floret bisexual, lemma deeply lobed, ciliate on the lobes and margins, 3mm long; awn 20mm long, glabrous; palea present, 2mm long, ciliate on margins and apex; lodicules 2, fleshy, glabrous; no anthers seen; caryopsis obovate, 3mm long. Pedicellate spikelet neuter, linear to lanceolate, 6.5mm long; glumes papery; lower glume glabrous; upper slightly shorter than the lower, glabrous; lower lemma glabrous, with a truncate apex; epaleate; pedicel hairy.

Diagnostic characters and affinities: This species is assumed to be the wild progenitor of the grain sorghum, *S. bicolor*. The variability in the species can be attributed to human selection of grain races, and the introgression with the wild species.

Habitat: Swampy soils, streamsides and black clays; also found in disturbed places and old farmland.

Type: Ghana, *Isert* (B).

Representative specimens:

Botswana: North-east District, Tati river, south-east of Francistown, altitude 980m, 04.iii.1985, *Long* 12242 (E); Northern Division, Chadum valley, South-west African border, 16km west of Knau Knau, 14.iii.1965, *Wild & Drummond* 7024 (BM, SRGH).

Malawi: Central region, Mkhota Kota, altitude 490m, 17.vi.1970, *Brummitt* 11519 (MAL); Dedza District, Masasa controlled area, 22.v.1989, *Chikuni, Patel & Nachamba* 79 (MAL); Tanga District, Palombe river, 06.v.1952, *Jackson* 802 (MAL); Kga Boma, 29.i.1943, *Leech* 12 (PRE); Salmia District, Lifidzi Breeding Centre, 21.v.1985, *Patel & Nachamba* 2192 (MAL); Salima District, Chipoka, 25.v.1972, *Salubeni* 1811 (MAL); South, Njanje District, Mwanalundu Hills, 11.I.1990, *Salubeni & Nachamba* 5615 (MAL).

Mozambique: Baroma Province, Msusa, Zambesi valley, 25.vii.1950, *Chase* 2805 (BM); Namagoa, Mocuba, (no date), *Faulkner* 37 (PRE); Gaza Province, Chibute, Miniquenique, Estação Experimental do C.I.C.A., 13.vi.1960, *Lemos & Balsinhas* 98 (PRE); Tete, Cabora Bassa, altitude 215-220m, 09.v.1972, *Pereira & Correia* 2469 (WAG); Maputo Province, Umbeluzi State farm, near Boane, 19.ii.1985, *Timberlake* 3386 (SRGH).

Zambia: Mpika District, Mfuwe, 26.iv.1965, *Mitchell* 2683 (BM, SRGH); (no location given), 04.i.1963, *Rensburg* 1161 (WAG).

Zimbabwe: Urungwe District, Mana pools floodplain, 31.iii.1981, *Dunham* 73 (SRGH); Salisbury (Harare), Crowborough Sewage farm, Mufakose township, 06.ii.1974, *Lenton s.n.* (WAG); Salisbury (Harare) District, Salisbury Research Station, cultivated, 22.ii.1974, *Simon* 2386 (PRE).

Distribution: Throughout Africa, extending eastwards to Australia.

3. ***Sorghum versicolor***[*] Anderss., in Peters, Reise Mossamb.: 563 (1863).-Stapf, Fl. Trop. Afr. IX: 138 (1917).-Sturgeon, A revised list of the grasses of Southern Rhodesia Part IV: 6 (1954).-Chippindal, in Meredith (ed.), The grasses and pastures of South Africa: 459 (1955).-Bogdan, A revised list of Kenya grasses: 55 (1958).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 60 (1958).-Napper, Grasses of Tanganyika: 96 (1965).-Hood, A guide to the grasses of Zambia: 58 (1967).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 729 (1982).-Gibbs Russell et al, Grasses of Southern Africa: 302 (1990).

Synonyms: *Andropogon serratus* var. *versicolor* Hack., in DC., Monogr. Phan. 6: 522 (1889); *Sorghum purpureo-sericeum* (A. Rich.) Aschers. & Shweinf. var. *trinervatum* Chiov., Fl. Somal 2: 439 (1932).

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[*] **versicolor**, variously cloured or changing colour, referring to the differently coloured spikelets.

An annual of up to 2.5m tall. Culms slender, with a very conspicuous ring of long, silky white hairs spreading round the culm from each node. Leaf blades hairy on both surfaces, occasionally glabrous on the upper surface, 10-30cm long, up to 15mm wide; leaf sheaths glabrous, bearded with long cilia at the mouth; ligule an unfringed membrane, to 3mm long.

Inflorescence an open panicle to 25cm long; branches simple; main inflorescence axis glabrous, smooth, bearded at the nodes; raceme peduncles glabrous, smooth, with prominent pulvini; racemes 3-7-jointed; rachis internodes and pedicels long hairy. Sessile spikelet elliptic-oblong, (5-)5.5(-7)mm long; lower glume coriaceous, glossy, reddish brown to black, pilose on the back, bearded from the callus with pallid to reddish hairs; upper glume also coriaceous and same colour as lower, tapers to a fine apex, pilose above the middle, glabrous and shiny below. Florets 2: lower floret empty, lemma 4mm long, ciliate on the margins; epaleate; upper floret bisexual, lemma 3mm long, deeply lobed, ciliate on the lobes and margins, awned; awn (25-)40mm long, twisted, scabrid along the spiral; lodicules 2, fleshy, densely ciliate from the apical corners; anthers 3, 2.5mm long; ovary oblong. Pedicellate spikelet neuter, smaller than sessile [(3-)4(-5)mm long], lanceolate, greenish; lower glume membranous, hirsute on the back; upper glume also membranous, glabrous to scabrid, enclosed in the lower; pedicel hairy.

Diagnostic characters and affinities: This species and *S. purpureo-sericeum* (A. Rich.) Aschers. & Schweinf, are very similar that they may just represent a variation in one species. Differences between them are mainly in their spikelet length (shorter in *S. versicolor*), their apparent inability to hybridise (Garber, 1950), and their differing geographical distributions.

Habitat: In deciduous bushland or wooded grassland, commonly on waterlogged soils or black clays.

Type: Mozambique, Boror, *Peters* (whereabouts uncertain).

Representative specimens:

Botswana: Northern Division, 6km south-east of Tsau, 18.iii.1965, *Wild & Drummond* 7132 (BM, SRGH).

Malawi: Northern Province, Nzimba District, 25 miles south of Rumphi on M1, altitude 4000ft, 04.v.1974, *Pawek* 8571 (PRE, WAG); Zomba District, near Macheleni hill, Tembenu village, 05.iii.1978, *Seyani & Patel* 800 (MAL).

Mozambique: Malema, Mutuáli, Estação Experimental do Instituto do Algodão, 05.iv.1962, *Lemos & Marrime* 318 (PRE); Sul do Save, 26.xii.1953, *Myre & de Carvalho* 1731 (SRGH); Tete, Cabora Bassa, altitude 230-330m, 02.v.1972, *Pereira & Correia* 2328 (WAG); Laurenço Marques (Maputo), Macaéne-Magude, 22.i.1948, *Torre* 7179 (BM).

Namibia: Grootfontein District, 20km east of Otavi, altitude 1460m, 08.iv.1987, *Long & Rae* 712 (E).

Republic of South Africa: Transvaal: 200km south of Geysdorp, altitude 1300m, 22.i.1987, *Smook* 6283 (WAG); Pretoria, 09.ii.1938, *Wit* 20 (WAG).

Zambia: Kalomo District, Siatambo, 07.ii.1963, *Mitchell* 17/63 (BM); Mumbwa District, Sala Reserve, Cheta river, 26.iii.1963, *Vessey-Fitzgerald* 4019 (SRGH).

Zimbabwe: Gwelo District, Base, Gwelo kop., altitude 4700ft, 05.iii.1967, *Biegel* 1959 (BM); Victoria District, Fort Victoria, Victoria Reserve Zone, 19.iii.1956, *Cleghorn* 185 (BM); Melsetter District, Mutambara Tribal Trust Land on main road near Linsnacloon farm, altitude 1000m, 26.iii.1969, *Crook* 850 (PRE); Bubi District, Gwampa Forest Reserve, ii.1956, *Goldsmith* 6/56 (PRE); Victoria District, Fort Victoria area, 02.i.1949, *Robinson* 336 (SRGH); Melsetter District, Sabi Valley, Nyanyadzi, 26.iii.1956, *Whellan* 1009 (WAG).

Distribution: Eastern, central and southern Africa.

4. ***Sorghum stipoideum*** (Ewart & White) C. A. Gardner & C. E. Hubbard, in Hook. Ic. Pl. 34: t 3364 (1938).-Lazarides, Hacker & Andrew, Taxonomy, Cytology and

Ecology of indigenous Australian sorghums, in Aust. Syst. Bot. 4: 591-635 (1991).-Simon, A key to Australian grasses: 158 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 49 (1994).

Synonyms: *Sarga stupoidea* Ewart & White, in Proc. Roy. Soc. Vict. n.s. XXIII: 297 (1911); *Andropogon sargus* Ewart, in Proc. Roy. Soc. Vict. XXV: 113 (1912); *Chrysopogon stipoideus* (Ewart & White) Domin, in Biblioth. Bot XX: 271 (1915); *Sorghum Mjobergii* Cheel, in Kungl. Svensk. Vet.-Akad. Handl. n.s. LII(10): 3 (1916); *Andropogon stipoideus* (Ewart & White) C. A. Gardner, Enum. Pl. Austrl. Occid.: 5 (1930).

Annual, 1-3m tall, erect. Culms stout, usually branched; culm nodes glabrous, or pubescent to bearded. Leaf blades up to 30cm long, and 1.3cm wide, broadly linear-lanceolate, glabrous or with sparse tubercle-based hairs along the midrib, with cartilaginous and shortly spinulose margins; leaf sheaths glabrous, tightly clasping the culm internodes, bearded and constricted at the collar region; ligule an unfringed membrane, 0.7-3.7mm long.

Inflorescence an open panicle with simple branches; main inflorescence axis striate, glabrous; raceme peduncles glabrous or occasionally scabrid-ciliate, with prominent pulvini; racemes mostly 2-jointed (1-3-jointed); rachis internodes and pedicels hairy. Sessile spikelet elliptic, 10(-18)mm long (including callus); callus pungent, 3mm long, slightly curved; lower glume hirsute on the back or partly glabrous and glossy, narrowed upwards; upper glume with a sharp median keel, scabrid on the back. Florets 2: lower floret empty, lemma lanceolate, ciliate on the margins, 5mm long; upper floret bisexual, lemma deeply lobed, lobes and margins ciliate, about 3mm long, awned from the sinus; awn 60mm(-155mm) long, twisted, glabrous, ciliate along the column spiral, bristle scabrid-ciliate; lodicules 2, cuneate, ciliate on the prolonged apical corners; anthers 2(-3), 3.5mm long; ovary minute, obovate. Pedicellate spikelet male, 8mm(-18mm) long, subulate; lower glume hirsute on the back, narrowed upwards into a beak-like apex, ciliate on the margins, aristulate, awnlet 2.3mm long; upper glume scabrid on the back, cuspidulate, with ciliate margins; lower lemma lanceolate, ciliate on margins, 5mm long; upper lemma broadly ovate, ciliate on margins, 3.5mm long; lodicules 2, cuneate, ciliate on the corners; anthers 3, 4mm long; pedicels hairy.

Chromosome number: 2n = 10 (Garber, 1950; Pritchard & Gould, 1964; Hacker, 1991).

Diagnostic characters and affinities: The pungent, extremely long callus of the sessile spikelet and the awned glumes of the pedicellate spikelet are especially prominent features. Allied to *S. intrans*: the glabrous (not bearded) ovary and caryopsis *in S. stipoideum* is the only consistent dissimilarity (Lazarides et al, 1991).

Habitat: Occurs widely in deep or shallow clays, sands and loams, in flat or hilly country, on coastal dunes and beach sands, on the margins of permanent swamps and lakes or seasonally flooded river terraces, floodouts and levees, and in association with sandstone, limestone or laterite slopes, ridges or outcrops.

Type: Australia, Western Australia, Northern Province, Noonkanbah, ii.1911, *Mjoberg* 61 (S, K!).

Representative specimens:

Australia:

Northern Territory: on Stuart Highway, 12 miles south-east of Mataranka, 21.iii.1964, *Lazarides* 7092 (K); about 200 km south of Darwin on road to Pine Creek. 13°38'S 131°18'E, 01.iv.1977, *Pullen* 10.580 (E).

Queensland: about 6 km south of Wyndham, on road to Kununurra, 15°31'S 127°14'E, 25.iv.1977, *Pullen* 10.874 (E).

Western Australia: near Derby airport, 8 km south of Derby, 17°22'S 123°40'E, 18.iv.1985, *Alpin et al* 44 (K); 41 km east of Derby on Gibb river road at junction with road to Meda Station, 03.v.1983, *Fryxell & Craven* 3925 (E); Yamerra Gap, Napier Range, 17°20'S 124°49'E, 04.v.1983, *Fryxell & Craven* 3942 (E); 73 km west of Wyndham, about 13 km south of Paradise Pool on Ernest river, north-eastern Kimberly, 20.iii.1978, *Lazarides* 8638 (K).

Distribution: Australia: Western Australia and Northern Territory.

5. ***Sorghum nitidum****[*] (Vahl) Pers., Syn. Pl. I: 101 (1805).-Bor, Flora of Assam 5: 351 (1940).-Lazarides, Hacker & Andrew, Taxonomy, Cytology and Ecology of indigenous Australian sorghums, in Aust. Syst. Bot. 4: 591-635 (1991).-Simon, A key to Australian grasses: 158 (1993).

Synonyms: *Holcus nitidus* Vahl, Symb. Bot. II: 102 (1791); *Anatherum nitidum* (Vahl) Spreng., Syst. Veg. I: 290 (1825); *Andropogon nitidus* (Vahl) Kunth, Rev. Gram. I: 166 (1829); *Sorghum tropicum* Nees var. *muticum* Nees, in Hook. Kew Journ. Bot. II: 99 (1850); *Andropogon pedicellatus* Steud., Syn. Pl. Glum 1: 394 (1854); *Andropogon serratus* Thunb. var. *nitidus* Hack., in DC., Monogr. Phan. 6: 521 (1889); *Sorghum serratum* (Thunb.) O. Kuntze var. *nitidus* (Vahl) Domin, in Biblioth. Bot. XX: 270 (1915); *Holcus fulvus* R. Br. var. *nitidus* (Vahl) Honda, in Tokyo Bot. Mag. XL: 101 (1926); *Andropogon amboinicus* (L.) Merrill var. *nitidus* (Vahl) Backer, Handb. Fl. Java 2: 99 (1928).

Perennial grass. Culms 1.2-1.5m tall, branched; culm nodes bearded with white hairs. Leaf blades finely acuminate, 20-60cm long, up to 12mm wide, with a prominent white midrib, glabrous or sometimes hirsute with tubercle-based hairs; leaf sheaths hispid to hirsute with tubercle-based hairs or glabrous, sometimes ciliate on the margins, bearded at the mouth with stiff hairs to 5.3mm long; ligule a ciliolate (sometimes glabrous) membrane, 1.5-2mm long.

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[*] **nitidus**, shining, polished, referring to the shining brown spikelets.

Inflorescence an elongate panicle; main inflorescence axis glabrous, angular; racemes whorled; raceme peduncles glabrous, with prominent swollen bases (pulvini); racemes 3-5-jointed; raceme joints hairy; rachis internodes and pedicels with brownish hairs. Sessile spikelet 4mm long, oblanceolate; glumes crustaceous; lower glume 4mm long, dorsally compressed, mostly hirsute with tawny to brown hairs on the keels, polished and shiny; upper glume rounded on the back, 3.5mm long, hirsute in the upper third, glabrous, smooth and shiny below. Florets 2: lower floret empty, lemma 3.5mm long, margins inrolled clasping the base of the upper floret, ciliate; epaleate; upper floret bisexual, lemma 1.3-3mm long, deeply lobed, ciliate on the margins, awnless or awned; awn (when present) 20mm long, glabrous, column longer than the bristle; lodicules 2, fleshy (thickened), cuneate, ciliate on corners; anthers 3, 2.5mm long; ovary oblong. Pedicellate spikelet male (well developed) or neuter (rudimentary), 3.5mm long; glumes membranous or cartilaginous, mostly hairy; lower glume 3.5mm long, with brownish hairs on the back and keels, glabrous near the apex; upper glume 3.5mm long, with sparse brownish hairs, ciliate on the hyaline margins; lower lemma 3.5mm long, ovate, with ciliate margins, finely 2-nerved; upper lemma 3mm long, ovate with ciliate margins, finely single-nerved; anthers 3, 2mm long; lodicules 2, fleshy, ciliate on corners; pedicel 2.5mm long, hairy on the margins.

Chromosome number(s): 2n =10 (Celarier, 1958); 20 (Garber, 1950; Celarier, 1958).

Diagnostic characters and affinities: Distinguished by its small, often black spikelets, whorled simple panicle branches, 3-5-jointed racemes. The lemma of the upper floret may be awned or awnless. The awned specimens are indicated by an asterisk (*) in the specimens seen.

Habitat: Occurs on grey and black loams and sands, on hill slopes and in disturbed habitats.

Type: Australia, Queensland, 1802-5, **Brown* 6191 (E!, K!).

Representative specimens:

Australia:

Queensland: North Kennedy District, Ayr, 07.vii.1950, **Cowdry* 10 (K); between Ingham and Toobanna, altitude 35ft, 26.i.1931, *Hubbard & Winders* 6908 (K); Sarina, 19.i.1931, **Hubbard & Winders* 6495 (K); Port Curtis District, 24°22'S 151°50'E, 40km north-east from Lowmead on cleared pasture, 03.iv.1975, **Mcdonald & Batianoff* 1205 (K); Whitsunday Island, 10.vi.1934, **White* 10199 (K).

Bhutan: Punakha District, between Chuzomsa and Samtengang, altitude 1300m, 02.x.1987, *Wood* 5899 (E).

China: Ichang, v.1888, *Henry* 4234 (K).

Hong Kong: Tai Mo Shan, 10.x.1969, **Hu* 8155 (K).

India: North-west Himalaya, Kangra, Plampur, altitude 4000ft, 26.ix.1896, *Gammie* 18746 (K); Perola, Tehri, altitude 4000ft, 24.x.1948, **Koelz* 22236 (E).

Japan: Province Nagato, 31.x.1976, *Furuse* 11756 (K).

Nepal: South-west, Kauchaupur District, Royal Sukla Phanta Wildlife Reserve, altitude 600ft, 01.x.1975, **Schaaf* 10 (K).

Papua New Guinea: Eastern Highlands, near Miruma village, Upper Asaro Valley, Goroka subdistrict, altitude 1650m, 20.vi.1956, *Hoogland & Pullen* 5406 (K); Munumu village, District Central, subdistrict Port Moresby, altitude 500m, 18.ix.1973, *Isles & Vinas* LAE 29077 (E).

Philippines: Tadaya (Mt. Apo), District of Davao, Island of Mindanao, vi.1909, *Elmer* 11025 (E); Batanes Islands, v. - vi.1907, *Fenix* 3704 (K); Province of Cagayan, Luzon, ii.1912, *Ramos* s.n. (E).

Thailand: Hui Taleng, Korat, 21.xii.1928, **Put* 2178 (K).

Distribution: Australia and South-east Asia in the countries of India, Burma, Sri Lanka, Thailand, China and Japan.

6. ***Sorghum plumosum*** (R. Br.) Beauv., Agrost.: 132, 165, 178 (1812).-Lazarides, The grasses of Central Australia: 226 (1970).-Lazarides, Hacker & Andrew, Taxonomy, Cytology and Ecology of indigenous Australian sorghums, in Aust. Syst. Bot. 4: 591-635 (1991).-Simon, A key to Australian grasses: 158 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 49 (1994).

Synonyms: *Holcus plumosus* R. Br., Prodr.: 200 (1810); *Andropogon australis* Spreng., Syst. Veg. I: 287 (1825); *Andropogon australis* Spreng. subsp. *plumosus* (R. Br.) Hack. var. *genuinus* Hack., in DC., Monogr. Phan 6: 523 (1889); *Sorghum plumosum* (R. Br.) Beauv. var. *typicum* Domin, Journ. Linn. Soc. Bot. XLI: 275 (1912); *Sorghum plumosum* vars. *robustissimum* Domin et *piligerum* Domin, in Biblioth. Bot. XX: 271 (1915); *Andropogon plumosus* (R. Br.) Backer, Handb. Fl. Java 2: 100 (1928).

Densely tufted perennial. Culms to 6mm wide, 4-5 noded; culm nodes mostly bearded, occasionally glabrous. Leaf blades to 60cm long and 4-12mm wide, flat, sometimes loosely folded or terete, long-acuminate, hirsute on the lower surface and mostly glabrous (sometimes sparsely hairy) on the upper surface; lower leaf sheaths hirsute with simple and tubercle-based hairs 3-5mm long, upper glabrous, bearded at the mouth; ligule a 1.5-3mm long, ciliate membrane.

Inflorescence a panicle; main inflorescence axis terete, glabrous and smooth; raceme peduncles scabrous-hispid, pilose in the axils, with prominent pulvini; racemes 2-4(1-6)-jointed; rachis internodes and pedicels long hairy. Sessile spikelet 8mm long (including callus), elliptic; callus 1.3-2.5mm long, shortly pungent, bearded; lower glume elliptic, cartilaginous, hirsute on the back, brown and shiny, sharply and shortly ciliate on the keels towards the apex, apex hyaline and truncate; upper glume smooth and shiny, boat-shaped, ciliate on the inturned margins towards the apex. Florets 2: lower floret empty, lemma lanceolate, ciliate; upper floret bisexual, lemma bilobed, ciliate, finely 3-nerved, awned; awn 60 (-100)mm long, column twisted, with forward facing sharp cilia along the spiral, bristle hispidulous; palea present, small, ciliate; lodicules 2, cuneate, with 2 to 3 cilia on the apex corners; anthers not seen; ovary oblong, 2.8mm long, flattened on both surfaces. Pedicellate spikelet neuter, 8.5mm long, long-acuminate; lower glume coriaceous, hairy on the back; upper glume also coriaceous, hairy on the back; lower lemma like that of the sessile spikelet; upper lemma lanceolate, with ciliate margins; pedicel hairy on margins, 6mm long, those of the terminal spikelets subequal.

Chromosome number(s): 2n = 10 (Hacker, 1991); 20 (Garber, 1950); 30 (Pritchard & Gould, 1964).

Habitat: Occurs in a wide range of habitats including rocky hills and outcrops, coastal dunes, plains, swamps, seasonally flooded levees and other low-lying ground.

Type: Australia, Queensland, Burke District, Gulf of Carpentaria, Allen Island, 19.xi.1802, *Brown* 6192 (BM! K!).

Representative specimens:

Australia:

Northern Territory: 14 miles north-west of Ooratippra Station, 12.v.1955, *Lazarides* 5272 (K).

Queensland: North Kennedy District, Townsville, on exposed rocky slopes of Castle Hill, 22.iii.1935, *Blake* 8165 (K) and Pentland, 02.iv.1935, *Blake* 8393 (K); Forest Home Station, Gilbert river, iii.1931, *Brass* 1836 (K); Bowen, on upper slopes of hill north of town, 16.i.1931, altitude 200-300ft, *Hubbard & Winders* 6547 (BM); Warrigal, on Great Dividing Range, altitude 1400-1500ft, 02.ii.1931, *Hubbard & Winders* 7154 (BM); Chudleigh Park Station, 110 miles north of Hughenden, altitude 2700ft, 14.ii.1931, *Hubbard & Winders* 7654 (BM).

Indonesia: Sumba, lesser Sunda Island, between Waingapu and Melolo, narrow coastal plain, 10.vi.1950, *Monod* 1993 (K).

Distribution: Distributed in Western Australia, the Northern Territory and Queensland. Also a single specimen seen from the Indonesian island of Sumba.

8.2.6. ***Pseudosorghum*** A. Camus, in Bull. Mus. Hist. Nat. Paris 26: 662 (1920). The type species is *Pseudosorghum fasciculare* (Roxb.) A. Camus.

Decumbent annual. Inflorescence a small dense panicle, with subdivided but very short primary branches, bearing narrow racemes; rachis internodes ciliate. Sessile spikelet callus obtuse; lower glume firmly cartilaginous, glabrous, many-nerved, with narrowly inflexed margins; upper lemma bilobed, awned; palea present; lodicules glabrous. Pedicellate spikelet male or neuter, slightly smaller than the sessile; glumes thin.

Species 2. No material was seen for *Pseudosorghum zollingeri*.

Pseudosorghum fasciculare (Roxb.) A. Camus, in Bull. Mus. Hist. Nat. Paris 26: 662 (1920).-Bor, Flora of Assam 5: 353 (1940).-Bor, Grasses Burma Ceylon India & Pakistan: 205 (1960).

Synonyms: *Andropogon fascicularis* Roxb., Fl. Ind. 1: 269 (1820); *Andropogon gangenticus* Hack., in DC., Monogr. Phan. 6: 539 (1889); *Andropogon tonkinensis* Balansa in Morot., Journ. de Bot. 4: 112 (1890); *Andropogon nitidulus* Hook.f., Fl. Brit. Ind. 7: 199 (1896); *Sorghum fasciculare* (Roxb.) Haines, Bot. Bihar & Orissa: 1034 (1924); *Sorghum gangenticus* (Hack.) Stapf ex Haines, Bot. Bihar & Orissa: 1034 (1924).

Annual. Culms 60-150cm tall, decumbent at the base and finally erect, rooting from the decumbent lower nodes, branching at the base, slender, rounded in section, glabrous, simple or bearing flowering branches. Leaf blades linear-lanceolate, 30-50cm long, 4-8mm wide, contracted at the base, acuminate-setaceous at the tip, flat, rigid, glaucescent, scaberulous, midnerve somewhat thick; leaf sheaths compressed, tight or somewhat lax, throat hairy; ligule 5mm long, ovate, an unfringed membrane.

Inflorescence paniculate, composed of few to many simple or branched racemes with slender articulate rachis. Sessile spikelet falling with adjacent pedicel and rachis internode; lower glume with a narrow, truncate apex, and narrowly inflexed margins, flat, many-nerved; upper glume boat-shaped, keeled with a narrowed apex, 7-nerved. Florets 2: lower floret empty, lemma slightly shorter, ovate-oblong, with incurved margins, thinly membranous, 2-nerved, palea absent; upper floret bisexual, lemma well developed, thinly membranous, long ciliate, bilobed about half way, with stout, geniculate awn from sinus; palea present; lodicules 2, fleshy; stamens 3, 3mm long; ovary ovate, tiny. Pedicellate spikelet male or neuter, slender and slightly smaller than the sessile one; glumes thin.

Chromosome number: 2n = 20 (Raman, Chandrasekharan & Krishnaswami, 1959).

Habitat: Fairly common in grassy plains.

Type: India, Chauda Division, Central Province Forestry Dep., vii.1887, *Duthie* 10717 (K!).

Representative specimens:

Burma: Bassein District, Thabyu Chaung, 13.xii.1912, *Kermode* 7350 (K); Myitkyina District, Kadu, 08.xi.1925, *Parkinson* 286 (K); South Lamayi Research Station, 09.xii.1939, *Thein Lwin* 101 (K).

India: Northern, Dehra Dun, x.1890, *Duthie* 10721 (K); Khuri, Surguja State, 15.x.1947, *Koelz* 19323 (K); Pierie, 24.xi.1939, *Lahiri s.n.* (K); Balajhar, Tahher State, Orissa, altitude 450ft, 06.xii.1940, *Mooney* 1631 (K).

Philippines: Angat, Province of Bulaeau Luzon, xii.1914, *Ramos s.n.* (K).

Thailand: Northern Thailand, Province Tak, Lahn Sahng, 27.xii.1974, *Geesnik, Hiepko & Phengklai* 7926 (K); (without exact location), altitude 1100ft, 03.xii.1911, *Kerr* 2267 (K, 3 sheets); Loie, Phu Krading, Sam Kokkwak, altitude 700m, 09.xi.1954, *Smitinand* 2096 (K).

Distribution: Widespread in India, Burma, Philippines and most of South-east Asia.

8.2.7. *Chrysopogon* Trin., Fund. Agrost.: 187 (1820); nom. conserv. The type species is *Chrysopogon gryllus* (L.) Trin.

Synonyms: *Rhaphis* Lour., Fl. Cochin.: 552 (1790); *Pollinia* Sprend., Pl. Pugill. 2: 10 (1815); *Centrophorum* Trin., Fund. Agrost.: 106 (1822); *Trianthium* Desv., Opusc.: 69 (1831); *Chalcelytrum* Lunell, in Amer. Midl. Nat. 4: 212 (1915).

Tufted perennials; ligule a short membrane or a line of hairs. Inflorescence a panicle, its primary branches whorled, simple, each bearing a raceme reduced to a triplet of spikelets (rarely racemes with 2 sessile spikelets, e.g. *C. sylvaticus*); spikelets in triplets, or in triplets and pairs; the triplet consists of a sessile spikelet and two pedicellate spikelets; pedicels linear filiform, never longitudinally grooved. Sessile spikelet laterally compressed, its callus elongated, acute to pungent; glumes subequal, unequally awned or aristate or awnless; lower glume cartilaginous to coriaceous, often spinulose on the keels and muricate on the back; upper lemma entire or bilobed, awned; awn glabrous to pubescent and usually prominent. Pedicellate spikelet male or neuter; glumes awned or aristate or awnless.

Species 26.

A key to taxa sampled:

Pedicels glabrous:

Culm internodes terete:

Base of plant creeping, rhizomatous; racemes single-jointed; sessile spikelet 3-4.5mm long, with a very long (as long as spikelet) callus; upper lemma entire. 1. ***aciculatus***

Culms erect, not creeping at base; racemes 2-3-jointed; sessile spikelet 6.5-8mm long; upper lemma bilobed:

Racemes consistently 2-jointed; sessile spikelet 8mm long; lower glume of sessile spikelet smooth; palea 2.6mm long. 2. ***sylvaticus***

Racemes consistently 3-jointed; sessile spikelet 6.5mm long; lower glume of sessile spikelet echinulate along the lateral keels; palea 3.5mm long. ***gryllus*** subsp. ***echinulatus***

Culm internodes channelled on one side:

Callus of sessile spikelet 1.5-3.5mm long; awn not overtopping the pedicellate spikelet:

Leaves much less than 1cm wide; lower glume of sessile spikelet 5-7-nerved; callus straight or nearly so; lower leaf sheaths disintegrating into fibres. 3. ***fallax***

Leaves 1-2cm wide; lower glume of sessile spikelet 4-5-nerved; callus more or less curved; lower leaf sheaths not disintegrating into fibres. 4. ***latifolius***

Callus of sessile spikelet 4-6mm long; column of awn usually overtopping the pedicellate spikelet. 5. ***pallidus***

Pedicels hairy:

Pedicels half the length of the sessile spikelet or longer:

Sessile spikelet 8-9mm long; awn 60mm long. 6. ***orientalis***

Sessile spikelet 5.5-6mm long; awned or awnless:

Raceme peduncles bearded; sessile spikelet epaleate; both glumes of the pedicellate spikelet awned. 7. ***aucheri***

Raceme peduncles glabrous; sessile spikelet paleate; upper glume of pedicellate spikelet awnless.
8. ***gryllus*** subsp. ***gryllus***

Pedicels shorter than half the length of the sessile spikelet:

Awns of the glumes of the pedicellate spikelet plumose; upper lemma entire. 9. ***plumulosus***

Awns of the glumes of the pedicellate spikelet glabrous or if plumose then only at the extreme base; upper lemma bilobed:

Sessile spikelet 5mm long; upper glume of sessile spikelet keeled, pectinate-ciliate in the lower ¾ with long, golden brown rigid hairs. 10. ***fulvus***

Sessile spikelet 6mm long; upper glume of sessile spikelet rounded on the lower ¾, keeled and ciliate in upper ¼ only. 11. ***serrulatus***

1. ***Chrysopogon aciculatus***[*] (Retz.) Trin., Fund. Agrost.: 188 (1820).-Bor, Grasses Burma Ceylon India & Pakistan: 115 (1960).-Clayton, in Hepper (ed.), Flor. West Trop. Afr., Gramineae ed.2 (3): 468 (1972).-Lowe, The flora of Nigeria, Grasses: 227 (1989).

Synonyms: *Andropogon aciculatus* Retz., Obs. Bot. 5: 22 (1789); *Rhaphis trivalvis* Lour., Fl. Cochinch.: 553 (1790); *Andropogon acicularis* Retz. ex Roem. et Schult., Syst. Verz. 2: 812 (1817); *Centrophorum chinense* Trin., Fund Agrost.: 106 (1820); *Rhaphis acicularis* (Retz.) Desv., Opusc.: 69 (1831); *Chrysopogon trivialis* Arn. et Nees, in Nov. Act. Nat. Cur. 19(1): 171 (1843); *Andropogon trivialis* Steud., Syn. Pl. Glum. 1: 396 (1854).

Rhizomatous creeping perennial. Culms up to 50cm tall, prostrate at the base, rooting from the crowded nodes; the upper 2-3 internodes erect and elongated, the one

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[*] **aciculatus**, marked with very fine irregular streaks, as if produced by the point of a needle.

bearing the inflorescence the longest. Leaf blades densely crowded in the lower part, distant in the upper erect part; leaf blades rounded at the base, obtuse or subacute at the tips, the uppermost short or rudimentary, the others 2-15cm long, 3-5mm wide, frequently undulate near the margins, glabrous or sparingly pilose at the base; leaf sheaths terete, tight, smooth, glabrous or sparsely bearded at the mouth or more or less ciliate on the margins, much longer than the internodes in the lower decumbent part and shorter in the upper erect part; ligule minutely ciliolate, appearing as a scar.

Inflorescence a prominently exserted panicle of 5-10cm long, said to be open in the living state but contracted when dry; common axis angular, striate, consists of whorls of 4-9 racemes, hispid on the upper half, angular; racemes single-jointed. Sessile spikelet 6-10mm long (including callus), linear, acuminate from about the middle, purplish; callus acicular, very acute, 3-6mm long, bearded with rusty hairs; lower glume chartaceous, opaque, awnless, 4mm long, narrowly subtruncate, 2-keeled, the keels remotely spinulose, the spines somewhat thickened at the base; upper glume purplish, shortly awned, awnlet 1.5mm long (never exceeds 3mm), acuminate, keel spinulose on the upper half. Florets 2: lower floret empty, lemma hyaline, oblanceolate, 2.7mm long; upper floret bisexual, lemma oblong or linear, entire, 2mm long, glabrous, drawn into a yellowish, untwisted, imperfect awn 5mm long; palea short, 1.5-2mm long, linear-obtuse, nerveless; lodicules 2, fleshy, glabrous; anthers 3, 1mm long; ovary 2-2.5mm long. Pedicellate spikelet male, 4-6mm long, glabrous, purple (rarely pallid), subulate-lanceolate; lower glume 5-7-nerved, cuspidate; upper glume elliptic-lanceolate; lemmas hyaline, ciliate, the lower 3-4.5mm long, oblanceolate, acute, the upper 2-4mm long, oblanceolate acute; palea 1-1.5mm long, linear, glabrous; anthers 3, 2mm long; pedicels glabrous.

Chromosome number: 2n = 20 (Larsen, 1963).

Diagnostic characters and affinities: This species has a long (3-6mm), pungent callus, which is said to be a menace to grazing animals (Bor, 1960).

Habitat: Common in open places.

Uses: Lawns and or playfields (temperate climates).

Type: Type locality, India.

Representative specimens:

Cameroon: Victoria (no exact location), 06.iv.1961, *Ogu* 304 (E).

China: Kochow District (no exact location), 14.v.1929, *Tsiang Ying* 2281 (E).

Hawaii: Kauai Island (no exact location), 01.vii.1895, *Heller* 2476 (E).

Nepal: Arum Valley, altitude 5000ft, 27.v.1956, *Stainton* 463 (E); Agam, altitude 3000ft, 22.vi.1954, *Stainton, Sykes & Williams* 5862 (E).

Papua New Guinea: Moroba District, Lae, altitude 0m, 06.ix.1966, *Coode* 29519 (E).

Philippines: Butuan SubProvince, Mindanao, iii - v.1911, *Weber* 1047 (E).

Singapore: Mae Ritchie Reservoir, 04.xii.1948, *Sinclair* 5364 (E).

Thailand: Kucham, TakBai, altitude 0m, 18.ix.1987, *Niyomdham & Sriboonma* 1630 (E); Krungtep, 12.iii.1958, *Sorensen, Larsen & Hansen* 2060 (E).

Distribution: Widely distributed in the tropics of Asia, Polynesia and Australia.

2. ***Chrysopogon sylvaticus***[*] C.E. Hubbard, in Hook. Ic. Plant. t.3365 (1938).-Blake, in Univ. Queensl. Papers 2(3): 5 (1944).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 144 (1982).-Simon, A key to Australian grasses ed.2: 85 (1993).

A tufted perennial. Culms erect, suberect or oblique, 30-120cm tall, branched from the middle nodes, 3-5 noded; culm nodes exposed, glabrous. Leaf blades narrowly linear, to 50cm long, 6mm wide, mostly conduplicate, rarely flat, mostly basal, margins spinulose-ciliate; leaf sheaths glabrous, keeled, the basal ones flabellate,

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[*] **sylvaticus**, growing in the woods; pertaining to the woods.

imbricate and compressed, persistent, the upper ones shorter than the internodes; ligule minutely ciliolate.

Inflorescence a loose panicle, spreading and drooping, deep reddish purple; main inflorescence axis slender, scabrous, few noded; raceme peduncles verticillate, hispidulous; racemes consistently 2-jointed, but occasionally 1-jointed (very rarely 3-jointed). Sessile spikelet lanceolate, 8mm long (including the callus); callus acute, bearded with fulvous hairs 3mm long; lower glume narrowly truncate, spinulose on the lateral keels, scabrid above the middle, smooth below, purplish; upper glume lanceolate-oblong, spinulose on the keel, running into an awn 3mm long. Florets 2: lower floret empty, lemma oblong, ciliate on the upper margins, 5mm long; upper floret bisexual, lemma broadly linear, shortly bilobed, 5mm long, hardened in the upper half, awned; awn geniculate, twisted, 23mm long, scabrid; palea oblong, truncate, 2.6mm long; lodicules 2, fleshy; anthers 3, 2.5-3mm long; ovary oblong. Pedicellate spikelet very reduced, variable in length (3-7mm long), neuter, linear, muticous, represented by an empty glume; pedicel 5.5mm long, glabrous, flattened.

Diagnostic characters and affinities: This species differs from *C. pallidus* and its allies by its flabellate leaf sheaths, the lower ones of which are persistent and do not break up into fibres; the panicle is, on the whole, much looser, the racemes are usually 2-jointed, and the pedicellate spikelets are constantly muticous.

Habitat: A characteristic member of the grass flora of *Eucalyptus* forests of south-east Queensland, particularly on somewhat stony hillsides.

Type: Australia, Queensland, near Moggill, 03.iv.1931, *Hubbard* 8587 (K!).

Representative specimens:

Australia:

Queensland: Moreton District, Petrie, 13.ii.1931, *Blake* 148 (K); Port Curtis District, mid and upper slopes of Mt. Berserker, 06.iii.1937, *Blake* 12728 (K); Mt. Edwards 01.iv.1954, *Everist* 375 (K); Mt. Petrie, near Brisbane, 13.iv.1930, *Hubbard* 2156 (K); Moreton District, Enoggera, iii.1916, *White & Bick s.n* (K).

Distribution: Australia.

3. ***Chrysopogon fallax***[*] S. T. Blake, in J. M. Black, Fl. S. Austral. ed.2: 60 (1943).-Burbibge, Australian grasses 3: 44 (1970).-Lazarides, The grasses of Central Australia: 90 (1970).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 144 (1982).-Simon, A key to Australian grasses ed.2: 85 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 24 (1994).

Tufted erect perennial up to 2m tall, emergent above the foliage. Culms erect, slender or moderately robust, somewhat compressed and channelled on one side, with deeply embedded rootstock; culm nodes glabrous; uppermost culm internode terete, sometimes slightly pubescent. Leaf blades narrowly linear, tapering to a very acute point, 5-45cm long and 4-5mm wide, the upper side smooth, glabrous, the lower side variably smooth and glabrous or sparsely or densely hairy, with the hairs in all cases arising from tubercles; leaf sheaths tight, not keeled, with the basal ones somewhat persistent, at length more or less disintegrating into fibres, the upper ones shorter than the internodes; ligule ciliolate.

Inflorescence a linear or linear-lanceolate panicle, contracted; main inflorescence axis scabrous or slightly pubescent; nodes pilose; racemes up to 16 in each whorl; racemes 1-jointed with a spikelet triad of 1 sessile spikelet and 2 pedicellate spikelets; raceme peduncles scabrous, filiform. Sessile spikelet narrowly lanceolate, 11mm long (including the callus); callus 1.7mm long, bearded with fulvous hairs, straight, narrowly conical; lower glume 8mm long, cartilaginous, convex on the back, 2-keeled in the upper 1/3, tip truncate, awnless, more or less smooth in the lower part, lateral keels muricate and spinulose towards the tip; upper glume narrowly obtuse, sharply keeled, the keel pectinate and running into a slender scabrous awn 11mm long.

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[*] **fallax**, deceptive, fallacious.

Florets 2: lower floret represented by a lemma, lemma 6mm long, oblanceolate, ciliate on margins; upper floret bisexual, lemma oblong-linear, shortly bidentate (bilobed), 6mm long, membranous, thickened upwards, awned; awn geniculate, 40mm long, column tawny, scabrous, bristle paler, scabrous, straight; palea linear, nerveless, 3.5mm long, sparsely ciliate on the upper part; lodicules 2, fleshy, cuneate; no anthers seen; ovary narrowly ovate, minute. Pedicellate spikelet male; lower glume lanceolate, gradually acute, 9mm long, aculeolate on the lateral keels, scabrous elsewhere, awned; awn oblique, 6.5mm long, straight; callus minute, smooth; upper glume lanceolate, aristulate, lower lemma elliptic-linear, 7.5mm long, ciliate on the margins; upper lemma linear-lanceolate, 6.5mm long, acute; palea lobed, 4mm long, sparsely ciliate at the tip; anthers 3, 3-5mm long; pedicels subequal, flattened, the longer 4.5mm long, smooth, slightly broadened near the tip.

Diagnostic characters and affinities: In North-western Queensland it is known as "woolly-butt" by reason of the fibrous remains of the basal leaf sheaths usually being prominent (Blake, 1944). It is very similar to *C. pallidus* from which it may be distinguished by the rather shorter spikelets, the sessile with a distinctly shorter callus and shorter more slender awns, the column of the latter not usually overtopping the pedicellate spikelets.

Habitat: Widely spread in a variety of habitats on both light and heavy soils.

Type: Australia, Queensland, Leichhardt District, Emerald, in open sandy places, altitude 600ft, 18.iii.1935, *Blake* 8108 (MEL).

Representative specimens:

Australia:

Northern Territory: about halfway between Anthony Lagoon and Brunnette Downs, altitude 232m, 16.v.1947, *Blake* 17805 (K); 'Manbulloo', Katherine, 01.iv.1946, *Hartely* 11711 (K); near Wavehill Police Station, 25.vi.1949, *Perry* 2246 (K).

Queensland: North Kennedy District, slopes of Great Dividing Range, west of Alpha, altitude 1200ft, 22.ii.1931, *Hubbard* 7856 (K); Cook District, Chillangoe, altitude 1154ft, 22.i.1931, *Hubbard & Winders* 6790 (K).

Western Australia: 14 km west of Forest Creek near Ord Hill, Ord River Station, east Kimberly, 13.iv.1977, *Pullen* 10.736 (E).

Distribution: Australia: Queensland, Northern Territory and Western Australia.

4. ***Chrysopogon latifolius***[*] S.T. Blake, in Univ. Queensl. Papers, Dept. Biol. II No.3: 7 (1944).-Simon, A key to Australian grasses ed.2: 85 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 24 (1994).

Tall, erect, tussocky perennial 2m tall, with a fibrous rootstock. Culms strongly branched from the upper nodes, somewhat robust, channelled on one side; culm nodes exposed, glabrous. Leaf blades up to 60cm long (except for the uppermost which are short), very broad, 0.7-1.3 (- 2)cm wide, barely distinct from the sheaths, linear, flat or somewhat conduplicate with many primary nerves, margins with regularly spaced forward facing spines, midrib prominent, glabrous or softly pubescent; leaf sheaths prominently striate but not keeled, lower at length gaping, others rather tight, the lower not splitting into fibres; ligule ciliate with hairs up to 0.5mm long.

Inflorescence a linear panicle, 20-25cm long, rather contracted; main inflorescence axis stout, pubescent, terete, many-noded, with up to 30 racemes per whorl; raceme peduncles filiform, straight, hispid; racemes single-jointed. Sessile spikelet linear-lanceolate, 7.7mm long (including the callus); callus 2mm long, curved, bearded with rusty hairs up to 2mm long; lower glume narrowly truncate, incurved, cartilaginous with very narrowly hyaline margins and apex, smooth on the lower part, the rest

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[*] **latifolius**, with broad leaves.

muricate or mammillate, becoming spinulose on the keels towards the apex, awnless; upper glume smooth in the lower part, the rest scabrid, with the keel becoming aculeolate towards the apex, sparsely ciliate on the hyaline margins, awned, awn 9mm long, scabrid. Florets 2: lower floret empty, lemma obovate, emarginate, ciliate, 4.5mm long; upper floret bisexual, lemma broadly linear, entire, the back membranous in the upper half with the remainder hyaline, margins glabrous, awned; awn geniculate, twisted, 40mm long; palea lanceolate, emarginate; anthers not seen; ovary oblong. Pedicellate spikelet male, lanceolate, 8mm long; lower glume lanceolate, papery, scabrous, spinulose on the nerves terminating into an awn 6.5mm long; upper glume as long, acute, awnless or aristate, smooth; lower lemma linear-elliptic, ciliate, 6.5mm long; upper lemma narrowly elliptic, ciliate, 5.5mm long; palea linear, ciliate, 3.2mm long; anthers (only disintegrating remains seen); pedicels 5mm long, scabrous.

Blake (1944) reports of shorter anthers (2.2-3.5mm) in the sessile spikelet than in the pedicellate spikelet (3.5-5mm).

Chromosome number: 2n = 20 (Celarier, 1959).

Diagnostic characters and affinities: The species is very distinctive by reason of its stoutness, its broad many-nerved leaves and the numerous panicle-branches (racemes) to each whorl.

Habitat: Savannah woodland and *Eucalyptus* forests. Also found on roadsides and rocky ledges.

Type: Australia, Northern Territory, without definite locality, July-August 1911, *Gilruth & Spencer* (MEL).

Representative specimens:

Australia:

Northern Territory: Stuart Hwy, about 5 miles north-west of Katherine, 01.iv.1964, *Adams* 926 (K); Katherine, altitude 110m, 21.vi.1946, *Blake* 16047 (K); 4 miles south of Katherine on Wyndham road, 03.i.1965, *Wilson* 55 (K); ½ mile north-west of Edith River Siding, 30.i.1965, *Wilson* 226 (E).

Western Australia: 16 miles south-east of Mt. House Station, 22.iv.1955, *Lazarides* 5156 (K); Inglis Gap, Gibb river road, King Leopold Ranges, 09.iv.1988, *Simon* 3844 (K); Lennard river, viii.1905, *Staer s.n.* (E).

Distribution: Australia.

5. ***Chrysopogon pallidus**** (R. Br.) Trin. ex Steud., Nomencl. Bot. ed. 2(i): 360 (1840).-Blake, in Univ. Queensland Papers 2(3): 14 (1944).-Lazarides, The grasses of Central Australia: 93 (1970).-Simon, A key to Australian grasses ed.2: 85 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 24 (1994).

Synonyms: *Holcus pallidus* R. Br., Prodr.: 199 (1810); *Pollinia pallida* (R. Br.) R. & S., Syst. II: 829 (1817); *Andropogon palidus* (R. Br.) Kunth, Revis. Gram. i: 165 (1829); *Chrysopogon gryllus* (L.) Trin. var. *pallidus* (R. Br.) Benth., Fl. Austr. VII: 537 (1878); *Andropogon gryllus* (L.) Trin. subsp. *pallidus* (R. Br.) Hack., in DC., Monogr. Phan. 6: 552 (1889); *Andropogon gryllus*(L.) Trin. subsp. *calcaratus* Hack., in DC., Monogr. Phan. 6: 553 (1889); *Chrysopogon gryllus* (L.) Trin. subsp. *pallidus* (R. Br.) Domin, in Biblioth. Bot. XX. Heft 85: 272 (1915).

Tussocky perennial with well developed stolons, to 1m tall, erect, the base covered with the fibrous remains of old leaf sheaths. Culms sparingly branched, channelled on one side, 3-5 noded. Leaf blades numerous, folded, up to 40cm long and 6mm wide (when flattened), pubescent in the ligule area; leaf sheaths bearded at the mouth, those of the basal leaves disintegrating into long persistent fibres; ligule densely ciliate with hairs up to 0.7mm long.

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* **pallidus**, pale.

Inflorescence a panicle; main inflorescence axis bearded at the nodes; racemes single-jointed, verticillate, up to 15 per whorl; raceme peduncles capillary, up to 7cm long (never more than 10cm long), scabrid, slightly thickened near the tip and there obliquely truncate. Sessile spikelet lanceolate, pallid, 11mm long (including the callus); callus very slender, curved, pungent, bearded with tawny hairs of 2.5mm long; lower glume muricate on the lateral keels, becoming spinulose towards the apex, tip muticous or sometimes the keel nerves running into awnlets, cartilaginous; upper glume smooth, ciliate on the hyaline margins, carinate, scabrous on this keel, awned, awn straight and 14mm long (up to 18mm long). Florets 2: lower floret empty, lemma oblanceolate, 6.5mm long, ciliate on margins; upper floret bisexual, lemma broadly linear, shortly bilobed, thickened in the upper half in the centre, margins sparsely ciliate in the upper half, 6.3mm long, awned; awn 54mm long (up to 70 mm long), sharply geniculate, column densely scaberulous, about ½ the length of the awn, strongly twisted, dark brown, bristle paler, scabrid; palea linear, obtuse, sparsely ciliate, 2.5mm long; lodicules 2, fleshy, opaque, cuneate and highly vascularised; anthers not seen (just filament remains); ovary ovate to lanceolate. Pedicellate spikelet male, lanceolate, 11-14mm long; lower glume 7-nerved, more or less spinulose on the keels, papery, scabrid or glabrous elsewhere, awned, awn 9mm long (up to 12mm long); upper glume as long as the lower, elliptic-lanceolate, membranous, awnless but sometimes aristulate. Florets 2: lower floret empty, lemma linear-elliptic, thinly membranous with hyaline margins, 2-nerved, ciliate to the base; upper floret male, lemma linear, acute with broad hyaline ciliate margins; palea linear, sparsely ciliate on the upper part; anthers 3, 5.5-5.8mm long; pedicels glabrous, thickened upwards, strongly convex on the back, 6.5mm long (up to 7mm long).

Blake (1944) reports that the anthers of the sessile spikelet are 3-5mm long, which means that they are shorter than those of the pedicellate spikelet.

Diagnostic characters and affinities: Distinguished particularly by the long pungent callus to the sessile spikelet and the long stout awn with the column overtopping the pedicellate spikelet. The basal leaf sheaths readily disintegrate into a mass of fibres (as in *C. fallax*). The fibres, as far as could be observed, seemed more numerous in this species than in *C. fallax*.

Habitat: Found in association with other grasses in *Eucalyptus* forests.

Type: Australia, Queensland, Burke District, Islands of the Gulf of Carpentaria, 1802, *Brown* 6190 (E!).

Representative specimens:

Australia:

Northern Territory: on Stuart Highway, 16 miles south-east of Katherine, 18.xii.1963, *Lazarides* 6997 (K).

Western Australia: 1.5km south-east of mining Campsite, Mitchell Plateau, North Kimberly, 21.i.1982, *Kenneally* 7874 (K); 6km north of mining Campsite on track to Port Warrender, Mitchell Plateau, North Kimberly, 05.xii.1982, *Kenneally* 8626/A (K).

Distribution: Australia.

6. ***Chrysopogon orientalis***[*] (Desv.) A. Camus, in Lecomte, Fl. Gen. de Indo-Chine 7: 332 (1922).-Bor, Flora of Assam 5: 359 (1940).-Bor, Grasses Burma Ceylon India & Pakistan: 118 (1960).

Synonyms: *Rhaphis orientalis* Desv., Opusc.: 69 (1831); *Andropogon wightianus* Nees ex Steud., Syn. Pl. Glum. 1: 395 (1854); *Andropogon aristulatus* Hochst. ex Steud., Syn. Pl. Glum. 1:397 (1854); *Andropogon breviaristatus* Steud., Syn. Pl. Glum. 1: 396 (1854); *Chrysopogon wightianus* (Nees ex Steud.) Thw., Enum Pl. Zeyl.: 366 (1864).

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[*] **orientalis**, eastern.

Perennial. Culms 50-90cm tall, caespitose and erect, slender, branching above. Leaf blades collected mostly at the base, narrow, linear, 3-10cm long, 3-4mm wide, flat or rolled, glabrous; leaf sheaths carinate, smooth or scabrid, tight, shorter than the internodes; ligule a rim of short hairs.

Inflorescence a panicle, with 4-12 branches/peduncles per whorl, somewhat thickened at the top. Sessile spikelet linear, laterally compressed, 8-9mm long; lower glume glabrous, 8-8.5mm long, flat towards the base, compressed above and hispid, coriaceous, margins glabrous and involute; upper glume 8-9mm long, clasping at the base, margins hyaline, coriaceous, awned, awn 12-15mm long, covered with stiff spreading hairs, the rest of the body scabrid. Florets 2: lower floret empty, lemma hyaline, linear-obtuse, ciliate; upper floret bisexual, lemma entire, 8-9mm long, terminates into a subulate awn 5-6cm long; lodicules 2, small, glabrous; anthers 3, 3mm long; ovary oblanceolate. Pedicellate spikelet male, linear-lanceolate, 10-12mm long, pale violet, dorsally compressed; lower glume with 7 equidistant nerves, keel somewhat ciliate, awned, awn about the same length as glume or longer, hispid; upper glume shortly aristate, ciliate on the margins. Florets 2: lower floret empty, lemma linear-obtuse, hyaline, ciliate, 2-nerved; upper floret male, lemma hyaline, shorter than the upper glume, ciliate, 1-nerved; anthers 3, 3.5mm long; pedicel 7-11.5mm long, with rigid reddish cilia on margins.

Chromosome number: 2n = 20 (Gould & Soderstrom, 1974).

Diagnostic characters and affinities: The vegetative shoots have a characteristic appearance due to the equitant arrangement of the leaf sheaths.

Habitat: Common grass on sandy soil, meadow and roadsides.

Type: India, Mont. Nilagiri, *Hohenacker* 1285 (K!).

Representative specimens:

China: Hainan, 18-30/vii-1932, *Fung* 20258 (E).

India: Madras (no exact location), xi.1899, *Bourne* 3124 (K); Madras, altitude 2000m (no exact location), vii.1889, *Gamble* 21442 (K).

Singapore: Kampong Padang, 04.vii.1953, *Sinclair & Salleh* 7530 (E).

Sri-Lanka: Northern Province, Jaffna District, Pallai, altitude 4m, 14.i.1970, *Clayton* 5250 (K); Irat, 18.iii.1927, *Galston* 1441 (K); about 28 miles east of Kandy on Malinyangana road near Madugoda, altitude 800m, 12.iv.1970, *Gould* 13383 (K).

Thailand: Kok Kradunk Nuu, TakBai, altitude 0m, 02.ix.1988, *Niyomdham & Ueachirakan* 1925 (K).

Distribution: Indian subcontinent.

7. ***Chrysopogon aucheri*** (Boiss.) Stapf, in Kew Bull. 1907: 211 (1907).-Bor, Grasses Burma Ceylon India & Pakistan: 116 (1960).-Clayton, in Hepper (ed.), Flora West Tropical Africa, Gramineae ed.2 (3): 468 (1968).

Synonyms: *Andropogon aucheri* Boiss., Diagn. ser. 1(5): 77 (1844); *Chrysopogon ciliolatus* var. *aucheri* Boiss., Fl. Or. 5: 458 (1884); *Andropogon aucheri* var. *genuinus* Hack., in DC., Monogr. Phan. 6: 560 (1889).

Perennial tussock forming grass. Culms 10-60cm tall, only the flowering culms issuing from the dense tufts; culm nodes glabrous or rarely with short velvety hairs. Leaf blades with tubercle-based hairs, densely puberulous (very rarely glabrous), linear-lanceolate, 1.5-3mm wide, up to 10cm long, equitantly arranged giving the plant a distinct appearance; leaf sheaths also densely puberulous and hairy at their mouths; ligule a ciliolate rim.

Inflorescence a terminal panicle; inflorescence axis with up to 10 joints, with each joint supporting a whorl of a few to many racemes; racemes single-jointed; raceme peduncles fulvously or pallidly bearded. Sessile spikelet laterally compressed; lower glume glabrous except for the pilose apex, 5.5-6mm long, awnless; upper glume, 6.5mm long, with flimsy inner ciliate margins and a pilose apex, awned, awn puberulous and 7.5mm long. Florets 2: lower floret empty, lemma hyaline, elliptic and entire; upper floret bisexual, lemma oblong and bidentate (bilobed), with ciliate margins near place of attachment to the lower ovary region, with a minutely hispidulous awn 2.3cm long; lodicules 2, fleshy, with a truncate apex and cuneate base; anthers 3, 3.5mm long; ovary ovate. Pedicellate spikelet dorsally compressed, male; lower glume coriaceous, glabrous with a pilose apex, 7-nerved, ovate, awned, awn obscurely hispid, 5mm long; upper glume shortly awned, 3-nerved, glabrous with ciliolate margins. Florets 2: lower floret empty, lemma ovate, ciliolate; upper floret male, lemma entire, awnless; anthers 3, 4mm long (i.e. slightly longer than those of the bisexual flower of the sessile spikelet); pedicels unilaterally long plumose, 2mm long.

Chromosome number(s): 2n = 20 (Faruqi, Quiraish & Halai, 1979); 40 (Celarier, 1959).

Diagnostic characters and affinities: Some specimens seen having culm nodes with short velvety hairs, a character not at all associated with *Chrysopogon.*

Habitat: Common on roadsides and rocky slopes.

Type: Type not seen. Type locality unknown.

Representative specimens:

Iran: (no location given), altitude 400m, 31.iii.1974, *Davis & Bokhari* 56217 (E); Kerman Province, altitude 1400-1700m, 01.v.1975, *Parris* 75.583 (E); Baluchestan, altitude 200m, 08.iii.1977, *Runemark, Assdi & Sardabi* 22497 (E).

Pakistan: Baluchistan, Quetta, altitude 1500-1600m, 14.v.1965, *Lammond* 1234 (E); Baluchistan, Kalat, 10.iv.1965, *Lammond* 333 (E); Baluchistan, Quetta, 21.viii.1942, *Sinclair* 2722 (E).

Distribution: Arabia, Tropical Africa, and the Indian subcontinent.

8. ***Chrysopogon gryllus*** (L.) Trin., Fund. Agrost.: 188 (1820).-Bor, Grasses Burma Ceylon India & Pakistan: 117 (1960).

Synonyms: *Andropogon gryllus* L., Cent. Pl. 2: 33 (1756); *Holcus gryllus* (L.) R. Br., Prodr.: 199 (1810); *Pollinia gryllus* (L.) Spreng., Pugill. 2: 10 (1815); *Apluda gryllus* (L.) Presl, Cyp. et Gram. Sci.: 55 (1820); *Chrysopogon glabratus* Trin., in Mem. Acad. Sci. Petersb. ser. 6(2): 318 (1832); *Andropogon glabratus* (Trin.) Steud., Syn. Pl. Glum. 1: 395 (1854); *Andropogon voyleanus* Steud., Syn. Pl. Glum. 1: 397 (1854).

C. gryllus subsp. ***gryllus***:

A large coarse tufted perennial grass of up to 2m tall. Culms somewhat robust, a number of them coming out of the same clump with a common root system; culm nodes glabrous, exposed. Leaf blades up to 30cm long, up to 6mm wide, linear or linear-lanceolate; leaf hairiness variable, most with sparse tubercle-based hairs (especially those of vegetative plants), more especially towards the leaf base and ligule vicinity but others only with echinulate margins, and still others glabrous; leaf sheaths striate, glabrous or with a few tubercle-based hairs towards the mouth; ligule a short ciliolate rim.

Inflorescence a large open panicle, to 30cm long; raceme peduncles with fulvous tips, capillary, glabrous with a tint of purple; racemes are single-jointed. Sessile spikelet glumes very firm; lower glume glabrous, scabrid, echinulate on the keels, 6.5mm long, awnless; upper glume 7.5mm long, awned, minutely hispid, glabrous and glossy, margins ciliate. Florets 2: lower floret empty, lemma 5mm long, ovate, with ciliate margins; upper floret bisexual, lemma bidentate (bilobed), 6mm long, oblong, with a puberulous awn of 4cm long; palea present, 3.5mm long, entire; lodicules 2, fleshy; anthers 3, 3.5mm long; ovary ovate, 3mm long. Pedicellate spikelet neuter; glumes with a tinge of purple; lower glume 7mm long, ovate, shortly awned, glabrous, hispid along the keels; upper glume 7mm long, boat-shaped, glabrous, awnless, ciliate along the margins; pedicels 5.5mm long, fulvously hairy along one margin, the rest of its body glabrous.

Chromosome number(s): 2n = 20 (Mehra, Subramanyam & Swaminanthan, 1962); 40 (Celarier, 1959).

Habitat: Found in dry open slopes.

Uses: A pasture plant up to the flowering stage.

Type: Described from southern Europe ("In Phaetia, Helvetia, Verone sauvages" (Tsvelev, 1976)). Type not seen.

Representative specimens:

Afghanistan: Province Nangarhar, Torkham, altitude 700m, 30.iv.1969, *Hedge, Wendelbo & Ekberg* W7448 (E).

Nepal: Mugu Karnali Valley, altitude 7000ft, 15.viii.1952, *Polunin, Sykes & Williams* 5230 (E); Tumar Valley, altitude 6500ft, 02.viii.1956, *Stainton* 1194 (E); Kusma, altitude 3000ft, 05.ix.1954, *Stainton, Sykes & Williams* 7047 (E).

Turkey: Usak, altitude 1000m, 13.vi.1965, *Coode & Jones* 2367 (E); Mardin, altitude 400m, 10.v.1966, *Davis* 42730 (E); Nigole/Katseri, altitude 1200-1300m, 22.vi.1952, *Davis* 19146 (E); Province Tunceli, Pertek-Hozat, altitude 1100m, 13.vii.1957, *Davis & Hedge* D31015 (E).

Distribution: Arabia, Temperate Himalaya.

*C. **gryllus*** subsp. ***echinulatus***[*] :

Inflorescence smaller and narrower than that of subsp. *gryllus*, brownish purple in colour; racemes consistently 3-jointed. Sessile spikelet: lower glume 6.5mm long, awnless, echinulate along the keels; upper glume 6.5mm long, awned, base of awn/apex of glume echinulate. Florets 2: lower floret empty, lemma 5mm long, ciliate, palea entire, 3.5mm long; upper floret bisexual, lemma bidentate (bilobed),

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[*] **echinulatus**, echinulate, with very small prickles.

ciliate towards the apex, 3-nerved, elliptic; awn 2cm long, glabrous or hispid; anthers 3, 3.5mm long; caryopsis oblong-obovate. Pedicellate spikelet male or neuter; lower glume glabrous, awned, purplish, hispid at the apex and along the keels; lemmas (i.e. both upper and lower) same as lower lemma of sessile spikelet; upper glume awnless, with involute ciliate margins; anthers 3, 3.5mm long; pedicels glabrous, gradually thickened upwards, laterally flattened.

Type: Northwest India, *Royle* 226 (LIV).

Representative specimens:

India: Bashahr State (no exact location), 09.vii.1890, *Lace* 376 (E); Punjab, Baspa Valley, altitude 12 500ft, 12.vii.1939, *Ludlow & Sherriff* 7424 (E).

Pakistan: Harara District, altitude 2000ft, 18.ix.1958, *Burt & Kazmi* B1288 (E); Kashmir, Sonamarg, altitude 8500ft, 02.ix.1956, *Polunin* 56/641 (E).

Distribution: Northwest Himalaya.

9. ***Chrysopogon plumulosus*** Hochst., in Jahreshefte Württ. 3: 62 (1847).-Clayton & Renvoize, in Polhill (ed.), Flor. Trop. East Afr., Gramineae (3): 737 (1982).-Chaudhary, Grasses of Saudi Arabia: 413 (1989).-Cope & Hosni, A key to Egyptian grasses: 54 (1989).

Synonyms: *Aristida chrysopila* Steud., Nom. Bot., ed. 2, 1: 131 (1840); *Chrysopogon quinqueplumis* A. Rich., Tent. Fl. Abyss. 2: 450 (1851); *Andropogon aristidoides* Steud., Syn. Pl. Glum. 1: 397 (1854); *Andropogon quinqueplumis* (A. Rich.) Steud., Syn. Pl. Glum. 1: 398 (1854); *Andropogon aucheri* Boiss. var. *quinqueplumis* (A. Rich.) Hack., in DC., Monogr. Phan. 6: 561 (1889); *Chrysopogon aucheri* (Boiss.) Stapf var. *quinqueplumis* (A. Rich.) Stapf, in Kew Bull. 1907: 211 (1907); *Chrysopogon aucheri* (Boiss.) Stapf var. *pulvinatus* Stapf, in Prain, Flora Tropical Africa IX: 161 (1917).

Perennial with wiry culms, 10-90 cm tall; culm nodes exposed and glabrous. Leaf blades cauline, sometimes forming cushions at the bottom, 1-15cm long, 1-3mm wide, linear-lanceolate, glabrous or sometimes with sparse tubercle-based hairs underneath (on adaxial surface) and around the ligule area, bluntly acute and becoming acuminate; leaf sheaths glabrous, very tight, the uppermost clasping the culm, ending in a small flag leaf; leaf ligule a short ciliolate rim.

Inflorescence a terminal panicle of about 3-7cm long, with delicate capillary branches with a fulvous beard at the tip; the inflorescence axis slender, jointed and with whorls of 3-to-many pedunculate racemes coming off at the joints. Sessile spikelet narrowly oblong; lower glume laterally compressed to a rounded keel, 6mm long, slightly pilose at the tip; upper glume sparsely ciliate on the keel, bears a plumose awn 12mm long. Florets 2: lower floret empty, lemma hyaline and ciliate towards the base; upper floret bisexual, lemma entire, bears a puberulous awn 3cm long; ovary ovate; lodicules 2, fleshy; callus short and blunt, 1.2mm long. Pedicellate spikelet 6.5mm long, pallid or purplish, male or neuter, both the upper and lower glumes with plumose awns; upper glume awn is 6mm long and lower glume awn is 10mm long. The texture of the glumes of the pedicellate spikelet is different from those of the sessile spikelet. Those of the sessile spikelet are tough and shiny while those of the pedicellate spikelet are papery; pedicels taper downward, unilaterally villous and about half the length of the sessile spikelets.

Chromosome number: 2n = 40 (Fedorov, 1974).

Diagnostic characters and affinities: This species is characterised by the long plumose awns of the glumes.

Habitat: Found in fixed sand dunes, dry rocky slopes and dry wadi beds.

Type: Saudi Arabia, Jedda to Mecca, *Schimper* (whereabouts uncertain; based on same gathering as *Aristida chrysopila* Steud.).

Representative specimens:

Oman: Salalah, altitude 10m, 15.x.1984, *Mcleish* 139 (E); Dhofar, altitude 810m, 22.ix.1985, *Miller* 7754 (E).

Saudi Arabia: Dawadimi Camp, altitude 2900ft, 02.iii.1983, *Collenette* 4050 (E); Ulayyah, altitude 570m, 17.iv.1982, *Podzorski* 969 (E).

Somalia: Upper Sheekh, altitude 1500m, 09.x.1978, *Allen & Elmi* 454 (E); Shabeellaha Dhexe, altitude 50m, 30.v.1989, *Thulin & Dahir* 6740 (E).

Yemen Arab Republic: Marib, altitude 1300m, 04.iv.1981, *Miller & Long* 3418 (E).

Distribution: Arabia, Tropical East Africa.

10. ***Chrysopogon fulvus****[*] (Spreng.) Chiov., Fl. Somala. 1: 327 (1929).-Bor, Grasses Burma Ceylon India & Pakistan: 116 (1960).

Synonyms: *Pollinia fulva* Spreng,. Pugill. 2: 10 (1815); *Andropogon monticola* Roem. et Schult., Syst. Verz. 2: 665 (1827); *Andropogon sprengelii* Kunth, Rev. Gram. 1: 166 (1829); *Chrysopogon monticola* (Roem et Schult.) Haines, in Indian For. 40: 495 (1914); *Andropogon montanus* Koen. ex Trin., in Spreng., Neue Entdeck. 2: 93 (1921) *Chrysopogon montanus* Trin. ex Spreng., in Spreng., Neue Entdeck. 2: 93 (1921).

Perennial grass. Culms densely tufted, erect and branching, 50-70cm tall. Leaf blades linear-acuminate, glabrous, 4mm wide; leaf sheaths keeled, glabrous, lower ones overlapping; ligule a hairy rim.

Inflorescence consists of racemes with or filiform peduncles; main inflorescence axis with a whorl of racemes; racemes single-jointed (rarely 2-jointed), with fulvously

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[*] **fulvus**, tawny, dull yellow with a mixture of grey and brown, yellowish-brown, this is the predominant colour of the inflorescence parts.

villous tips; the spikelets purplish in colour and this together with the yellowish-brown colour of the peduncles give the inflorescence a distinct facies. Sessile spikelet 5mm long, laterally compressed; lower glume linear, hispid towards the apex on the keels, awnless; upper glume pectinately ciliate (fulvus) on the keel, 3-nerved, awned, awn obscurely hispidulous, 8.5mm long. Florets 2: lower floret empty, lemma hyaline with ciliate margins; upper floret bisexual, epaleate, lemma bidentate (bilobed), hyaline, with an awn 2cm long, glabrous; callus short and blunt, 0.5mm long, shortly bearded; lodicules 2, fleshy; anthers 3, 3mm long; ovary ovate. Pedicellate spikelet male or neuter, both glumes awned; lower glume ovate, sparsely hairy on the keel, awn 6mm long, obscurely hispid, lemma oblong-ovate, hyaline, ciliate on margins; upper glume hyaline, glabrous, awn 5.5mm long, obscurely hispid; pedicel 2mm long, unilaterally villous.

Chromosome number(s): 2n = 20, 80 (Mehra & Gill, 1968).

Habitat: Shrubby or grassy hill slopes.

Uses: Cultivated fodder.

Type: Type locality, India.

Representative specimens:

India: (no location given), ix.1920, *Anderson s.n.* (E); Khundura District (no exact location), 10.xii.1888, *Duthie* 8489 (E); Tehri, altitude 400ft, 14.iv.1948, *Koelz* 21766 (E); Bashahr State, Taughin Dogn - Upper Kauawar, altitude 6500ft, 26.ix.1890, *Lace* 628 (E); Bombay Presidency, Belguam, 28.xi.1944, *Sinclair* 3781 (E); Nagarjuna Kouda Valley, altitude 300ft, 14.vii.1961, *Thothathrii* 9666 (E).

Distribution: Tropics of Asia and East Africa.

11. ***Chrysopogon serrulatus***[*] Trin., in Mem. Acad. Sci. Petersb. Ser. 6(2): 318 (1832).-Bor, Grasses Burma Ceylon India & Pakistan: 118 (1960).-Clayton & Renvoize, in Polhill (ed.), Flor. Trop. East Africa: 736 (1982).-Gibbs Russell et al, Grasses of Southern Africa: 85 (1991).

Synonyms: *Andropogon trinii* Steud., Syn. Pl. Glum. 1: 395 (1854); *Andropogon ciliolatus* Steud., Syn. Pl. Glum. 1: 396 (1854); *Andropogon caerulens* Steud., Syn. Pl. Glum. 1: 395 (1854); *Chrysopogon ciliolatus* (Steud.) Boiss., Fl. Orient. 5: 458 (1884); *Andropogon trinii* Steud. var. *increscens* Hack., in DC., Monogr. Phan. 6: 558 (1889); *Andropogon monticola* Schult. var. *trinii* Hook.f., Fl. Brit. Ind. 7: 193 (1896); *Chrysopogon montanus* Trin. var. *serrulatus* (Trin.) Stapf, in Prain, Fl. Trop. Afr. IX: 160 (1917); *Chrysopogon montanus* Trin var. *tremulus* (Hack.) Stapf, in Prain, Flora of Tropical Africa IX: 160 (1917); *Chrysopogon fulvus* (Spreng.) Chiov. var. *tremulus* (Hack.) Chiov., Rac. Bot. Miss. Consol. Kenya: 325 (1935); *Chrysopogon fulvus* (Spreng.) Chiov. var. *serrulatus* (Trin.) R. B. Stewart, in Brittonia 5: 446 (1945).

Perennial. Culms up to 150cm tall, sometimes robust. Leaf blades glabrous except in the ligule vicinity where there are sparse tubercle-based hairs on the margins on both surfaces, linear-lanceolate, 2-10mm wide; leaf sheath glabrous, rarely hairy at the top; leaf ligule a ciliolate rim.

Inflorescence paniculate, up to 15cm long; consists of racemes with peduncles fulvously bearded at the tips. Sessile spikelet narrowly oblong, 6mm long; lower glume awnless, slightly hispid at the tip, 6mm long; upper glume with few white hairs on the back, with a glabrous awn about 12mm long, obscurely hispidulous. Florets 2: lower floret empty, lemma hyaline, single-nerved with sparsely ciliolate margins; upper floret bisexual, lemma hyaline, bilobed (bidentate), awn 2.5cm long, slightly

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[*] **serrulatus**, finely serrate, i.e., saw edged with sharp teeth pointing forwards.

puberulous, ovary about 1mm long, completely enclosed by 2 fleshy lodicules, anthers 3, 3mm long. Pedicellate spikelet male or neuter, glumes awned; lower glume 6mm long, with white short hairs on the back, awn 5mm long, hispidulous; upper glume glabrous, 6.5mm long, awn 2.5mm long, obscurely hispidulous, lemma hyaline, sparsely ciliolate on the margins; anthers 3, 3mm long; pedicel 2.5mm long, fulvously villous unilaterally.

Diagnostic characters and affinities: This species is very similar to *C. plumulosus* except that it has a longer callus (up to 1.5mm long), longer upper glume of sessile spikelet (4-7mm long) and the glabrous or obscurely hispidulous (not plumose) awns of the glumes of both the sessile and pedicellate spikelets. Also the upper lemma apex is bilobed in *C. serrulatus* and entire in *C. plumulosus*.

Habitat: Common in shallow sandy soils and rocky landscape. Also in dry overgrazed soils in deciduous bushland.

Type: Nepal, *Wallich* (LE).

Representative specimens:

Botswana: Gaborone, Aedume Park, altitude 1050m, 09.xi.1977, *Hansen* 3276 (K).

Zimbabwe: Nuanetsi District, Sengwe Tribal Trust Land, 15.xi.1973, *Cleghorn* 2910 (K); Gwanda District, Tuli Pasture Research Sub-Station, altitude 2500ft, 5.i.1955, *Oates* 1742 (E); Urungwe District, altitude 1700ft, 16.x.1957, *Phipps* 797 (K); Nyamandhlovu District (no exact location), 21.ix.1956, *Plowes* 1880 (K).

Distribution: Tropical Africa, Northwest India.

8.2.8. ***Vetiveria*** Bory in Lem.-Lisanc., in Bull. Sci. Soc. Philom: 42 (1822). Type species is *Vetiveria zizanioides* (L.) Nash.

Synonyms: *Lernomandia* Steud., in Flora 33: 229 (1850); *Mandelorna* Steud., Syn. Pl. Glum. 1: 359 (1854).

Tufted perennials with tough rhizomes; lower leaf sheaths much compressed, flabellate-imbricate; conduplicate leaf blades which do not bend away from the culm at the collar region but just a lateral indentation marks the end of the sheath and the beginning of the blade; leaf sheaths flattened. Inflorescence a panicle, its primary branches whorled, simple or unbranched, each bearing a raceme; racemes (2-)3 to many-jointed, pedunculate; spikelets paired, compressed laterally, differing in sex, one sessile, the other pedicellate; rachis internodes and pedicels slender and gradually thickened upwards. Sessile spikelet laterally compressed, its callus obtuse to pungent, often large and conical; lower glume papery to coriaceous, muticus, spinulose on the keels and muricate or mammilate on the back; upper glume aristate; upper lemma entire or bilobed, awned or awnless. Pedicellate spikelet male or neuter.

Species 10.

A key to taxa sampled:

Sessile spikelet awnless. 1. ***zizanioides***

Sessile spikelet awned:

Lower glume of sessile spikelet 8mm long. 2. ***filipes***

Lower glume of sessile spikelet 5-7mm long:

Racemes 2 to 3-jointed; leaf blades long-attenuate. 3. ***elongata***

Racemes many-jointed:

Lower glume of sessile spikelet 5mm long, smooth; upper lemma awn 10mm long. 4. ***fulvibarbis***

Lower glume of sessile spikelet 7mm long, muricate on the back; upper lemma awn 5mm long. 5. ***nigritana***

1. ***Vetiveria zizanioides*** (L.) Nash, in Small, Fl. Southeast U. S.: 67 (1903).-Stapf, in Kew Bull. 1906: 346-349, 362 (1906), & in Prain, Flor. Trop. Africa IX: 157 (1917).-Sturgeon, A revised list of the grasses of Southern Rhodesia Part IV: 8 (1954).-

Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 470 (1955).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 70 (1958).-Bor, Grasses Burma Ceylon India & Pakistan: 258 (1960).-Napper, Grasses of Tanganyika: 99 (1965).-Clayton, in Hepper (ed.), Flor. West Trop. Africa ed.2 (3), Gramineae: 470 (1972).-Lowe, The flora of Nigeria, Grasses: 291 (1989).

Synonyms: *Phalaris zizanioides* L., Mant. Pl. 2: 183 (1771); *Andropogon muricatus* Retz., Obs. Bot. 3: 43 (1783); *Agrostis verticillata* Lamk., Ecycl. Meth. Bot. 1: 59 (1783); *Anatherum muricatum* (Retz.) P. Beauv., Ess. Agrost.: 150 (1812); *Vetiveria odoratissima* Lem.-Lisanc., in Bull. Soc. Philom. (Paris): 43 (1822); *Vetiveria odorata* Vivey, J. Pharm. 13: 501 (1827); *Andropogon festucoides* J. S. Presl ex C. B. Presl, Rel. Haenk. 1: 340 (1830); *Vetiveria muricata* (Retz.) Griseb., Fl. Brit. West Ind.: 560 (1864); *Vetiveria arundinacea* Griseb., Fl. Brit. West. Ind.: 559 (1864); *Sorghum zizanioides* (L.) O. Ktze., Rev. Gen. Pl. 2: 791 (1891); *Andropogon zizanioides* (L.) Urban, Symb. Antill. 4: 79 (1903); *Holcus zizanioides* (L.) O. Ktze. ex Stuck., in Ann. Mus. Nac. Buenos Aires 11: 48 (1904); *Anatherum zizanioides* (L.) Hitchc. et Chase, in U.S. Natl. Herb. Contrib. 18: 285 (1917).

Perennial grass of up to or greater than 2m tall; culms erect, usually sheathed all along. Leaf blades linear, acute, up to 90cm long, 4-20mm wide, erect, rigid, firm or somewhat spongy, striate; leaf sheaths compressed, particularly the lower ones, sharply keeled, fan shaped, imbricate, very smooth; ligule a scarious rim.

Inflorescence a long oblong panicle of up to and over 30cm long, contracted; the main inflorescence axis stout, glabrous, smooth; whorls 6-10 with up to 20 pedunculate racemes; peduncles filiform, slightly scabrous; racemes very slender; rachis internodes about the same length as spikelets or slightly longer, glabrous; pedicels shorter than the sessile spikelets, glabrous. Sessile spikelet linear-lanceolate, variable in colour (yellowish, olive, violet brown, purplish); callus obtuse, 1mm long or less, glabrous; lower glume muricate on the back, spinulose on the keels; upper glume spinulose on the keel. Florets 2: lower floret empty, lower lemma as long as the glumes, acute, retrorsely ciliate; upper floret bisexual, lemma up to 3mm long, narrow, oblong-lanceolate, mucronate, glabrous; anthers 3, 2-3mm long; ovary ovate, 3.5mm long. Pedicellate spikelet sparingly aculeolate or almost smooth, male; lower lemma same as for sessile spikelet; upper lemma acute, entire; anthers 3, 2.5mm long; pedicel glabrous.

Chromosome number: 2n = 20 (Celarier, 1959).

Diagnostic characters and affinities: The awnless spikelets give the inflorescence a different facies from other species of *Vetiveria*. Raceme peduncles are much shorter, making the inflorescence much contracted and compact. The lower glumes of both the sessile and pedicellate spikelets are muricate, giving the inflorescence a 'prickly' appearance. Spikelets much smaller, inflorescence characteristically long.

Habitat: Mostly in cultivated fields and basically in places associated with the function it is intended for, e.g., it might be grown as edging to roads.

Uses: Principally used for thatching; not grazed except when young and tender. Its root is the scented *khas khas* which is used for *tattis* or grass screens which are kept wetted to cool rooms. Commercial oils are extracted from its roots and used in perfumery.

Type: India, *Koenig* (LINN).

Representative specimens:

Ghana: Achimota, v.1931, *Irvine* 1638 (E).

India: Najafgarh, 29.vii.1956, *Bilandi s.n.* (E); Kissar, Autumn 1884, *Coldstream s.n.* (E).

Malay Peninsula: near Kampong Sungei Kluang, Penang, 14.xi.1950, *Sinclair* 6668 (E).

Mauritius: Curepipe, altitude 1840ft, 27.iv.1889, *Johnston s.n.* (E).

Nepal: Butwal, altitude 500ft, 07.x.1954, *Stainton, Sykes & Williams* 8823 (E).

Pakistan: Shekhupung District, near Sadhoke, about 25 miles north of Lahore, 20.vii.1958, *Burt* B1166 (E).

Thailand: altitude 300m (no location given), 05.ix.1911, *Kerr* 2007 (E); Maharat, altitude 400m, 02.iii.1958, *Sorensen, Larsen & Hansen* 1820 (E).

Distribution: Southeast Asia to Tropical Africa; introduced to most parts of the world.

2. ***Vetiveria filipes*** (Benth.) C.E. Hubbard, in Kew Bull. 1934: 444 (1934).-Blake, in Univ. Queensland Papers 2(3): 23 (1944).-Burbidge, Australian grasses 3: 46 (1970).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 268 (1982).-Simon, A key to Australian grasses ed. 2: 175 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 54 (1994).

Synonyms: *Chrysopogon elongatus* (R. Br.) Benth. var. *filipes* Benth., Fl. Austral. VII: 539 (1878); *Andropogon elongatus* (R. Br.) Spreng. var. *filipes* (Benth.) Hack., in DC., Monogr. Phan. VI: 565 (1889); *Chrysopogon gryllus* (L.) Trin. var. *spicigera* Maid. & Betche, in Proc. Linn. Soc. N. S. W.: 15 (1916).

A tufted perennial. Culms relatively slender, 70-100cm tall, unbranched or sparingly branched from the middle nodes, closely sheathed in the lower part. Leaf blades rather obtuse, 15-45cm long, 3-6mm wide, with a scabrous adaxial surface, smooth abaxial surface; leaf sheaths smooth.

Inflorescence a whorl of paniculate racemes, narrow and with a few (up to 6) joints; racemes are longer than their peduncles, purple; peduncles filiform, puberulous near the base, the rest of their length scabrid, with an obliquely truncate tip, slightly thickened upwards; rachis internodes glabrous. Sessile spikelet grey or purple, linear-lanceolate, narrowed from about the middle, 8mm long, acute or acuminate; callus subulate-conical, about 2.5mm long with fulvous hairs on the sides; lower glume coriaceous, with an indistinct median keel near the tip which is sometimes spinulose, scabrid, muricate along the keel nerves from the middle towards the base, spinulose along the keels towards the apex; upper glume mucronate, spinulose along the keel. Florets 2: lower floret barren, lower lemma elliptic, ciliate along the margins, nearly as long as the glumes; upper floret bisexual, lemma entire or shortly bilobed, elliptic or becoming ovate, about same length as lower, awned; awn well developed, about 16mm long, slightly twisted but not geniculate, scabrous; anthers 3, 2.5mm long; ovary elliptic, 4mm long. Pedicellate spikelet neuter, narrowly lanceolate, 5.5mm long; lower glume smooth, lower lemma very much like that of the sessile spikelet but much shorter; upper glume oblong-elliptic; upper lemma linear, sparsely ciliate in the upper part, very short; pedicels rarely exceeding the top of the sessile spikelet, flat, glabrous.

Chromosome number(s): 2n = 40 (Celarier, 1959).

Diagnostic characters and affinities: This species is less robust in form relative to other species of *Vetiveria*. Blake (1944) mentions that the peduncles sometimes are subdivided and the racemes coming from these single-jointed. The specimens observed did not show this.

Habitat: Common on sandy river banks or alluvium soils.

Type: Australia, Queensland, Banks of the Baloon, 05.iv.1946, *Michell s.n.* (K!).

Representative specimens:

Australia:

Queensland: Cook District, Mareeba, altitude 1300ft, 18.vi.1935, *Blake* 9475 (E); Cook District, near Cooktown, 14.v.1970, *Blake* 23230 (E); North Kennedy District, Magnetic Island, near Townsville, altitude 0m, 18.i.1931, *Hubbard & Winders* 6643 (E); Leichhardt District, Mackenzie river, 90 miles south-east of Nebo Township, 13.vii.1962, *Story & Yapp* 163 (E).

Distribution: Australia, mainly eastern Queensland.

3. ***Vetiveria elongata*** (R. Br.) Stapf ex C. E. Hubbard, in Kew Bull.: 444 (1934).-Blake, in Univ. Queensland Papers 2(3): 19 (1944).-Simon, A key to Australian grasses ed.2: 175 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 54 (1994).

Synonyms: *Holcus elongatus* R. Br., Prodr.: 200 (1810); *Sorghum elongatum* Beauv., Agrost.: 178 (1812); *Andropogon elongatus* (R. Br.) Spreng., Syst. Veg. 1: 287 (1825).-F. Muell., Fragm. VII: 121 (1873), First Census: 132 (1882), Second Census: 222 (1889).-Hack, in DC., Monogr. Phan VI: 564 (1889).-Ewart & Davies, Fl. N. Territ.: 30 (1917); *Chrysopogon elongatus* Benth., Fl. Austral. 7: 538 (1878).-F.M. Bail., Synops. Queensland Fl.: 645 (1883), Catal. Queensl. Pl.: 620 (1913); *Rhaphis elongata* (R. Br.) Chase, in Contrib. U. S. Nat. Herb. XXIV: 205 (1925).

Perennial tussock forming grass, tussocks of up to 1m in diameter. Culms up to 2.5m tall, smooth, sheathed nearly all along. Leaf blades long-attenuate, mostly conduplicate for most of their length, up to 50cm long and 8mm wide, spinulose on the margins and keel, abaxial surface glabrous and smooth, upper with scattered rather short tubercle-based hairs.

Inflorescence a long (up to 30cm) and contracted panicle; consists of more than 10 whorls of pedunculate racemes; peduncles up to 4.5cm long, glabrous and smooth. Racemes mostly 2-3-jointed, purplish to pallid; rachis internodes 3.2-4.2mm long, glabrous; pedicels shorter, 2-3mm long, also glabrous. Sessile spikelet bisexual, linear-lanceolate, 5-7mm long; callus narrow-cuneate, 2mm long, bearded on the margins with white hairs up to 4mm long; lower glume muticus, coriaceous, 5.5mm long, 2-keeled, spinulose along the keels; upper glume coriaceous, aristate, carinate, the keel spinulose upwards. Florets 2: lower floret empty, lower lemma elliptic oblong, slightly shorter than the glumes, ciliate; upper floret bisexual, lemma oblong, bidentate (bilobed), awned; awn 7mm long, scabrid, weakly twisted; palea present, small, hyaline; lodicules 2, fleshy; anthers 3, 4mm long; caryopsis oblong. Pedicellate spikelet male, linear-lanceolate, 5.5mm long; lower glume with a median keel below the tip in the middle of the two lateral ones, smooth; upper glume elliptic-obtuse; both lemmas ciliate along the margins, the lower about the same length as the glumes, elliptic-oblong, the upper narrowly oblong and slightly shorter; anthers 3, 4mm long; pedicel glabrous.

Diagnostic characters and affinities: This species is easily distinguished by its tall culms with narrow and dense inflorescences, and the long attenuate leaves, usually permanently folded. Blake (1944) used the number of raceme joints as another character separating this species from *V. pauciflora*. Even though I did not see specimens of *V. pauciflora*, I found this character very unreliable because the *V. elongata* specimens I observed had mostly 2-3-jointed racemes, a character associated with *V. pauciflora*.

Habitat: Prefers moist habitats such as beach ridges, river and stream banks or sea facing slopes.

Type: Australia, 1802-1805, *Brown s.n.* (K!).

Representative specimens:

Australia:

Northern Territory: Leila Creak and McArthur river, altitude 112-178m, 14.v.1947, *Blake* 17766 (K); Yirrkala, 07.viii.1948, *Specht* 839 (K); 250km east-northeast of Darwin, altitude 60m, 15.vi.1978, *Story* 8351 (K); 66 miles east of Borroloole, 05.vi.1967, *Symon* 5068 (K).

Queensland: Cook District, 7km east-southeast of Aurukun Mission, 05.xii.1981, *Clarkson* 4112 (K).

Distribution: Australia.

4. ***Vetiveria fulvibarbis**** (Trin.) Stapf, in Prain, Fl. Trop. Afr. IX: 158 (1917).-Clayton, in Hepper (ed.), Flor. West Trop. Africa, Gramineae ed.2 (3): 470 (1972).-Lowe, The flora of Nigeria, Grasses: 289 (1989).

Synonyms: *Andropogon verticillatus* Schumach., in Schumach. & Thonn., Beskr. Guin. Pl.: 50 (1820); *Andropogon fulvibarbis* Trin., in Mem. Acad. Petrsb. 6mer ser.II: 287 (1832).-Hack., in DC., Monogr. Phan. 6: 544 (1889).

A tufted perennial. Culms up to 2m tall, less robust, sparingly branched; most of the middle and upper culm nodes of the flowering culms exposed and glabrous. Leaves folded, linear with compressed leaf bases, glabrous or sparsely hairy on the abaxial surface in the ligule vicinity; leaf sheaths sharply keeled, separated from the leaf blades by an indentation at the collar area; ligule a ciliolate rim.

Inflorescence consists of raceme whorls (6-8 nodes) with up to and over 12 pedunculate racemes per whorl (joint); raceme joints with fulvous hairs; rachis joints oblique, minutely ciliolate; rachis internodes glabrous, flat on the sessile spikelet side and rounded on the back, gradually thickened upwards; pedicels similar but shorter. Sessile spikelet subulate-linear; lower glume smooth on the back except for the rigidly ciliolate margins, 5mm long; upper glume sharply keeled and also rigidly ciliolate along the keel, aristulate from the tip, the margins flexible and ciliate. Florets 2: lower floret empty, lower lemma oblong, about the same length as glumes, ciliate; upper floret bisexual, lemma short, bilobed, awned; palea linear, glabrous; awn slender, about 1cm long; ovary tiny, oblong; lodicules 2, fleshy, completely enclosing the ovary; anthers 3, 3.5 mm long. Pedicellate spikelet male, as long as the sessile, glumes smooth, papery; lower glume acutely acuminate, purplish, smooth, with a short bristle; upper glume opaque, ciliate along margins; both lower lemma and upper

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* **fulvibarbis**, with yellowish-brown (**fulvus**), hairs (**barbis**), referring probably to the rachis joints.

lemma narrowly oblong, hyaline and ciliate along margins; palea present, ciliate on margins; anthers 3, 3.5mm long.

Diagnostic characters and affinities: The perfect awns give it a distinct facies from *V. nigritana* and *V. zizanioides*. The glumes are papery and relatively smooth.

Habitat: Common in wet and swampy waterlogged grass plains.

Type: Type not seen. Type locality indicated as West Africa.

Representative specimens:

Chad: Mêma, 300km north of Segou, x.1955, *Wintrebert* 9/1957 (K).

Ghana: Legon Hill, 05.x.1955, *Adams* 3343 (K); Accra Plains, 25.ii.1927, *Dalziel* 8429 (E); Accra Plains, 15 miles south of Akosombo, 28.xii.1969, *Easterly* 1287 (E); Achimota, vi.1961, *Irvine* 4503 (E); on Akuse to Kpong road, 18.x.1953, *Morton s.n.* (K); between Nyamalege and Fuu villages, Tamale-Salaga road, 02.viii.1963, *Rose Innes* 31873 (K).

Distribution: Mainly a West African species.

5. ***Vetiveria nigritana*** Stapf, in Prain, Fl. Trop. Afr. IX: 157 (1917).-Sturgeon, A revised list of the grasses of Southern Rhodesia Part IV: 8 (1954).-Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 469 (1955).-Napper, Grasses of Tanganyika: 99 (1965).-Hood, A guide to the grasses of Zambia: 58 (1967).-Clayton, in Hepper (ed.), Flor. West Trop. Africa ed.2 (3), Gramineae: 470 (1972).-Clayton, in Polhill (ed.), Flor. Trop. East Africa, Gramineae (3): 739 (1982).-Lowe, The flora of Nigeria, Grasses: 291 (1989).-Gibbs Russell et al, Grasses of Southern Africa: 353 (1991).

Synonyms: *Andropogon nigritanus* Benth., in Hook., Niger Fl.: 573 ();*Mandelorna insignis* Steud., Syn. Pl. Glum. 1: 359 (1854); *Andropogon squarrosus* var. *nigritanus* Hack., in DC., Monogr. Phan. 6: 544 (1889); *Anatherum muricatum* Rendle, in Cat. Afr. Pl. Welw. II: 153 (1899).

Tufted perennial. Culms 1.5-3m tall, unbranched: upper culm nodes exposed, glabrous, lower ones hidden by leaf sheaths. Leaf blades narrow, up to 90cm long and 7mm wide, cauline; leaf sheaths sharply keeled; ligule a scarious rim.

Inflorescence a terminal panicle of whorled, pedunculate racemes; racemes many-jointed; the main inflorescence axis and raceme peduncles minutely ciliolate towards the apex (upward facing cilia); raceme peduncle length reduces upwards, giving the panicle a lanceolate appearance; whorls 8-10 and with up to 15 racemes; rachis internodes and pedicels gradually thickened upwards. Sessile spikelet: lower glume compressed laterally, leathery, spinulose on the back, narrowly linear-lanceolate, 7mm long; upper glume sharply keeled in the middle, spinulose along the keel, with an inflexed margin, drawn to a short aristate tip, 7mm long. Florets 2: lower floret represented by a hyaline lemma, lemma ovate; upper floret bisexual, lemma hyaline, with a bilobed apex; awn 5mm long, slightly exserted from the glumes or enclosed, bristle-like, glabrous on the lower half (column) and minutely toothed on the bristle; lodicules 2, fleshy; no anthers seen; ovary oblong-lanceolate. Pedicellate spikelet neuter, shorter than the sessile one; both glumes less coriaceous, and less spinulose; lower glume 5mm long, sparingly aculeolate along the keel towards the apex or almost smooth; upper glume smooth with flexible ciliate margins; lower lemma hyaline with ciliate margins; pedicel solid, glabrous, thickened upwards.

Diagnostic characters and affinities: Very much like *V. zizanioides* except for the fact that it has longer spikelets and is awned. Awn bristle-like, enclosed or more or less exserted from the sessile spikelet.

Habitat: Occurs mainly on river banks, occasionally on roadsides and forested areas.

Type: Nigeria, Nun R., *Vogel* (K!).

Representative specimens:

Botswana: Northwest District, Okavango river, Old Mohembo, 16km north of Shakawe on Botswana border, 19.iii.1965, *Wild & Drummond* 7074 (BM).

Malawi: Port Herald, Tengam, 28.xi.1950, *Jackson* 310 (MAL); Khonjeni Estate, Thyolo, altitude 2400ft, 16.xii.1974, *Schwarz* 14 (MAL).

Mozambique: Boroma Province, Ulere station, Zambezi river, 10.vii.1956, *Chase* 2671 (BM); Chitengo, 13km to Acampamento, 02.v.1978, *Diniz* 163 (WAG).

Ghana: near Tamale, viii.1964, *Irvine* 4552 (E).

Zambia: Mankoya District, near resthouse, Mankoya, 20.xi.1959, *Drummond & Cookson* 6644 (E, BM); Kafue District (no exact location), 09.ii.1963, *Van Rensberg* 1359 (BM).

Zimbabwe: Gokwe District, Copper Queen N.R.A, near Morowa river, 21.xii.1963, *Bingham* 901b (BM).

Distribution: Tropical Africa.

8.2.9. ***Pseudodichanthium*** Bor, in Indian For. 66: 271 (1940).-Bor, in Hook. Ic. Pl. t3598: 1-3 (1962). The type species is *Pseudodichanthium serrafalcoides* (Cooke et Stapf) Bor.

Annual. Inflorescence a terminal solitary raceme; lowest 2-3 rachis internodes short and glabrous, the upper ones longer and ciliate on the edges; spikelets much imbricate, distichous; lowest 2-3 spikelet pairs homogamous. Sessile spikelets callus obtuse; lower glume cartilaginous, broadly convex, the margins expanded into wings; upper glume papery, shorter than the lower. Pedicellate spikelets larger than the sessile .

Species 1.

Pseudodichanthium serrafalcoides (Cooke et Stapf) Bor, in Indian For. 66: 272 (1940).-Bor, Grasses Burma Ceylon India & Pakistan: 204 (1960).-Bor, in Hook. Ic. Pl. t3598: 1-3 (1962).

Synonyms: *Andropogon cookei* Stapf ex Woodrow, in J. Bombay Nat. Hist. Soc. 13: 438 (1893); *Andropogon serrafalcoides* Cooke et Stapf Blatt. et McCann, in Kew Bull. 1908: 450 (1908); *Dichanthium serrafalcoides* (Cooke et Stapf) Blatt. et McCann, in J. Bombay Nat. Hist. Soc. 32: 426 (1928).

Annual grass. Culms slender, ascending from a slender base, 60cm tall; culm nodes glabrous. Leaf blades narrowly linear, up to 7.5mm wide, more or less hirsute; sheaths glabrous; ligule an unfringed membrane, 1mm long.

Inflorescence a solitary raceme at the end of culms and branches; raceme with 4-10 spikelet pairs; lowest 2-3 rachis internodes short, glabrous, the upper ones ciliate on the edges; lowest 2-3 spikelet pairs homogamous, neuter. Spikelets much imbricate, glabrous, pedicellate spikelet larger than the sessile. Sessile spikelet bisexual; lower glume broadly winged, margins narrowly inflexed; upper glume papery, shorter than the lower. Florets 2: lower floret empty, lemma oblong, obtuse, hyaline, epaleate; upper floret bisexual, lemma stipiform; lodicules, 2, fleshy; anthers 3, 1.5mm long; ovary obovate, tiny. Pedicellate spikelet similar to the sessile but longer, neuter; lower glume with inflexed margins; lowest pedicels very short, glabrous, the remainder longer, densely ciliate on one edge.

Diagnostic characters and affinities: The lower glumes of both the sessile and pedicellate spikelets are broadly winged. Bor (1940) notes the following peculiarity about this species: "Above the attachment of the leaf sheath is a broad band of tissue consisting of large pith-like cells. In many grasses the culms are swollen at the nodes, but this swelling is not on the stem but at the base of the leaf sheath. In *Pseudodichanthium*, however it is the base of the internode, above the attachment of the leaf, which is enlarged. It is from the 'supranodal' cushions that the adventitious roots are produced and it is here, presumably, that cell division takes place so that the internode can increase in length. In contrast to the hard and woody shaft of the internode, the supranodal cushion is soft and spongy, even in dried specimens".

Habitat: Occurs on limestone escarpments under dense monsoon forests.

Type: India, Western Ghats, Sakarpattar, near Lanauli, x.1898, *Woodrow s.n.* (K!).

Representative specimens:

India: Khandala, near Echo point, x.1918, *McCann* 9403 (K); Bombay State, Mahableshwar, x.1923, *McCann s.n.* (K); Bombay, Purandhar Fort top, 10.x.1950, *Santapau s.n.* (K); Bombay, Merwar, x.1918, *Talbot s.n.* (K).

Oman: Dhofar, above Dhalqut, 16°43'N 53°14'E, altitude 790m, 04.xi.1991, *Cope* 504 (E, K); Dhofar, on the inland road to Dhalqut from Sarfait, 16°43'05"N 53°12'16"E, altitude 1100m, 02.x.1993, *Cope* 683 (K); Dhofar, near Tobruk Fort, between Salalah and Taqah, altitude 600m, 28.ix.1993, *Cope* 673 (K); Dhofar, cliff overlooking Dhalqut, 03.x.1993, *McLeish* 2870 (K).

Distribution: India and Oman.

8.2.10. *Capillipedium* Stapf, in Prain, Fl. Trop. Afr. IX: 169 (1917). The type species is *Capillipedium parviflorum* (R. Br.) Stapf.

Synonym: *Filipedium* Raiz. & Jain, in J. Bombay Nat. Hist. Soc. 49: 682 (1951).

Annuals or perennials; mostly rambling. Inflorescence a delicate, loose panicle, bearing short 1-5(-8)-jointed racemes at the ends of capillary primary and secondary branches; rachis internodes and pedicels finely filiform, with a translucent longitudinal groove. Sessile spikelet callus obtuse; lower glume cartilaginous, broadly convex to slightly concave, acute or obtuse; upper lemma hyaline base of the awn, entire; awn glabrous. Pedicellate spikelet male or neuter.

Species ± 14.

A key to taxa sampled:

Annual grass; culms weak, decumbent and trailing, markedly geniculately branched.

1.***filiculme***

Perennial grasses; culms robust, erect, simple or branched:

Culm nodes glabrous; lower glume of sessile spikelet slightly depressed along the middle:

Culms woody; lower glume of sessile spikelet glabrous; racemes 2-3-jointed. 2. ***assimile***

Culms herbaceous; lower glume of sessile spikelet hairy; racemes 3-8-jointed. 3. ***spicigerum***

Culm nodes bearded; lower glume of sessile spikelet not slightly depressed along the middle:

Rachis internodes hairy; lower glume of sessile spikelet flat, glabrous; upper glume of sessile spikelet emarginate. 4. ***huegelii***

Rachis internodes glabrous; lower glume of sessile spikelet concave, hairy; upper glume of sessile spikelet mucronate. 5. ***parviflorum***

1. ***Capillipedium filiculme***[*] Stapf, in Hook. Ic. Pl.: t 3085 (1922).-Bor, Grasses Burma Ceylon India & Pakistan: 111 (1960).

Synonym: *Andropogon filiculmis* Hook.f., Fl. Brit. Ind. 7: 181 (1896).

A weak and trailing annual, 30-60 cm tall. Culms slender, branched from the geniculate nodes; culm nodes bearded. Leaf blades lanceolate, 5-20cm long, 0.8-1.2cm wide, constricted at base, glabrous or hairy, apex acute to acuminate or produced to a setaceous point, margins scabrid; leaf sheaths terete, glabrous, bearded at the mouth; ligule an unfringed membrane.

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[*] **filiculme**, with thread-like stem (culm).

Inflorescence a panicle, slender; primary branches and raceme peduncles capillary; racemes 3-4-jointed; rachis internodes with a median translucent longitudinal groove, margins densely hairy. Sessile spikelet elliptic-lanceolate, hairy, acute; callus short, bearded; lower glume oblong-lanceolate, glabrous, shortly ciliate on the keels towards the apex; upper glume boat-shaped, single-keeled, emarginate, glabrous. Florets 2: lower floret empty, lemma ovate, 1.5mm long, hyaline; upper floret bisexual, lemma stipiform; awn 15-20mm long, hispid; epaleate; lodicules 2, fleshy; anthers 3, 1.3mm long; ovary tiny, ovate. Pedicellate spikelet male, elliptic-lanceolate; lower glume glabrous, 2.5mm long, lanceolate; upper glume lanceolate, 2.5mm long (or slightly shorter), smooth; lower lemma oblong, 2mm long, obtuse; anthers 3, 1.5mm long; pedicel with a median translucent longitudinal groove, hairy along the raised margins.

Diagnostic characters and affinities: Has very slender culms. The epithet *filiculme* alludes to these.

Habitat: In low lying areas of river flood plains.

Type: India, Dhondsee, 08.xii.1894, (without a collector's name) (K!).

Representative specimens:

India: Madras, Tellicherry, 29.xii.1938, *Ammal* 1240 (K); Tellicherry, North Malaher, 03.i.1969, *Ammal* 1832 (K); Chodan, 2 miles east of Sasan, altitude 600ft, 19.x.1970, *Hodd* 275 (K); Bombay, Unai, south to S.B. hills, 02.xi.1953, *Santapau* 17201 (K).

Distribution: India (endemic).

2.***Capillipedium assimile*** A. Camus, in Lecomte, Fl. Gen. Indo-Chine VII: 314 (1922).-Bor, Flora of Assam 5: 363 (1940).-Bor, Grasses Burma Ceylon India & Pakistan: 110 (1960).

Synonyms: *Andropogon assimilis* Steud., in Zoll., Syst. Verz.: 58 (1854); *Andropogon subrepens* Steud., Syn. Pl. Glum. 1: 397 (1854); *Andropogon glaucopsis*

Steud., Syn. Pl. Glum. 1: 397 (1854); *Capillipedium glaucopsis* (Steud.) Stapf, in Hook. Ic. Pl.: t 3085 (1922); *Capillipedium subrepens* (Steud.) Henr., in Blumea III: 463 (1940).

Perennial suffrutescent grass. Culms slightly woody, more or less round in section, but somewhat flattened on one side, highly branched from the nodes, branches spreading, decumbent, 1.8-3.5m tall; internodes glabrous; culm nodes bearded or glabrous. Leaf blades flat, linear-lanceolate, narrowed at the base, 3-10mm wide, up to 25cm long, upper surface hirsute, lower glabrous or hispid, margins spinous toothed, midrib thick, broad and white above; leaf sheaths compressed, the lower somewhat lax, shortly bearded in the throat, with tubercle-based hairs along most of their length; ligule a short, truncate, ciliolate membrane.

Inflorescence a panicle; main inflorescence axis, primary branches and raceme peduncles all glabrous; bearded at the nodes; racemes solitary or paired, 2-3-jointed; rachis internodes and pedicels with a linear-elliptic translucent longitudinal groove, hairy along the margins. Sessile spikelet linear-oblong, 2-3.5mm long; lower glume linear-oblong, glabrous on the back, slightly depressed, ciliate along the keels, with a narrowly truncate apex; upper glume broadly lanceolate, acute, single-keeled, depressed longitudinally along both sides of the keel, glabrous. Florets 2: lower floret empty, lemma ovate, obtuse, nerveless; upper floret bisexual, lemma stipiform, narrow, glabrous; awn 6-12mm long, very slender; epaleate; lodicules 2, fleshy, opaque, cuneate; anthers not seen; ovary ovate. Pedicellate spikelet neuter, linear-lanceolate, smaller than the sessile; lower glume linear-lanceolate, acute, glabrous, keels ciliate; upper glume acute, ciliate.

Chromosome number(s): 2n = 20 (De Wet, Borgaonkar & Richardson, 1963); 40 (Larsen, 1963).

Diagnostic characters and affinities: Has highly branched woody culms.

Habitat: Found mainly in wooded valleys and forests.

Uses: Has a very hard solid stem used as a pipe cleaner by smokers (Bor, 1960).

Type: Type locality, India.

Representative specimens:

China: Yunnan, western flank of the Shweli-Salwin divide, latitude 25°20'N, altitude 6000-7000ft, viii.1912, *Forrest* 9135 (E); Tuhshan, altitude 400m, 20.viii.1930, *Tsiang* 6513 (E).

India: Mussoorie, altitude 6000ft, ix.1920, *Anderson s.n.* (E); Chutia Magpur, Tundi hills, altitude 1500ft, xi.1886, *Campbell* 7743 (E); Western Himalayas, Punjab, Larji, Kulu, altitude 4500ft, 04.xi.1931, *Koelz* 3096; Bashr, North-western Himalayas, Manglad valley, altitude 6000ft, 29.ix.1891, *Lace* 1051 (E); Ghogar Dhar, Mandi, Himachal Pradesh, altitude 1800m, 16.x.1985, *Mcbeath* 1672 (E); Bihar, near the summit of Perisnath, altitude 4300ft, xi.1884, *Watt* 9904 (E).

Thailand: Chiang Mai, lower elevation of Doi Suthep, altitude 350-700m, 08.ix.1967, *Iwatsuki, Koyama & Fukuoka* T9434 (E); 12km south-east of Fang along the Fang-Chiengrai trail, 19°56'N 99°18'E, altitude 550m, 26.vii.1968, *Larsen, Santisuk & Warncke* 2734 (E).

Tibet: Kougbo Province (no collecting details), (no date), *Ludlow, Sherriff & Taylor s.n.* (E).

Distribution: South-east Asia.

3. ***Capillipedium spicigerum*** S. T. Blake, in Univ. Queensl. Papers, Dept. Biol. II No.3: 43 (1944).-Burbidge, Australian grasses 3: 42 (1970).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 136 (1982).-Simon, A key to Australian grasses (ed.2): 82 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 23 (1994).

Stout and tall perennial grass. Culms 1-1.5m tall, glabrous; culm nodes with a ring of short velvety hairs or glabrous. Leaf blades narrowly linear, narrowed towards the base, tapering to a fine point, flat, up to 40cm long, 5-8mm wide, hirsute behind the ligule, lower surface sparsely hairy; leaf sheaths longer or shorter than the internodes, glabrous or hairy with tubercle-based hairs; ligule a short scarious fringed membrane, ciliolate.

Inflorescence a panicle; main inflorescence axis terete, shortly villous; primary branches semiverticillate, opposite or the upper ones alternate, glabrous or pubescent; raceme peduncles glabrous. Racemes 3-8-jointed; rachis internodes and pedicels subequal, with a median translucent longitudinal groove, ciliate on the sides. Sessile spikelet oblong-lanceolate, 3-4.2mm long; lower glume truncate, slightly depressed along the middle, more or less hairy on the back, keels scabrous-ciliate upwards; upper glume glabrous, scabrous on the keel upwards. Florets 2: lower floret empty, lemma ovate, acute, 2.8mm long; upper floret bisexual, lemma stipiform; awn with stipe 12-18mm long; lodicules 2, fleshy, opaque, cuneate; anthers 3, 1.3mm long; ovary oblong. Pedicellate spikelet male, 3mm long; lower glume acute, ciliate on the keels; upper glume glabrous; lower lemma ovate, obtuse; anthers 3, 1mm long.

Chromosome number: 2n = 40 (De Wet, Borgaonkar & Richardson, 1963).

Diagnostic characters and affinities: This species is often thought to be a hybrid between *Bothriochloa bladhii* and *Capillipedium parviflorum*. It certainly shows affinities with *C. parviflorum*. They differ in the sense that *C. parviflorum* has a prominently concave lower glume, while in *C. spicigerum*, the lower glume is slightly depressed. They also differ in the number of raceme joints, which are 1-2 (rarely 3) in *C. parviflorum*, and 3-8 in *C. spicigerum*. These inflorescence characteristics make these species easily distinguishable at a glance.

Habitat: Widely spread over the coastal and subcoastal districts of eastern Australia in *Eucalyptus* forests.

Type: Australia, Queensland, Moreton District, Northgate, Brisbane, 02.vi.1940, *Blake* 14267 (K!).

Representative specimens:

Australia:

New South Wales: 6.4km by road south-west of Singleton on the Windsor road, altitude 90m, 12.vi.1975, *Coveny & Powell* 6562 (K).

Queensland: Moreton District, Brisbane, in railway enclosure between Northgate and Virginia, altitude 25ft, 01.i.1941, *Blake* 14307 (K).

New Caledonia: Noumea, Montravel, altitude 120m, 20.xii.1964, *Mackee* 196 (K); Noumea, Montravel, altitude 50-100m, 20.iii.1969, *Mckee* 20305 (K).

Distribution: Mainly an Australian species but also found in the Pacific Islands.

4. ***Capillipedium huegelii*** (Hack.) Stapf, in Hook. Ic. Pl.: t 3085 (1922).-Bor, Grasses Burma Ceylon India & Pakistan: 111 (1960).

Synonyms: *Andropogon huegelii* Hack., in DC., Monogr. Phan. 6: 49 (1889); *Andropogon foetidus* Donna Lisboa ex Lisboa, in J. Bombay Nat. Hist. Soc. 6: 205 (1891); *Andropogon schmidii* Hook.f., Fl. Brit. Ind. 7: 180 (1896); *Capillipedium huegelii* (Hack.) Blatt. et McCann, in J. Bombay Nat. Hist. Soc. 32: 420 (1928); *Capillipedium foetidum* (Lisboa) Raitz. et Jain, in Indian For. 77: 752 (1951).

A perennial grass. Culms 30-80cm tall, erect or branching from base, shortly creeping; culm nodes hairy. Leaf blades 10-25cm long and 8mm wide, linear, constricted at the base, glabrous, margins scabrid; leaf sheaths compressed; ligule a fringed membrane, lacerate.

Inflorescence a somewhat contracted panicle; main inflorescence axis hirsute or glabrous, with long cilia at the joints; primary branches and raceme peduncles glabrous; number of raceme joints variable, but mostly 2-4-jointed; rachis internodes with a median longitudinal groove, hairy along the margins. Sessile spikelet oblong-lanceolate, 3.5mm long; lower glume flat on the back, glabrous, shortly ciliate along the keels towards the apex, truncate at the apex; upper glume smooth, single-keeled, scabrous upwards along the keel, ciliate on the inturned margins. Florets 2: lower floret empty, lemma oblong with an incised apex, 2mm long; upper floret bisexual, lemma stipiform, single-nerved; awn 15mm long; lodicules 2, fleshy, cuneate; anthers not seen; caryopsis obovate. Pedicellate spikelet neuter, 4-4.5mm long, lanceolate; lower glume lanceolate, dorsally flat, glabrous, ciliate on the keels; upper glume smooth, single-keeled, ciliate on the margins, lanceolate; lower lemma lanceolate, emarginate; pedicel with a median longitudinal groove, hairy on the margins.

Chromosome number(s): 2n = 20 (De Wet, Borgaonkar & Richardson, 1963).

Habitat: Found on grassy plains.

Type: India, Nilagiri, 1818-1835, *Schmid s.n.* (K!).

Representative specimens:

India: Central Province, Jubbulpur District, Marble Rocks, near Jubbulpur, 25.xi.1889, *Duthie* 9898 (K); Bombay, Khandala, Western Ghats, xii.1922, **Sedgwick* 7970 (K); Bombay, 20.xi.1907, *Talbot s.n.* (K).

* - with a pilose inflorescence axis, and hispid primary branches and raceme peduncles.

Distribution: Central to Western India (endemic).

5. ***Capillipedium parviflorum***[*] (R. Br.) Stapf, in Prain, Fl. Trop. Afr. IX: 169 (1917).-Bor, Flora of Assam 5: 362 (1940).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 8 (1954).-Bogdan, A revised list of Kenya grasses: 56 (1958).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 32 (1958).-Bor, Grasses Burma Ceylon India & Pakistan: 112 (1960).-Napper, Grasses of

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[*] **parviflorum**, **parvus**, small, tiny, and **florum**, flowers, alluding to the small spikelets.

Tanganyika: 99 (1965).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 718 (1982).

Synonyms: *Holcus parviflorus* R. Br., Prodr.: 199 (1810); *Sorghum parviflorum* Beauv., Agros: 132 (1812); *Anatherum parviflorum* Spreng., Syst. 1: 290 (1825); *Holcus caerulescens* Gaud., in Freycin. Voy. Bot.: 411 (1829); *Andropogon micranthus* Kunth, Rev. Gram. I: 165 (1829); Steud., Syn. Pl. Glum. 1: 396 (1854); Hack., in DC., Monogr. Phan. 6: 488 (1889); Hook.f., Fl. Brit. Ind. VII: 178 (1896); *Andropogon alternans* J. S. Presl., in C. B. Presl., Reliq. Haenk. 1: 342 (1830); *Rhaphis caerulescens* Desv., Opusc.: 69 (1831); *Chrysopogon violascens* Trin., in Mem. Ac. Petersb. 6 me ser. II: 319 (1832); *Andropogon quartianianus* A. Rich., Tent. Fl. Abyss. II: 469 (1851); *Andropogon violascens* Nees ex Steud., Syn. Pl. Glum. 1: 396 (1854); *Andropogon parvispicus* Steud., Syn. Pl. Glum. 1: 397 (1854); *Andropogon capilliflorus* Steud., Syn. Pl. Glum. 1: 397 (1854); *Rhaphis villosula* Nees ex Steud., Syn. Pl. Glum. 1: 397 (1854); *Rhaphis microstachya* Nees ex Steud., Syn. Pl. Glum. 1: 397 (1854); *Andropogon serratus* Miq., Ann. Mus. Lugd.-Bat. II: 290 (1866); *Chrysopogon parviflorus* Benth., Fl. Austr. VII: 537 (1878); *Chrysopogon parvispicus* (Steud.) Wats., in Atkins., Gaz. N. W. Ind.: 392 (1882).

Tufted perennial, mostly 75-100cm tall. Culms with bearded nodes. Leaf blades glaucous, the blades expanded, erect and straight, linear from an often narrowed and slightly contracted base, 30cm long, 2.5mm wide, finely pointed, margins scabrid; leaf sheaths terete, tight or at length slipping from the culms, the lowermost ones longer, the others usually shorter than the internodes, more or less with tubercle-based hairs and frequently villous on the collar; ligule a very short, truncate, ciliolate membrane.

Inflorescence a profusely divided delicate panicle; main inflorescence axis terete; primary branches alternate, opposite or semiverticillate, divided from low down and up to the third degree; raceme peduncles filiform, glabrous. Racemes 1-jointed, reduced to 1 sessile and two pedicellate spikelets, rarely 2-jointed with 2 sessile and 3 pedicellate spikelets; rachis internodes very similar to the raceme peduncles and glabrous. Sessile spikelet narrowly oblong, 2.8-5mm long; lower glume with short hairs on the back, shallowly concave in the middle, ciliate upwards on the keels, truncate, with 2 intracarinal nerves; upper glume single-keeled, scabrid on the keel, the median nerve drawn to a mucro. Florets 2: lower floret empty, lemma 2-2.5mm long, ovate; upper floret bisexual, lemma stipiform, linear, flattened, entire, single-nerved; awn 20mm long (including the upper lemma), minutely hispidulous; anthers 3, 1.5mm long; ovary oblong, 2.1mm long. Pedicellate spikelet lanceolate, male or neuter, 2.5-3.5mm long; lower glume shortly hairy on the keels, truncate, with 3 intracarinal nerves, acute; upper glume glabrous, lanceolate, with 2 intracarinal nerves; lower lemma oblong, truncate; anthers 3, 1.5mm long; pedicels with a median translucent longitudinal groove, subequal, hairy on the raised margins.

Chromosome number(s): 2n = 20, 40 (De Wet, Borgaonkar & Chheda, 1961; De Wet, Borgaonkar & Richardson, 1963).

Diagnostic characters and affinities: The racemes consist of a single triad of spikelets at the ends of branches. Also the lower glume of the sessile spikelet is prominently concave along the back between the nerves.

Habitat: Occurs on grasslands.

Type: Australia, 14.i.1803, *Brown* 6188 (BM! K!).

Representative specimens:

Malawi: Dowa District, Uperere Mission, Chankalamu Dambo, 02.xi.1950, *Jackson* 249 (MAL); Agricultural Research Station near Lilongwe, 30.ix.1952, *Kantikana* 4 (BM); Chipata mountain, altitude 6000ft, 04.v.1963, **Verboom* 978 (SRGH).

Zambia: Fort Jameson, 25.v.1963, **Verboom* 761 (SRGH, BM).

Zimbabwe: Gwelo District, 6 miles south from Gwelo, altitude 4600ft, 18.iii.1967, *Biegel* 2000 (BM); Irelawney, 26.iv.1931, *Brian* 3757 (SRGH); Salisbury (Harare) District, Ballantyne Park, altitude 4950ft, 26.iii.1965, *Crook* 730 (BM); Salisbury (Harare), university grounds near main entrance gate, altitude 1500m, 01.i.1968, *Crook* P55 (PRE); Salisbury (Harare), Marlborough, ii.1954, *Kerr* 6 (PRE); Irelawney District, v.1931, *Litt* 162 (BM); Salisbury (Harare), wet ground bordering Gwebi river, Mazoe road, 22.ii.1974, *Simon* 2385 (SRGH, PRE).

* - racemes 2-jointed (i.e. with 2 sessile and 3 pedicellate spikelets).

Distribution: Widely distributed throughout the tropics of the Old World, China and Japan.

8.2.11. ***Spathia*** Ewart, in Ewart & Davies, Fl. N. Terr.: 26 (1917). The type species is *Spathia neurosa* Ewart & Archer.

Tufted annual. Inflorescence terminal and axillary, of digitate racemes enclosed in a large membranous spathe; raceme with one homogamous pair; internodes and pedicels solid, oblique at the tip, densely ciliate on edges; sessile spikelet callus obtuse; lower glume coriaceous, convex, acute, covered with brown hair on the back; upper lemma entire, awned. Pedicellate spikelet well developed, neuter, with a short oblong callus.

Species 1.

Spathia neurosa Ewart & Archer, in Ewart & Davies, Fl. N. Terr.: 26 (1917).-Blake, in Univers. Queensl. Papers 2(3): 47 (1944).-Lazarides, The grasses of Central Australia: 228 (1970).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 49 (1994).

Tufted, rather coarse, reddish or straw-coloured annual, up to 75cm tall. Culms erect or somewhat bent at the lower nodes, simple or sparingly branched, flattened or shallowly channelled on one side, hairless, smooth, powdery close below the nodes or shiny, with 2-5 densely hairy nodes. Leaf blades up to 16cm long and 4mm wide, usually flat, tapered to a long fine point with thickened sharp edges; leaf sheaths loose, hairless, more or less smooth, strongly curved, the lower ones much shorter than the internodes, the upper ones longer than the internodes, broad, inflated, with short blades; ligule thin, papery, transparent, fringed with minute hairs.

Inflorescence of 3 (sometimes 4 or 5) racemes, spatheate, terminating the culm and branches; spathe membranous, broad, up to 25cm long; racemes digitate, sessile to subsessile, villous with brown hairs, each with the basal pair of spikelets homogamous (male or neuter) and persistent; rachis internodes and pedicels linear-filiform, curved, solid, densely ciliate on both margins. Sessile spikelet lanceolate, 5.5-6.2mm long, dorsally compressed; callus very small, with dense fulvous hairs; lower glume 2-keeled, narrowed upwards, densely hairy on the back and with a subapical beard of longer, tubercle-based, rich brown hairs about 6mm long extending downwards close to the keels; upper glume slightly longer, lanceolate, acute, keeled upwards, 3-nerved, villous on the back in the lower part, ciliate on the keel with tubercle-based hairs. Florets 2: lower floret empty, lower lemma hyaline, nerveless, lanceolate, acute, ciliate upwards, 2.5-2.7mm long; upper floret bisexual, upper lemma stipiform, 1.8-2.7mm long, passing into a geniculate scabrous awn; awn 19-35mm long, with a villous twisted column and a yellowish weakly twisted bristle; palea present, small; anthers 3, 0.5mm long; ovary oblong, 2-2.8mm long. Pedicellate spikelet neuter, awnless, dorsally compressed, reduced to very unequal glumes, about 5mm long, oblanceolate; lower glume oblong-elliptic, membranous, with narrowly inflexed hyaline ciliate margins, pubescent like that of the sessile spikelet; upper glume much shorter, pubescent upwards on the midvein; pedicel about half as long as the pedicellate spikelet.

Diagnostic characters and affinities: Racemes protected by large sheathing bracts, spathes, which are actually enlarged bases of foliage leaves. The inflorescence is only partly exserted at maturity. Spathes are large and have prominent veins. This is the only member of the subtribe that has spathes. In contrast to other spatheate inflorescence, the spathe in *S. neurosa* does not interrupt the inflorescence, hence producing partial inflorescence, but rather encloses the inflorescence.

Habitat: Grasslands with cracking clay soils.

Type: Australia, Northern Territory, 30 miles southeast of Newcastle Waters, 09.viii.1911, *Hill* 504 (K!).

Representative specimens:

Australia:

Northern Territory: Sondan Station, 14.vii.1947, *Ardut* (K); 26 miles north-northwest of Brunette Downs, altitude 222m, 16.v.1947, *Blake* 17818 (K, BM); between Sondan Station and Rankine Store, altitude 253m, 21.v.1947, *Blake* 17911 (K); north of Austral Downs, altitude 200m, 30.v.1947, *Blake* 17973 (K); Austral Downs Station, 27.vii.1971, *Latz* 1681 (K); 25 miles west-northwest of Rockhampton Downs Station, 02.vii.1948, *Perry* 1590 (K).

Queensland: about 35 miles north of Camooweal, altitude 302m, 25.v.1947, *Blake* 17951 (K); about 50miles south-southeast of Camooweal, altitude 204m, 28.v.1947, *Blake* 17955 (K).

Distribution: Australia.

8.2.12. *Bothriochloa* Kuntze, Rev. Gen. Pl. 2: 762 (1891). The type species is *Bothriochloa bladhii* (Retz.) S. T. Blake.

Synonyms: *Andropogon* subgen. *Gymnoandropogon* Nees, Fl. Afr. Austr.: 103 (1841); *Gymnandropogon* (Nees) Duthie, in Atkinson, Gaz. N.W. Prov. & Oude 10: 638 (1882); *Amphilophis* Nash, in Britton, Man. Fl. North. States: 71 (1901).

Perennials. Inflorescence of few to many-jointed pedunculate digitate or subdigitate racemes, the branches undivided or the lower ones sparingly branched; racemes without homogamous spikelet pairs, always terminate in a triad; spikelets paired, one sessile, the other pedicellate, similar in shape or the pedicellate reduced and smaller, always differing in sex; rachis internodes and pedicels linear-filiform, with a translucent longitudinal groove. Sessile spikelet callus obtuse; lower glume mostly cartilaginous, broadly convex to slightly concave, sometimes with 1-3 circular pits on the back, acute; upper lemma hyaline base of the awn, entire (bilobed in *B. biloba* and *B. erianthoides*). Pedicellate spikelet much like the sessile or smaller, male or neuter.

Species ± 35.

A key to taxa sampled:

Culm nodes glabrous:

  Culm internodes terete:

    Lower glume of the sessile spikelet hairy on the lower ½, upper ½ glabrous, slightly depressed longitudinally. 1. ***ischaemum***

    Lower glume of the sessile spikelet glabrous, convex on the back. 2. ***saccharoides***

  Culm internodes channelled on one side:

    Sessile spikelet 5.5mm long; anther 1. 3. ***decipiens***

    Sessile spikelet 7mm long; anthers 3:

      Lower glume with a single pit above the middle; palea absent; upper lemma stipiform. 4. ***macera***

      Lower glume without a pit above the middle; palea present; upper lemma bilobed. 5. ***biloba***

Culm nodes with a ring of hairs:

  Lower glume of the sessile spikelet not pitted. 6. ***radicans***

  Lower glume of the sessile spikelet pitted:

    Inflorescence paniculate. 7. ***bladhii***

Inflorescence subdigitate or digitate:

Inflorescence digitate. 8. ***pertusa***

Inflorescence subdigitate:

Culm internodes terete; sessile spikelet 5.5mm long; lower glume of pedicellate spikelet with a single slit-like pit. 9. ***kuntzeana***

Culm internodes channelled on one side; sessile spikelet 4.5mm long; lower glume of pedicellate spikelet with 0-4 slit-like pits. 10. ***insculpta***

1. ***Bothriochloa ischaemum*** (L.) Keng, in Contr. Biol. Lab. Sc. Soc. China, Bot. Ser. X: 201 (1936).-Bor, Grasses Burma Ceylon India & Pakistan: 108 (1960).

Synonym: *Andropogon ischaemum* L., Sp. Pl. : 1047 (1753).

A tufted perennial of up to 70cm tall; shortly rhizomatous. Culms branched or unbranched above; culm nodes exposed, either hairy or glabrous; lower culm nodes (most) with prophylls; culm internodes solid and glabrous. Leaf blades linear and narrow, 1-3.5mm wide, mostly basal; young leaves with tubercle-based hairs, mature ones glabrous or at most with a few scattered hairs towards the leaf base; leaf sheaths keeled, glabrous and about half the length of internodes; leaf ligule a fringed ciliate membrane.

Inflorescence terminal and of 3-10 subdigitate racemes with a characteristic purple tinge; the racemes are either solitary or clustered, and the lower longer than the inflorescence axis, 15-20-jointed; rachis internodes and pedicels linear and have a longitudinal translucent groove; rachis nodes somewhat hairy. Sessile spikelet oblong to elliptic; callus bearded with hairs; glumes membranous; lower glume lightly haired on the lower ½, with a slight depression longitudinally; upper glume glabrous, boat-shaped, ciliate on the margins towards the apex. Florets 2: lower floret empty, lemma oblong to obtuse, sparsely ciliate; upper floret bisexual, lemma stipiform, awned; awn slightly twisted, glabrous; lodicules 2, fleshy, glabrous; anthers not seen; ovary ovate. Pedicellate spikelet subequal to the sessile.

Chromosome number(s): 2n = 40, 60 (De Wet, Borgaonkar & Richardson, 1963).

Diagnostic characters and affinities: There seems to be no reliable way of separating this species from *B. radicans* (Lehm.) A. Camus. The glabrous black nodes are a noticeable feature, but they are found occasionally among tropical specimens. Nevertheless, the two species, though intergrading, appear to be cytogenetically distinct (De Wet & Higgins, 1963).

Habitat: Dry stony places, borders of fields, and slopes.

Uses: Native pasture species.

Type: Described from southern Europe ("In Europae australiorus" (Tsvelev, 1976)). Type not seen.

Representative specimens:

China: Chihh Province (no exact location), 26.vii.1912, *Mary Strong Clemens* 1580A (E); Kweichow Province (no exact location), altitude 600m, 14.xi.1931, *Steward, Chiao & Cheo* 921 (E).

Greece: Mt. Peristeria, altitude 3700ft, 20.vii.1937, *Balls & Balfour Gourlay* B3668 (E).

Nepal: Yara, altitude 12000ft, 02.viii.1954, *Stainton, Sykes & Williams* 2133 (E).

Pakistan: Harara District, Abbottabad, 15.xi.1958, *Burt* 1547 (E); Chitral, altitude 8000ft, 27.vi.1958, *Stainton* 2769 (E).

Saudi Arabia: Abba-Jabal Sawdah, altitude 5500ft, 17.viii.1983, *Collenette* 4450 (E); Dalaghran National Park, altitude 7000ft, 21.viii.1983, *Collenette* 4480 (E).

Tibet: Lhasa, altitude 12500ft, 11.vii.1943, *Ludlow & Sherriff* 9476 (E).

Turkey: B6 Yozgat, Melikli, altitude 1300-1400m, 10.vii.1982, *Davis & Ekim* 69043 (E).

USSR: Lennisky District, altitude 1500-2000m, 01.viii.1985, *Elias, Murray & Newcombe* 10027 (E).

Yugoslavia: (no exact location), 20.vii.1960, *Webster* 4074 (E).

Distribution: South-east Asia, Southern Europe, USSR, USA, and North Africa.

2. ***Bothriochloa saccharoides*** (Swartz) Rydb, in Brittonia 1: 81 (1931).-Gould, The grasses of Texas: 592 (1975).

Synonyms: *Andropogon saccharoides* Swartz, Prodr. Veg. Ind. Occ. 26 (1788); *Andropogon saccharoides* ssp. *leucopogon* subvar. *paucirameus* Hack., in DC., Monogr. Phan. 6: 407 (1889); *Sorghum saccharoides* Kuntze, Rev. Gen. Pl. 2: 792 (1891); *Holcus saccharoides* Kuntze, in Stuckert, An. Mus. Nac. Buenos Aires 11: 48 (1904); *Amphilophis saccharoides* Nash, N. Amer. Fl. 17: 125 (1912); *Andropogon saccharoides* var. *surius* Krause, Bot. Centbl. Beuhefte 32: 334 (1914).

Caespitose perennial with culms erect or somewhat geniculate; culm nodes exposed, shortly bearded. Leaf blades glabrous except for a few long hairs in the ligule area, linear, firm, flat or irregularly folded, mostly 3-6(-8)mm wide, tapering to a long attenuate tip; ligule a hyaline unfringed membrane, 1-3mm or more long.

Inflorescence of densely-flowered subdigitate racemes; racemes numerous, erect or loosely spreading in age, 6-10-jointed, silvery hairy; rachis internodes and pedicels with a translucent longitudinal groove, both long plumose. Sessile spikelet: lower glume 4.5mm long, ovate, glabrous, with a short hairy callus, minutely spinulose on the keels towards the apex, convex on the back; upper glume 4-4.5mm long, glabrous, boat-shaped, sharply keeled, the keel minutely spinulose upwards. Florets 2: lower floret empty, lemma hyaline, ovate, slightly ciliate on the upper margins; upper floret bisexual, lemma stipiform, awned; awn 13mm long; epaleate; lodicules 2, fleshy; anthers not seen; caryopsis oblanceolate. Pedicellate spikelet neuter, somewhat shrivelled and smaller than the sessile spikelet; lower glume narrowly ovate, glabrous.

Chromosome number(s): 2n = 60, 120 (Gould, 1975).

Diagnostic characters and affinities: Has a characteristic silvery hairy inflorescence.

Habitat: Restricted to relatively dry, usually sandy soils, or on well-drained clay soil sites such as railroads and road embankments and dry banks of ditches and gullies.

Type: Type locality, Jamaica.

Representative specimens:

Jamaica: Isla de Pinos, near Nueva Gerona, 02.iii.1904, *Curtis* (BM); Hall's Delight, above Hope, altitude 1000ft, 25.x.1912, *Harris* 11293 (BM); below New Castle, altitude 3500ft, 03.xi.1912, *Harris* 11396 (E); Mavis Bank, altitude 3500ft, 26.xi.1912, *Harris* 11449 (E); Rams Horn Range, xi.1912, *Hitchcock* 267 (BM).

Distribution: Tropical regions of the Americas and the Caribbean Islands.

3. ***Bothriochloa decipiens***[*] (Hackel) C. E. Hubbard, in Kew Bull. 1934: 444 (1934).-Blake, In Univ. Queensl. Papers 2(3): 32 (1944).-Burbidge, Australian grasses: 146 (1968).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 128 (1982).-Simon, A key to Australian grasses (ed.2): 77 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 20 (1994).

Synonyms: *Andropogon pertusus* (L.) Willd. var. *decipiens* Hack., in DC., Monogr. Phan. 6: 483 (1889); *Andropogon decipiens* Domin, in Biblioth. Bot. 20: 266 (1915).

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[*] **decipiens**. deceiving

There are two varieties in this species, var. *decipiens* and var. *cloncurrensis*, which key out as follows:

Culms tall and stout, up to 170cm high, always glabrous and smooth; leaves always glabrous, up to 35cm long and 6mm wide; racemes up to 15 in number.
var. ***cloncurrensis***

Culms up to 150cm tall, slender; leaves 25cm long and 2-5mm wide, with a few hairs from tubercles on the lower surface; racemes 3-5 in number. var. ***decipiens***

Tufted perennial, 30-170cm tall. Culms erect or geniculate at base, slender and channelled along one side, branched above; culm nodes glabrous; lowest internodes with a few hairs often from tubercles. Leaf blades 6-35cm long, 2-6mm wide, slightly narrowed towards the base, revolute, lower surface hairy from minute tubercles, upper glabrous to scabrous near the apex particularly on the margins; leaf sheaths glabrous, keeled, striate, most shorter than the internodes except for the lowermost which are longer than the internodes; ligule an unfringed membrane, rounded, truncate, about 1mm long.

Inflorescence consists of 3-5 subdigitate erect racemes; main inflorescence axis slender, angular; racemes 10-12-jointed, pedunculate; peduncles alternate or the lowermost opposite, bearded at the nodes; racemes silvery hairy, 4-7cm long; rachis internodes with a translucent longitudinal groove, hairy, hairs increasing upwards to 5mm long. Sessile spikelet lanceolate, up to 5.5mm long (4.5-5.5mm long); callus short, shortly bearded; lower glume with a deep circular pit above the middle, pilose on the back in the lower third, ciliate on the lateral keels towards the apex, flat; upper glume scabrous near tip, compressed laterally, sharply carinate. Florets 2: lower floret empty, lemma oblong, obtuse; upper floret bisexual, lemma 2.3mm long, stipiform with narrowly hyaline margins, single nerved, awned; awn 13mm long; epaleate; lodicules 2, fleshy, glabrous; anther 1, 1.5mm long; ovary narrowly obovate. Pedicellate spikelet neuter, represented by a subulate lower glume, 3.5mm long, scabrous; pedicel with a translucent longitudinal groove, 4mm long, hairy.

Chromosome number: 2n = 40 (De Wet, Borgaonkar & Richardson, 1963).

Diagnostic characters and affinities: This species has a single anther placed between the two feathery stigmas. Apparently both varieties have unpitted forms (Blake, 1944). I was only able to see the unpitted forms of var. *cloncurrensis*, indicated by asterix in the specimens. In this form the lower glume of the sessile spikelet is concave on the back, otherwise it has similar features to the pitted form.

The species is closely related to *B. pertusa*. It differs in having more hairy racemes and narrowly lanceolate sessile spikelets, and in the narrow linear pedicellate spikelets being neuter and reduced to the lower glume.

Habitat: Abundant in *Eucalyptus* forests of Queensland.

Uses: Palatable to stock when desirable grasses are not available (Blake, 1944).

Type: Australia, Queensland, Darling Downs District, Oakey, 1930, *Donges* 32 (K!).

Representative specimens:

Australia:

var. ***decipiens***:

New South Wales: Triangie District (no exact location), 25.i.1966, *Campbell* NSW 89959 (K); Mt. Lindsay basins, 23.i.1932, *Davies s.n.* (K).

Queensland: Moreton District, Woolowin, Brisbane, altitude 76ft, 14.v.1930, *Hubbard* 2550 (K); Maranoa District, between Amby and Eurella, altitude 1250ft, 06.i.1931, *Hubbard & Winders* 6329 (K).

var. ***cloncurrensis***:

Queensland: Port Curtis District, Charon's Ferry Station, near Styx, altitude 40-50ft, 01.vi.1942, *Blake* 14614 (K); Cook District, Lyndbrook, in railway enclosure, abundant Lyndbrook to Einasleigh, 20.xi.1942, **Blake* 14709 (K); North Kennedy District, Regional Station, Ayr, 07.vi.1950, *Cowdry* 3 (K); Horse Creek, near Dimbulah, on Mareeba road, altitude 400m, 21.iv.1962, **McKee* 9255 (K); North

Kennedy District, Mt. Woodhouse, about 40km south-west of Ayr, altitude 1200m, 20.vi.1949, *Smith* 04313 (K).

Distribution: Australia.

4. ***Bothriochloa macera*** (Steud.) S. T. Blake, in Proc. Roy. Soc. Queensl. 80: 64 (1969).-Burbidge, Australian grasses 3: 204 (1970).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 128 (1982).-Simon, A key to Australian grasses (ed.2): 77 (1993).

Synonyms: *Andropogon macer* Steud., Syn. Pl. Glum. 1: 371 (1854); *Bothriochloa ambigua* S. T. Blake, in Univ. Queensl. Papers, Dept. Biol. II No.3: 29 (1944).

Tufted perennial grass, 50-60cm tall. Culms geniculate or erect, glabrous, branched from the nodes; culm nodes glabrous; culm internodes (except the terminal flowering one) channelled on one side. Leaf blades flat, up to 15cm long, 2.5-5.5mm wide, scabrous on the upper surface, sparsely hairy beneath, the hairs arising from tubercles; leaf sheaths keeled, striate, auriculate, mostly shorter than the internodes; ligule a fringed membrane, 1.5mm long, with 2mm long cilia.

Inflorescence of 3-6 (mostly 4) subdigitate racemes; main inflorescence axis glabrous at the nodes; racemes solitary or paired, usually with 1 below the others, glabrous, 12-jointed; rachis internodes and pedicels with a translucent longitudinal groove, 4.5mm long, margins with hairs increasing upwards to 4.5mm long. Sessile spikelet lanceolate-linear, 7mm long (including callus), narrowed to both sides from the middle; callus 0.75mm long, bearded; lower glume narrowly rounded at the tip, concave on the back, 6.2mm long, loosely hairy on the lower third, spinulose along the keels above the middle, sometimes with a deep circular pit above the middle; upper glume sharply carinate and depressed on either side of the keel, smooth, 6mm long. Florets 2: lower floret empty, lemma ovate-lanceolate, 4.5mm long; upper floret bisexual, lemma stipiform, entire, 2.7mm long, awned from the tip; awn 22mm long;

palea absent; lodicules 2, fleshy, cuneate; no anthers seen; caryopsis oblanceolate, 3.25mm long. Pedicellate spikelet neuter; lower glume 6mm long, lanceolate acute, scabrous.

Diagnostic characters and affinities: Apparently pitted and unpitted forms appear to be nearly equally common. *B. macera* is closely related to *B. decipiens*, differing chiefly in the slightly differently shaped, and on the whole, rather larger sessile spikelet which is more gently narrowed towards the distinctly rounded tip, with 3 anthers and in the slightly more developed pedicellate spikelet.

Habitat: Common in disturbed grasslands. It is evidently a drought resistant species which thrives on soils of low fertility, and which under some conditions produces a fair amount of forage (Blake, 1944).

Type: Australia, New South Wales, Central Western Slopes, Merriwa, iii.1914, *Cheel* (NSW, BRI).

Representative specimens:

Australia:

New South Wales: Glen Davis, altitude 300m, 24.iv.1977, *Coveny & Hind* 9271 (K); Canberra, 02.vi.1962, *McKee* 9009 (K); lower eastern slopes of Black mountains, Canberra, altitude 200ft, 23.xii.1960, *Pullen* 2504 (K); 11 miles south-west of Scone, 16.iii.1960, *Story* 7074 (K).

Victoria: lower Deddick river, about 1½ miles from Snowy river bridge, 20.i.1953, *Melville & Wakefield* 3001 (K); 17 km west of Werribie, 02.v.1978, *Muir* 5723 (K).

Distribution: Australia: New South Wales; Queensland; Victoria.

5. ***Bothriochloa biloba***[*] S. T. Blake, in Univ. Queensl. Papers, Dept. Biol. II No.3: 27 (1944).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 128 (1982).-Simon, A key to Australian grasses (ed.2): 76 (1993).

Tufted perennial. Culms erect or geniculate at base, up to 1m tall, simple or sparingly branched from the lower nodes; culm nodes glabrous; culm internodes channelled on one side. Leaf blades narrowly linear, tapering to a fine point, flat, up to 20cm long, 3-5mm wide, smooth beneath, upper surface with scattered tubercle-based hairs; leaf sheaths loose, glabrous, smooth, striate; ligule an unfringed membrane, 1-2mm long, truncate, surrounded by long ciliate hairs.

Inflorescence of 3-6 subdigitate racemes; main inflorescence axis glabrous or ciliate on the upper part, hairy at the nodes; racemes 15-jointed; raceme peduncles similar to the main inflorescence axis but slender; rachis internodes and pedicels hairy on the sides, with a translucent longitudinal groove, somewhat rounded at the back; racemes villous with white hairs. Sessile spikelet lanceolate, widest at or below the middle, 7mm long (6.4-8mm long); callus bearded, 1mm long, hairs up to 3.5mm long; lower glume minutely truncate, pilose on the lower third or half, margins ciliate in the upper part, slightly depressed longitudinally; upper glume mucronate due to the middle nerve drawn into a short tip, sharply carinate, the keel scaberulous towards the apex. Florets 2: lower floret empty, lemma broadly ovate, acute, 4mm long; upper floret bisexual, lemma 3.7mm long, narrowly linear but more or less stipiform, membranous below and thickened upwards, bilobed, lobes filiform, 0.75mm long, awned from the sinus; awn scaberulous, 25mm long (including lemma); palea ovate, more or less jagged and ciliate at the apex, 1.5mm long; lodicules 2, fleshy, cuneate; anthers 3, 2mm long; ovary elliptic-oblong. Pedicellate spikelet neuter, inrolled-

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[*] **biloba**, named becuase of the bilobed upper lemma of the sessile spikelet, a feature uncommon in the genus *Bothriochloa* (found also in *B. erianthoides*).

subulate, 5.3mm long; lower glume scabrous, minutely ciliolate on the lateral keels; pedicel with a longitudinal translucent groove, villous with hairs increasing upwards, 5.2mm long.

Diagnostic characters and affinities: The body of the upper lemma of the sessile spikelet is more or less stipiform but slightly wider than in other species of *Bothriochloa*; the upper lemma has two fine lobes; and the palea is well developed. In most other species of *Bothriochloa,* the upper lemma is entire and very narrow, scarcely wider than the body of the awn.

Habitat: Common in cleared areas of *Eucalyptus* forests.

Type: Australia, New South Wales, Western Plains, Wirialda, 17.iv.1937, *Glenfield Vet. Res. Station* (NSW, BRI).

Representative specimens:

Australia:

New South Wales: Hunter Valley, 16 miles south-east of Coolah, 25.ii.1960, *Story* 7056 (K); Rookwood (near Sydney), 31.iii.1935, *Vickery* 12242 (K).

Queensland: Darling Downs District, near Oakey, towards Toowomba, 05.iv.1958, *Blake* 20340 (K); 13 miles south of Toowomba, *De Wet* Okla. 10942 (K); Darling Downs District, Allora, 24.iii.1953, *Melville, Blake & Everist* 3423 (K).

Distribution: Australia.

6. ***Bothriochloa radicans****[*] (Lehm.) A. Camus, in Ann. Soc. Linn. Lyon 1930 n.s. LXXVI: 164 (1931).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 9 (1954).-Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 48 (1955).-Bogdan, A revised list of Kenya grasses: 56 (1958).-Napper,

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[*] **radicans**, roooting, putting forth aerial roots.

Grasses of Tanganyika: 100 (1965).-Hood, A guide to the grasses of Zambia: 57 (1967).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 721 (1982).-Müller, Grasses of South West Africa/Namibia: 86 (1984).-Chaudhary, Grasses of Saudi Arabia: 420 (1989).-Gibbs Russell et al, Grasses of Southern Africa: 63 (1991).

Synonyms: *Andropogon radicans* Lehm., in Ind. Sem. Hort. Hamb. (1828); *Andropogon ischaemum* var. *radicans* Hackel, in DC., Monogr. Phan. 6: 476 (1889); *Amphilophis radicans* Stapf, in Prain, Fl. Trop. Afr. IX: 172 (1917).

A tufted, often stoloniferous perennial of up to 70cm tall; has a shrubby growth form and or can be decumbent (including rooting at the nodes). Culms herbaceous and branching from the lower nodes to form cushions; culm nodes exposed and bearded, the lower with small velvety hairs and the upper glabrous; culm internodes terete. Leaf blades linear-lanceolate, 6-20cm long, 2-6mm wide, gradually tapering to a fine point; sheaths glabrous except at the usually bearded mouth, those of the basal leaves loose and open, others closely clasping the culms; leaf ligule a ring of white hairs.

The inflorescence is of clustered 5-16 hairy subdigitate racemes up to 70mm long; the main inflorescence axis is slender and shorter than the lower racemes; racemes 10-20-jointed, shortly pedunculate; rachis internodes and pedicels linear and have a longitudinal translucent groove in the middle, hairy; rachis joints densely long hairy. Sessile spikelet lanceolate, 2.5-4mm long; lower glume slightly concave on the back and hairy on the lower half, firmly membranous; upper glume with an acute apex, with a single keel, minutely hispid along this keel towards the apex. Florets 2: lower floret empty, lemma oblong-linear, 3mm long, ciliolate at the apex; upper floret bisexual, lemma stipiform, glabrous, 1.5mm long, awned; awn twisted, geniculate, 25mm long; epaleate; lodicules 2, fleshy and glabrous; callus short and blunt; anthers 3, 1.5mm long; ovary oblong. Pedicellate spikelet neuter; lower glume 3.5mm long, oblong, with sparse long white hairs along the lateral keels and ciliolate towards the apex on these keels; upper glume flimsy, ciliate on margins, lanceolate, 3mm long; lower lemma oblong, obtuse, truncate, 2mm long; pedicels linear.

Chromosome number: 2n = 40 (De Wet & Higgins, 1963).

Diagnostic characters and affinities: This species is similar to *B. ischaemum*, except that *B. ischaemum* tends to have glabrous black nodes as a noticeable feature.

Habitat: Open deciduous bushland.

Uses: Native pasture species.

Type: Cultivated in Hamburg, seed from South Africa (whereabouts uncertain).

Representative specimens:

Botswana: Northern, Sigare Pan, 30 miles west of Nata river, altitude 896m, 26.iv.1957, *Drummond & Seagrief* 5240 (K, SRGH); Nxai Pan National Park, 14.iii.1976, *Smith* 1654 (K).

Zimbabwe: Nuanetsi District, Nuanetsi Ranch, Bubi Section, 23.ii.1967, *Cleghorn* 1421 (K); Hlekwani, approximately 10 km south-west of Bulawayo, altitude 1350m, 19.xii.1990, *Laegaard* 1528 (K).

Distribution: Tropical Africa; introduced to tropical America.

7. ***Bothriochloa bladhii****** (Retz.) S. T. Blake, in Proc. Roy. Soc. Queensl. 80: 62 (1969).-Clayton, In Hepper (ed.), Fl. West Trop. Afr. ed.2(3): 470 (1972).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 719 (1982).-Lowe, The flora of Nigeria, Grasses: 225 (1989).- Gibbs Russell et al, Grasses of Southern Africa: 62 (1991).

Synonyms: *Andropogon bladhii* Retz., Obs. Bot. 2: 27 (1781); *Andropogon intermedius* R. Br., Prdr.: 202 (1810). Hack., in DC., Monogr. Phan. 6: 485 (1889); *Andropogon punctatus* Roxb., Hort. Beng.: 7 (1814) and Fl. Ind. 1: 268 (1820); *Andropogon haenkei* J. S. Presl, in C. B. Presl, Reliq. Haenk. 1: 340 (1830); *Rhaphis*

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[*] **bladhii**, named for Bladh, who collected the type in China.

stricta Nees, in Hook. J. Bot. Kew. Misc. 2: 99 (1850); *Andropogon inundatus* F. Muell., Linnaea 25: 444 (1853); *Andropogon leptanthus* Steud., Syn. Pl. Glum. 1: 391 (1854); *Andropogon perfosus* Nees & Meyen ex Steud., Syn Pl. Glum. 1: 391 (1854); *Bothriochloa anamitica* O. Kuntze, Rev. Gen. Pl. 2: 762 (1891); *Sorghum intermedium* (R. Br.) O. Kuntze, Rev. Gen. Pl. 2: 792 (1891), based on *Andropogon intermedius*; *Sorghum intermedium* (R. Br.) O. Kuntze var. *haenkei* (Presl) O. Kuntze, Rev. Gen. Pl. 2: 792 (1891), based on *Andropogon haenkei*; *Amphilophis intermedia* (R. Br.) Stapf, in Agric. News W. Indies 15: 179 (1916), based on *Andropogon intermedius*; *Amphilophis glabra* (Roxb.) Stapf var. *haenkei* (PresL) E. G. & A. Camus, in Lecomte, Fl. Gen. Indo-Chine 7: 311 (1922), based on *Andropogon haenkei*; *Amphilophis haenkei* (Presl) Haines, Bot. Bihar & Orissa: 1029 (1924), based on *Andropogon haenkei*; *Bothriochloa intermedia* (R. Br.) A. Camus, Ann. Soc. Linn. Lyon n.s. 76: 164 (1931); S. T. Blake, in Univ. Queensl. Papers, Dept. Biol. II No.3: 37 (1944), based on *Andropogon intermedius*; *Bothriochloa glabra* (Roxb.) A. Camus, in Ann. Soc. Linn. Lyon n.s. 76: 164 (1931); Bor, Grasses Burma Ceylon India & Pakistan: 107 (1960); *Bothriochloa inundata* (F. Muell.) J.M. Black, Trans. & Proc. Roy. Soc. S. Aust. 60: 163 (1936), based on *Andropogon inundatus*; *Bothriochloa caucasica* (Trin.) Hubbard, in Kew Bull. 1939: 101 (1939); Bor, Grasses Burma Ceylon India Pakistan: 106 (1960); *Bothriochloa glabra* (Roxb.) A. Camus subsp. *haenkei* (Presl) Henr., Blumea 3: 456 (1940), based on *Andropogon haenkei*; *Bothriochloa haenkei* (Presl) Ohwi, Acta Phytotax. & Geobot. 11: 168 (1942), based on *Andropogon haenkei*; *Dichanthium bladhii* (Retz.) Clayton, in Kew Bull. 32: 3 (1977).

A variable and tufted perennial. Culms rather straggling, up to 1m tall, culm nodes glabrous, rarely bearded; culm internodes terete or channelled on one side. Leaf blades to 30cm long and 10mm wide, tapering gradually to a slender tip, almost glabrous; leaf sheaths bearded at the nodes; ligule a ring of white hairs.

Inflorescence a panicle, with numerous slender branches 2-5cm long, along a common axis 3-10cm long; lower branches sometimes rebranched; rachis internodes and pedicels with a translucent longitudinal groove, hairy, hairs up to 2.5mm long. Spikelets usually dark purple or strongly flushed with purple; sessile spikelet 3-4mm long, with a ring of short white hairs at the base; lower glume hairy below the middle on the back, rarely glabrous, rigidly ciliate in the margins on the upper part, depressed along the middle, with a deep or shallow pit in the upper part, the pit sometimes not occurring in all spikelets, rarely absent altogether; upper glume lanceolate, margins sparsely ciliate in the upper part or glabrous, depressed longitudinally on both sides of the median keel, keel scabrid in the upper part. Florets 2: lower floret empty, lemma oblong, obtuse, glabrous; upper floret bisexual, lemma stipiform; awn 10-18mm long, geniculate, weakly twisted, glabrous; epaleate; lodicules 2, tiny, fleshy, glabrous; anthers 3, 1.5 mm long; ovary oblong. Pedicellate spikelet usually smaller than the sessile and reduced to 1 or 2 glumes, rarely well developed and with the lower glume pitted.

Diagnostic characters and affinities: The only species of *Bothriochloa* with a paniculate inflorescence. *B. bladhii* is often confused with *Capillipedium* species because of the paniculate nature of the inflorescence and the somewhat capillaceous inflorescence branches. It has 10-25 jointed panicle branches compared to 1-10 jointed ones in *Capillipedium* species. Work on genetic barriers of *B. bladhii* (as *B. intermedia*) has established that this species is capable of crossing with other species of *Bothriochloa* and species of the related genera *Dichanthium* and *Capillipedium* (De Wet & Harlan, 1966; Faruqi, 1969). This led De Wet & Harlan (1966) to unite the three genera taxonomically using the biological species concept, and calling the species a compilospecies.

Habitat: Streamsides, swamp margins and cracking clays.

Type: China, *Bladh* (LD, K!).

Representative specimens:

Bangladesh: Dacca District, Norsingdi, 23.ix.1975, *Huq & Rahman* H1624 (E).

Bhutan: Lingmenthang, Shongar Chu, altitude 950m, 02.vii.1979, *Grierson & Long* 2423 (E); Thimpu District, Ramtokto, Namselling, altitude 2300m, *Parker* 7060 (E).

Botswana: Tubu Island, east of Gumare, 15.i.1983, *Astle* 8228 (SRGH); Mahalapye, Madibeng, altitude 3200ft, 11.xii.1959, *De Beer* 870 (BM); Tati river, south-east of Francistown, altitude 980m, *Long* 12246 (E).

Malawi: Blantyre District, Chichiri Campus, University of Malawi, Limbe, 04.vii.1971, *Banda* 1160 (MAL); Kasungu Game Reserve, altitude 3300ft, 18.ii.1970, *Hall-Martin* 563 (PRE); Lilongwe District, Diampwe river, 18.iv.1952, *Jackson* 764 (MAL); Ruo-Tuchila plain, Mulanje, altitude 2000ft, 22.v.1934, *Lawrence* 143 (MAL).

Mozambique: Chitengo, 13km to Acampamento, 02.v.1978, *Diniz* 164 (WAG); Sul do Save, Ilha Mariana, 07.iv.1954, *Myre & Cavalho* 1776 (PRE).

Nepal: Between Kunjuri and Tambawa, 27°22'N 87°50'E, altitude 1500-1900m, 01.x.1989, *Keke* 1140 (E); near Maikot, altitude 8500ft, 08.x.1954, *Stainton, Sykes & Williams* 4756 (E).

Zambia: Lusaka District, Mount Makulu, 30.i.1973, *Delmotte* 949 (SRGH); Namwala District, Kafue river at Kialala, Kafue National Park, 08.xii.1963, *Mitchell* 24/29 (BM; SRGH); Ngomi area, Fort Jameson, iii.1962, *Verboom* 588 (WAG).

Zimbabwe: Lomagundi, Saroi-Sinaia road, altitude 3500ft, ii.1972, *Davies* 3180 (SRGH); Lomagundi District, Alaska, General Office, altitude 3985ft, 16.ii.1966, *Jacobsen* 2827 (PRE); Bubi District, Gwampa vlei, altitude 3000ft, i.1956, *Goldsmith* 45/56 (PRE); Wankie District, Matetsi Safari Area LK 82096, altitude 3200ft, 14.iii.1978, *Gonde* 131 (PRE); Sipolilo, Nyamunyeche Estate, Gwenzi dam, 20.iii.1979, *Nyariri* 772 (PRE).

Distribution: Africa, India to Australia, and the Pacific; introduced to United States.

8. ***Bothriochloa pertusa***[*] (L.) A. Camus, in Ann. Soc. Linn. Lyon 1930 n.s 76: 164 (1931).-Bor, Flora of Assam 5: 368 (1940).-Bogdan, A revised list of Kenya grasses: 57 (1958).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 31 (1958).-Bor, Grasses Burma Ceylon India & Pakistan: 109 (1960).

Synonyms: *Holcus pertusus* L., Mant. Alt.: 301 (1771); *Andropogon pertusus* (L.) Willd., Sp. Pl. 4: 922 (1806); *Andropogon angustifolius* Parl., Fl. Paterm. 1: 269 (1845); *Lepeocercis pertusa* (L.) Hassk., Pl. Jav. Rar.: 52 (1848); *Elionurus pertusus* Nees ex Steud., Syn. Pl. Glum. 1: 364 (1854); *Amphilophis pertusa* (L.) Nash ex Stapf, in Agric. News W. Ind. 15: 179 (1916).

Perennial grass, shortly rhizomatous. Culms slender, up to 30cm tall, branched above, suberect or geniculately ascending or often weak, trailing and rambling over the ground, rooting and throwing up tufted or single shoots from the nodes; culm nodes exposed, hairy. Leaf blades mostly basal, lanceolate, up to 15cm long, 3-4mm wide, flat, glabrous, pubescent or hirsute, often with tubercle-based hairs; leaf sheaths of innovation shoots compressed, more or less keeled, the others terete, glabrous, smooth, usually bearded at the mouth; ligule very short, truncate, an unfringed membrane.

Inflorescence of digitate racemes, to 5cm long; main inflorescence axis shorter than the racemes; racemes 6-10-jointed, pedunculate; peduncles glabrous, 4mm long, smooth; rachis internodes and pedicels with a longitudinal translucent groove, hairy, hairs much longer at the tip, up to 3.5mm long. Sessile spikelet oblong, 4mm long (including the callus); lower glume with a single very pronounced pit, hairy below the middle, 3.5mm long, keels rigidly ciliolate upwards, flat on the back; upper glume 3.5mm long, lanceolate, acute, margins ciliate upwards. Florets 2: lower floret empty, lemma oblong, obtuse, 2.8mm long; upper floret bisexual, lemma stipiform, 1.5mm

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[*] **pertusus**, having holes or slits, perforated, alluding to the glume pits.

long, awned from the tip; awn 18mm long; lodicules 2, fleshy, opaque, cuneate; anthers not seen; ovary lanceolate. Pedicellate spikelet male, much like the sessile in shape and size; glumes equal, 3.5mm long; lower glume sometimes shallowly pitted (0-1 pit, rarely 2), glabrous on the back, ciliate on the lateral keels; upper glume thinly membranous, narrowly lanceolate; lower lemma like that of the sessile spikelet, a bit shorter; upper lemma linear-lanceolate; anthers 3, 1.7mm long.

Chromosome number: 2n = 40 (De Wet & Higgins, 1963; De Wet, Borgaonkar & Richardson, 1963).

Diagnostic characters and affinities: Very close to *B. insculpta*, except that *B. insculpta* has a glabrous lower glume of the sessile spikelet, and one to four shallow pits on the lower glume of the pedicellate spikelet. *B. pertusa* is smaller with slightly smaller inflorescence and shorter spikelets.

Habitat: Grassland on clay soils and open woodland.

Uses: Used as fodder and hay, and in erosion control.

Type: Type not seen. Type locality unknown.

Representative specimens:

Kenya: on the Machakos Talta Plains, 02.vii.1938, *Pole Evans & Erens* 1067 (E).

India: Dehra Dun, Saharanpur, 22.x.1888, *Duthie* 7686 (E).

Pakistan: Harara District, south-east of Haripur on road to Taxila, 09.iv.1958, *Burt* B519 (E).

Somalia: 80km east of Hargesia, on road to Burao, 21.xii.1969, *Lavranos* 7392 (E).

Thailand: Ayuthia, 80km north of Bangkok, altitude 100m, 12.iii.1958, *Sϕrenson, Larsen & Hansen* 2061 (E); Rachasima, 25km north of Korat, altitude 400m, 24.iii.1958, *Sørenson, Larsen & Hansen* 2477 (E).

Distribution: Eastwards from Arabia to Southeast Asia, Tropical Africa, and the Caribbean Islands.

9. ***Bothriochloa kuntzeana***[*] (Hack.) Henr., in Blumea 3: 456 (1940).-Bor, Grasses Burma Ceylon India & Pakistan: 108 (1960).

Synonyms: *Andropogon kuntzeanus* Hack., in DC., Monogr. Phan. 6: 478 (1889); *Andropogon pertusa* var. *longifolia* Hack., in DC., Monogr. Phan. 6: 482 (1889); Hook.f., Flor. Brit. Ind. 7: 175 (1897); *Eulalia clarkei* Haines, Bot. Bihar & Orissa: 1017 (1924). Type: India, 28.ix.1873, *Clarke* 20557 (K!); *Amphilophis kuntzeana* (Hack.) Haines, Bot. Bihar & Orissa: 1031 (1924); *Bothriochloa longifolia* (Hack.) Bor, Grasses Burma Ceylon India & Pakistan: 108 (1960); *Dichanthium kuntzeana* (Hack.) Jain & Deshpande, in Bull. Bot. Soc. Ind. 20: 134 (1979)

Perennial grass. Culms erect, solitary, up to 1.5m tall, moderately robust; culm nodes bearded with a ring of silky hairs; culm internodes terete or slightly angular. Leaf blades mostly cauline, linear, about 30cm long, scabrid on both surfaces; leaf sheaths keeled, striate, sometimes with tubercle-based hairs (falling off early), tight, the lower longer than the internodes, but upper shorter than the internodes; ligule a short unfringed membrane.

Inflorescence of 9-15 subdigitate racemes, silky; main inflorescence axis angular, glabrous; racemes 20 to many-jointed; raceme peduncles glabrous; racemes up to 8cm long; rachis internodes and pedicels with a longitudinal translucent groove, hairy along the raised margins. Sessile spikelet 5.5mm long; lower glume lanceolate, glabrous on the back, shortly ciliate on the keels towards the apex, with a single pit above the middle, 5mm long; callus 0.5mm long, with long white hairs to 2mm long; upper glume sharply keeled and scabrous along this keel towards the tip, glabrous, mucronate, 5mm long, lanceolate, ciliate along the hyaline margins. Florets 2: lower floret empty, lemma narrowly ovate, 4mm long; upper floret bisexual, lemma stipiform, 2.5mm long, firm upwards, awned from the tip; awn 15mm long, bristle-

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[*] **kuntzeana,** named for O. Kuntze, a famous grass botanist.

like, minutely hispidulous; epaleate; lodicules 2, fleshy, cuneate; anthers 3, 2.3mm long; ovary ovate. Pedicellate spikelet male; lower glume with a single slit-like pit, narrowly lanceolate, 5.5mm long, glabrous on the back and shortly ciliate on the lateral keels towards the apex; upper glume almost flat on the back, 5.5mm long, smooth; lower lemma oblanceolate, 4mm long; upper lemma absent; anthers 3, 2.5mm long; pedicel hairy, hairs up to 3.5mm long.

Chromosome number(s): 2n = 20, 40 (De Wet, Borgaonkar & Richardson, 1963).

Diagnostic characters and affinities: Characterised by long, silky racemes.

Habitat: Occurs in grass plains.

Type: India, 28.ix.1873, *Clarke* 20557 (K!).

Representative specimens:

India: Deccan, (no date), *Ralph* 496 (K); (no date and location given), *Stocks s.n.* (E, K); Deccan, v.1880, *Woodrow s.n.* (K).

Distribution: India (Madhya Pradesh, Bombay, Deccan Peninsula).

10. ***Bothriochloa insculpta****[*]* (Hochst.) A. Camus, in Ann. Soc. Linn. Lyon 1930 n.s. LXXVI: 165 (1931).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 9 (1959).- Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 483 (1955).-Bogdan, A revised list of Kenya grasses: 56 (1958).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 31 (1958).-Bor, Grasses of Burma Ceylon India & Pakistan: 107 (1960).-Napper, Grasses of Tanganyika: 100 (1965).-Hood, A guide to the grasses of Zambia: 57 (1967).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 720 (1982).-Chaudhary, Grasses of Saudi Arabia: 419 (1989).-Gibbs Russell et al, Grasses of Southern Africa: 63 (1991).

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[*] **insculptus**, engraved, cut into, with sunken markings, alluding to the glume pits.

Synonyms: *Andropogon insculptus* Hochst. ex A. Rich., Tent. Fl. Abyss. II: 458 (1851); *Andropogon pertusus* (L.) Willd. var. *capensis* Hackel, in DC., Monogr. Phan 6: 482 (1889); *Andropogon pertusus* (L.) Willd. var. *insculptus* subvar. *trifoveolatus* Hackel, in DC., Monogr. Phan. 6: 482 (1889); *Andropogon pertusus* (L.) Willd. var. *capensis* Durand & Schinz, Consp. Fl. Afr. V: 718 (1895); *Andropogon pertusus* (L.) Willd. var. *insculptus* Durand & Schinz, Consp. Fl. Afr. V: 718 (1895); *Andropogon pertusus* (L.) Willd. var. *capensis* Stapf, in Dyer, Fl. Cap. VII: 345 (1897); *Amphilophis insculpta* (Hochst.) Stapf, in Prain, Fl. Trop. Afr. IX: 176 (1917).

Tufted perennial. Culms up to 2m tall, either decumbent and rambling or developing into stout woody stolons, branching and rooting at the prostrate nodes; culm nodes bearded with a ring of white hairs; internodes channelled on one side. Leaf blades 4-30cm long, 2-8mm wide, glabrous on both surfaces, occasionally with sparse tubercle-based hairs on the lower surface, margins rough; leaf sheaths glabrous, striate, clasping the internodes tightly, bearded at the mouth; ligule an unfringed membrane, acute.

Inflorescence of 3-20 subdigitate pedunculate racemes; main inflorescence axis up to 3cm long, bearded at the joints; racemes 10-20-jointed; raceme peduncles glabrous; raceme length variable but up to 10cm long; lower racemes longer than the main inflorescence axis; rachis internodes and pedicels with a longitudinal translucent groove, hairy on the margins, hairs increasing upwards to 3mm long. Sessile spikelet narrowly elliptic, 4.5mm long; lower glume with a single deep pit on the back just above the middle, glabrous, shortly ciliate on the lateral keels towards the apex, 4mm long; callus bearded, obtuse, 0.5mm long; upper glume sharply carinate, minutely ciliate on this keel towards the apex, glabrous, narrowly lanceolate, 4.5mm long. Florets 2: lower floret empty, lemma 3.5mm long, broadly ovate; upper floret bisexual, lemma stipiform, tapers downwards, 2mm long, awned from the tip; awn 25mm long, glabrous; epaleate; lodicules 2, fleshy, cuneate; anthers 3, 1.8mm long; ovary ovate. Pedicellate spikelet neuter, glabrous; lower glume with 0-4 slit-like pits (shallow), glabrous, oblong, 5mm long, with an irregular apex, sharply ciliate along the lateral keels; upper glume lanceolate, 4.5mm long, flimsy with ciliate margins; lower lemma oblong, truncate, 3mm long; pedicel hairy, with a longitudinal translucent groove.

Chromosome number(s): 2n = 50 (De Wet, Borgaonkar & Richardson, 1963); 60 (De Wet & Higgins, 1963).

Diagnostic characters and affinities: This species may be confused with *B. pertusa.* It differs in having the lower glume of the pedicellate spikelet always with 1-4 pits and that of the sessile spikelet always glabrous on the back.

Habitat: Overgrazed grasslands and weedy places.

Uses: Cultivated fodder; native pasture species.

Type: Ethiopia, Mt. Sholloda (Selleuda), *Schimper* 80 (K!).

Representative specimens:

Botswana: Northwest District, Tubu Island, east of Gumare, 15.i.1983, *Astle* 8228 (SRGH); South-east District, altitude 1000m, 04.iii.1987, *Long & Rae* 34 (E); Ngamiland District, altitude 910m, 31.iii.1987, *Long & Rae* 510 (E); Northwest District, Savuti-Selinda road, 26.ii.1983, *Smith* 4141 (SRGH).

Malawi: Ncheu District, South Ncheu, 20.iv.1956, *Jackson* 1851 (MAL).

Mozambique: Gaza District, Chibuto, Maniquenique, Estação Experimental do C.I.C.A., 13.vi.1950, *Lemos & Balsinhas* 100 (PRE, WAG); S'uldo S'ave, Licilo, 10.vii.1947, *Pedro & Pedrogão* 1404 (SRGH).

Zambia: Munibwa District, Lubungu Pontoon, Kafue river, Kafue National Park, 07.iv.1963, *Mataundi* 19/80 (SRGH).

Zimbabwe: Gokwe District, 3 miles north of Gokwe, 30.v.1963, *Bingham* 674 (SRGH); Balulima-Mangwe District, Dombodema Mission Farm, Tjompani Store, altitude 1300m, 29.iv.1972, *Norrgrann* 145 (WAG); Lower Sabi, altitude 1500ft, 27.i-2.ii.1948, *Rattray* 1262 (WAG).

Distribution: Tropical Africa, Arabia and India; introduced to Australia.

8.2.13. ***Euclasta*** Franch., in Bull. Soc. Hist. Nat. Autun 8: 335 (1895). The type species is *Euclasta condylotricha* (Hochst.) Stapf.

Synonym: *Indochloa* Bor, in Kew Bull. 9: 75 (1954).

Inflorescence terminal and axillary, of delicate solitary or subdigitate pedunculate racemes; racemes consist of spikelet pairs, one sessile, the other pedicellate; 1-3 large homogamous spikelet pairs at the base of the raceme; pedicellate spikelet larger than the sessile; rachis internodes and pedicels with a translucent longitudinal groove; lower glume papery, more or less flat; lower floret empty with a hyaline lemma; upper floret bisexual, lemma entire, stipiform; pedicellate spikelet male or neuter.

Species 3.

A key to the species:

Inflorescence of subdigitate pedunculate racemes; homogamous spikelet pairs male or neuter. 1. ***condylotricha***

Inflorescence a delicate solitary raceme (rarely two); homogamous spikelet pairs neuter:

Raceme peduncle glabrous; sessile spikelet 3.5mm long. 2. ***clarkei***

Raceme peduncle pilose; sessile spikelet 5mm long. 3. ***oligantha***

1. ***Euclasta condylotricha*** (Hochst.) Stapf, in Prain, Fl. Trop. Afr. IX: 181 (1917).-Jackson & Weihe, An annotated check-list of Nyasaland grasses: 41 (1958).-Napper, Grasses of Tanganyika: 100 (1965).-Hood, A guide to the grasses of Zambia: 65 (1967).-Clayton, in Hepper (ed.), Flora of West Tropical Africa, ed.2 (3): 471

(1972).-Clayton, in Polhill (ed.), Flora of Tropical East Africa, Gramineae(3): 722 (1982).-Lowe, Flora of Nigeria, Grasses: 237 (1989).

Synonyms: *Andropogon condylotrichus* Hochst., in Steud., Syn. Pl. Glum. 1: 377 (1854); *Andropogon piptatherus* Hack., in Mart. et Eichl., Fl. Bras. 2: 3, 293 (1883); *Sorghum piptatherum* (Hack.) O. Ktze., Rev. Gen. Pl. 2: 792 (1891); *Euclasta glumacea* Franch., in Bull. Soc. Hist. Nat. Autun 8: 336 (1895); *Euclasta graminea* Th. et Hel. Durand, Syll. Fl. Congol.: 649 (1909); *Amphilophis piptatherus* (Hack.) Nash, in North Amer. Fl. 17: 127 (1912).

Annual. Culms up to 1.5m tall, ascending but geniculate at the base, always bearded at the nodes. Plant shallowly rooted and rooting at the nodes (stilt rooted). Leaf blades linear-lanceolate, somewhat flaccid, up to 25cm long, 2-10mm wide, contracted at the base and drawn to a setaceous tapering point, glabrous on both surfaces or with very short sharp hairs along the midrib and immediate adjacent veins; midrib slender, whitish and prominent; leaf sheaths striate, glabrous, closely clasping the internodes for about half their length, with long tubercle-based hairs at the mouth, in the collar region; ligule ciliolate.

Inflorescence of subdigitate racemes; rachis internodes and pedicels with a translucent longitudinal groove; lowest 1-3 spikelet pairs of each raceme homogamous, male or neuter. Sessile spikelet bisexual; lower glume pale to whitish, elliptic-oblong, minutely truncate, 4mm long, with 5 nerves ending below the hyaline apex, hairy on the margins and lower half, 2-keeled, the keels scaberulous; upper glume ovate, strongly carinate, opaque, glabrous, 4mm long. Florets 2: lower floret empty, lemma ovate, carinate and ciliate along this keel and the margins; upper floret bisexual, lemma stipiform; palea present, broadly ovate, hyaline: awn 37mm long, minutely hairy; lodicules 2, fleshy, glabrous; anthers 3, 0.75mm long; ovary ovate, 2mm long. Pedicellate spikelet male; lower glume oblanceolate, many nerved (7-10-nerved), hairy on the lower 1/3, 5.5mm long; upper glume 4-nerved, 4-4.5mm long.

Upper floret male, lemma slightly shorter than the glume; anthers 3, linear, 1.5mm long; lodicules 2, fleshy; pedicel grooved, hairy on the sides.

Chromosome number: 2n = 20 (Davidse & Pohl, 1974; Olorode, 1975); 40 (Bor, 1960).

Diagnostic characters and affinities: The flaccid leaves, stilt roots and the subdigitate inflorescence distinguishes this species from the other *Euclasta* species.

Habitat: Occurs mainly on roadsides and shallow rock escarpments.

Type: Ethiopia, Dscheladscheranne, *Schimper* 2011 (BM!).

Representative specimens:

Zaire: Mweue District, Kakimba, altitude 120m, 09.v.1957, *Liken* 2876 (BM).

Zambia: Fort Jameson, Jumbe area, 24.iii.1963, *Verboom* 941 (BM).

Zimbabwe: Gokwe District, 10 miles from Gokwe, near top of basalt escarpment in Bonye Gorge, 25.iii.1963, *Bingham* 571 (BM); Gatooma District, Sanyati Reserve, 12.iii.1959, *Cleghorn* 451 (BM).

Distribution: Tropics of Africa.

2. ***Euclasta clarkei***[*] (Hack.) T. A. Cope, in Kew Bull. 35(3): 704 (1980).

Synonyms: *Andropogon clarkei* Hack., in Ost. Bot Zeit. 41: 49 (1891); *Dichanthium clarkei* (Hack.) Haines, Bot. Bihar & Orissa: 1040 (1924); *Indochloa clarkei (*Hack.) Bor, in Kew Bull. 9: 76 (1954).

A straggling annual with very slender culms, often rooting from the nodes. Culms up to 45cm tall, shiny, glabrous except at the bearded nodes, branched. Leaf blades

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[*] **clarkei**, named for C.B. Clark, who collected the type specimen in Parasnath, India.

linear-lanceolate, up to 8cm long and 7.5mm wide, hairless, scabrous, with serrated margins; lower leaf sheaths lax, and slipping from the culms, upper leaf sheaths clasping the culms very tightly and somewhat inflated, often with inflorescence in the axil, smooth and glabrous, markedly striate; ligule membranous, 1.5mm long, soon splitting into rigid hairs.

Inflorescence a single raceme, greenish in colour; raceme peduncle glabrous; lowest pair of spikelets homogamous, neuter, each pair consisting of a sessile and pedicellate spikelet, upper pairs differ in sex, with the sessile bisexual and the pedicellate neuter; raceme terminates in a triplet of two pedicellate spikelets and one sessile spikelet; rachis internodes with a translucent longitudinal groove, covered with dense white hairs. Sessile spikelet bisexual; lower glume 3.4mm long, flat or slightly depressed on the back, 5-nerved, covered with small glistening white hairs, has inflexed margins and slightly winged keels, elliptic-acute or truncate; upper glume 3.5mm long, 3-nerved, hyaline, glabrous, keeled on the back and sides, ovate-truncate, ciliate on the inflexed margins and on the median keel (on the back). Florets 2: lower floret empty, lemma hyaline, 3-3.5mm long, ciliate at the tip; upper floret bisexual, stipiform; awn geniculate, 2.5cm long, with a twisted column; epaleate; lodicules 2, fleshy, glabrous; anthers 3, 1mm long; ovary oblong, 2mm long. Pedicellate spikelet neuter; pedicels hairy, but glabrous on the sessile spikelet side, has a translucent longitudinal groove; lower glume broadly elliptic-acute, many-nerved, 5mm long, glabrous; upper glume 4mm long, 3-nerved; lower lemma 4mm long, nerveless, ciliate at the tip.

Habitat: Common in shaded places.

Type: India, Parasnath, altitude 4200ft, 07.x.1883, *Clarke* 33700 (K!).

Representative specimens:

India: Maha Deo caves, altitude 4100ft, 21.x.1958, *Bharadwaja* 32 (K); Mt. Abu, 14.x.1916, *Blatter* 2597 (K); Maharastetra, Katepani forest, Ambavane, Poona District, 26.x.1964, *Reddi* 99496 (K).

Oman: the Fort Nashib road, altitude 100ft, 03.x.1992, *Collenette* 8382 (K); Dhofar, altitude 750m, 07.xi.1991, *Cope* 536 (E); Dhofar, 12km on the lower Dhalqut road, 02.x.1993, *McLeish* 2835 (K).

Distribution: India and Oman.

3. ***Euclasta oligantha*** (Hochst. ex Steud.) Setshogo comb. nov.

Synonyms: *Andropogon oliganthus* Hochst. ex Steud, Syn. Pl. Glum 1: 368 (1854). *Heteropogon oliganthus* (Hochst. ex Steud.) Blatter & McCann, in J. Bombay Nat. Hist. Soc. 32: 623 (1928); *Indochloa oligantha* (Hochst. ex Steud.) Bor, in Kew Bull. 9: 79, t. 2 (1954); *Dichanthium oliganthum* (Hochst. ex Steud.) T.A. Cope, in Kew Bull. 35(3): 703 (1980).

An annual of up to 20cm tall, erect. Culms slender; culm nodes hidden, with long white hairs where exposed; culm internodes also hidden, glabrous where exposed. Leaf blades linear-acuminate, up to 4.5mm wide and up to 5cm long with thickened cartilaginous and serrated margins, and a thickened mid-nerve drawn into a median keel of the culm sheaths, hairy with tubercle-based hairs (becoming hirsute); leaf sheaths clasping the culms, hairy towards the margins, glabrous on the back; ligule an unfringed membrane, continues into the flimsy inflexed leaf sheath margins.

Inflorescence consists of a single raceme, rarely two; inflorescence peduncle pilose; lowest 2-3 spikelet pairs homogamous, neuter; rachis internodes and pedicels with a translucent longitudinal groove, flattened, densely ciliate on the margins. Sessile spikelet: lower glume 4.5mm long, rounded on the back, oblong-truncate, covered on the sides and base with short white hairs, slightly two-keeled towards the apex; upper glume boat-shaped, slightly longer than the lower (5mm long), keeled towards the tip, glabrous and shiny, ciliate towards the tip on the slightly inturned margins. Florets 2: lower floret empty, lemma hyaline, 2.5mm long; upper floret bisexual, stipiform, 2mm long; awn 3.8cm long, column minutely ciliate and bristle scabrid; palea a very small oblong or obtuse hyaline scale, oblanceolate, 2mm long; lodicules 2, fleshy, cuneate; anthers 3, 1mm long; ovary oblanceolate, 2mm long. Pedicellate spikelet neuter; lower glume 5.5mm long, elliptic-truncate with inturned hyaline margins, ciliate on the upper half and serrated on the outer edges of the inturned margins, many nerved; upper glume 4.5mm long, oblanceolate, with an acute apex, ciliate on the inturned margins.

Diagnostic characters and affinities: This species differs from the other two *Euclasta* species by having the hairy inflorescence peduncle.

Habitat: Common in overgrazed grasslands or along paths.

Type: India, Nilgri Hills, *Hohenacker* 1288 (K! BM!).

Representative specimens:

India: Madras, Anaimudi ridge, Travancore High Range, altitude 7000ft, xii.1963, *Barnes* 663 (K); Madras, Pukaa, altitude 6000ft, x.1886, *Gamble* 18308 (K); Madras (Tamilnadu), Dindigul District, Levinge path, altitude 2300m, 18.xii.1989, *Mathew & Mathew* 54067 (K); Kalbutty bababood, altitude 6000ft, x.1908, *Meebold* 10763 (K); Kerala, Eravikulan National Park, altitude 2100m, 27.xi.1979, *Rice* 55 (K).

Distribution: Southern India.

8.2.14. *Dichanthium* Willemet, in Usteri, Ann. Bot. 18: 11 (1796).-De Wet & Harlan, in Bol. Soc. Arg. Bot. 12: 206-227 (1968). The type species is *Dichanthium annulatum* (Forssk.) Stapf.

Synonyms: *Lepeocercis* Trin., Fund. Agrost.: 203 (1822); *Diplasanthum* Desv., Opusc.: 66 (1831); *Eremopogon* Stapf, in Prain, Fl. Trop. Afr. IX: 182 (1917).

Annuals or perennials. Inflorescence of single, digitate or subdigitate racemes; racemes rarely solitary but more often in pairs-to-many, arranged on a short primary axis; pedunculate or subsessile, sometimes with the lower branches divided; racemes always terminate in a triad of 1 sessile and 2 pedicellate spikelets; spikelets highly imbricate, paired, one sessile, the other pedicellate, subequal to equal in size and shape, usually differing in sex, except the lower 1-6 pairs, which are with rare exceptions homogamous male or neuter; rachis internodes and pedicels solid. Sessile spikelet callus obtuse; lower glume papery to cartilaginous, broadly convex to slightly concave, sometimes pitted, acute to broadly obtuse; upper lemma hyaline base of the awn, entire; awn glabrous. Pedicellate spikelet much like the sessile, male or neuter, awnless, rarely bisexual and awned (e.g. *D. annulatum* var. *fecundum*).

Species ± 20.

A key to taxa sampled:

Inflorescence a terminal solitary raceme; lower glume of sessile spikelet pitted, glabrous:

  Lower glume of pedicellate spikelet with a conspicuous pit. 1. ***micranthum***

  Lower glume of pedicellate spikelet never pitted. 2. ***foveolatum***

Inflorescence of 2-many digitate or subdigitate racemes; lower glume of sessile spikelet not pitted:

  Inflorescence of pedunculate subdigitate racemes:

    Lowest 1-6 spikelet pairs homogamous; raceme peduncles and flowering culm glabrous:

      Culm nodes bearded; rachis internodes hairy; lower glume of sessile spikelet concave, pubescent in the lower third, with long tubercle-based cilia above the middle, along the margins and forming a subapical fringe. 3. ***annulatum***

      Culm nodes glabrous; rachis internodes glabrous; lower glume of sessile spikelet narrowly winged on the lateral keels, without tubercle-based cilia. 4. ***aristatum***

Lowest 1-3 spikelet pairs homogamous; raceme peduncles and flowering culm pubescent. 5. ***caricosum***

Inflorescence digitate with 1-15 sessile to subsessile white villous racemes. 6. ***sericeum***

1. ***Dichanthium micranthum*** T. A. Cope, in Publ. Cairo Univ. Herb. 78: 325 (1977).

A perennial tussock grass of up to 30cm tall, shortly rhizomatous. Culms slender, branched upwards; culm nodes exposed, mostly glabrous (some bearded); culm internodes glabrous. Leaf blades linear-acute and mostly basal, forming the tussocks, glabrous, 1.5-2.5mm wide; leaf sheaths with a few tubercle-based hairs, otherwise glabrous, lower older sheaths lax; ligule a ciliate membrane.

Inflorescence a solitary raceme, 10-12-jointed. Sessile spikelets narrowly elliptic and shorter (2.5mm long) than the pedicellate ones (3mm long); lower glume with a single pit on the back, 2mm long, slightly concave to flat on the back, glabrous; upper glume slightly longer than the lower (2.5 mm long), with a single median keel, glabrous. Florets 2: lower floret empty, lemma hyaline; upper floret bisexual, lemma stipiform; awn 20mm long, minutely pubescent, with a twisted base; anthers 3, 1.25mm long. Pedicellate spikelet longer than the sessile one (3mm long), obovate in shape, male; lower glume with a conspicuously deep pit, with very fine short teeth (pectinato-ciliatis) on the margins towards the apex; anthers 3, 2mm long.

Diagnostic characters and affinities: This species is very similar to *D. foveolatum* in having solitary racemes but differs in the smaller spikelets and shorter callus hairs, and the longer and broader pedicellate spikelets than the sessile ones. Also the lower glume of the pedicellate spikelet is always pitted in *D. micranthum* but never pitted in *D. foveolatum*.

Habitat: Occurs in coastal areas, and occasionally in rocky hill slopes.

Type: Oman, Plain behind Salalah, Dhufar, 26.ix.1943, *Vesey -FitzGerald* 12316/1 (K!).

Representative specimens:

Oman: Raysat, 01.xi.1983, *Lawton* 2513 (E); Zeak, 05.vii.1982, *Maconochie* 3570 (E); Taqua, altitude 10m, 11.x.1984, *McLeish* 101 (E); Dhofar, wadi 5km east of Salalah, altitude 2m, 09.ix.1985, *Miller* 7546 (E); Dhofar, altitude 10m, 01.xi.1989, *Miller & Nyberg* M.9020 (E).

Distribution: Arabia.

2. ***Dichanthium foveolatum***[*] (Delile) Roberty, in Boissiera 9: 170 (1960).-Clayton & Renvoize, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 723 (1982).-Cope, in Nasir & Ali, Fl. Pak. 143: 279 (1982).-Chaudhary, Grasses of Saudi Arabia: 415 (1989).-Cope & Hosni, A key to Egyptian grasses: 54 (1989).

Synonyms: *Andropogon foveolatus* Delile, Memoires Botaniques, extracts de la Descriptionde L'Egypte, Paris: 16 (1813); *Eremopogon foveolatus* Stapf, in Prain, Fl. Trop. Afr. IX: 183 (1917).

A tufted perennial of about 50cm tall, with very short rhizomes. Culms slender and geniculate; culm nodes exposed and bearded. Leaf blades linear, flat, glabrous except on upper surface in the ligule area; leaf sheaths glabrous; ligule a ciliate membrane.

Inflorescence a terminal solitary raceme issuing from the tip of the culms and branches; rachis internodes and pedicels filiform, hairy except on the spikelet side; lowest 0-1 spikelet pair homogamous, male or neuter. Sessile spikelet lanceolate, shinning with a reddish tip; callus hairy, hairs extend to about ½ the length of the spikelet; lower glume glabrous, always with a pit just above the middle, 4mm long;

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[*] **foveolatus**, minutely pitted, alluding to the pitted glumes.

upper glume carinate, 3-nerved. Florets 2: lower floret empty, lemma hyaline, 3mm long, acute, emarginate; upper floret bisexual, lemma stipiform, 2mm long; awn 14mm long with a twisted brown column; lodicules 2, fleshy; anthers 3, 3mm long; ovary oblong. Pedicellate spikelet about equal or slightly longer than the sessile; glumes as for the sessile spikelet except that the lower glume is never pitted.

Chromosome number: 2n = 40 (Mehra, Subramanyam & Swaminanthan, 1962).

Diagnostic characters and affinities: Similar to *D. micranthum*, except that the lower glume of the pedicellate spikelet is never pitted in *D. foveolatum.*

Habitat: Sandy and rocky low lying areas subject to occasional flooding.

Type: Egypt, *Delile* (K!).

Representative specimens:

Bahrain: Jebel Dukha, 26.vii.1984, *Alder* 25 (E).

Oman: Wadi Dawkah, altitude 500m, 21.ix.1983, *Gallagher* 6898/A (E).

Pakistan: Baluchistan, 13.iv.1965, *Lamond* 443 (E); Sind, 05.v.1965, *Lamond* 872 (K).

Somalia: Ambouli Palm Grove, near Djibouti, 14.iv.1974, *Lavranos* 11481 (E).

Yemen: Hodeida, altitude 50m, 02.x.1978, *Miller* 302 (E).

Distribution: Arabia and East Africa.

3. ***Dichanthium annulatum***[*] (Forssk.) Stapf, in Prain, Fl. Trop. Afr. IX: 178 (1917).-Bor, Flora of Assam 5: 371 (1940).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 10 (1954).-Bogdan, A revised list of Kenya grasses: 57 (1958).-

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[*] **annulatus**, marked with rings, surrounded by raised rings or bands, having a ring, probably alluding to the subapical and marging rings of hairs on the lower glumes.

Bor, Grasses Burma Ceylon India & Pakistan: 133 (1960).-Hood, A guide to the grasses of Zambia: 65 (1967).-Clayton, in Hepper (ed.), Fl. West Trop. Afr. (ed.2) 3: 471 (1972).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 725 (1982).-Chaudhary, Grasses of Saudi Arabia: 417 (1989).-Cope & Hosni, A key to Egyptian grasses: 54 (1989).-Gibbs Russell et al, Grasses of Southern Africa: 105 (1991).

Synonyms: *Andropogon annulatus* Forssk., Fl. Aegypt.- Arab.: 173 (1775); *Andropogon bladhii* Retz., Obs. Bot. 2: 27 (1781); *Andropogon scandens* Roxb., Hort. Beng.: 7 (1814); *Andropogon obtusus* Nees, in Hook. et Arn., Bot. Beech Voy.: 243 (1838); *Lepiocercis annulata* (Forssk.) Nees, Fl. Afr. Aust.: 98 (1841); *Andropogon papillosus* Hochst., in Rich., Tent. Fl. Abyss. 2: 457 (1851); *Andropogon annulatus* var. *monostachya* F. Muell. ex Benth., Fl. Austr. 7: 531 (1878); *Andropogon annulatus* var. *bladhii* (Retz.) Hack., in DC., Monogr. Phan. 6: 572 (1889); *Andropogon annulatus* var. *decalvatus* Hack., in DC., Monogr. Phan. 6: 572 (1889); *Andropogon grandispiculatus* Domin, Biblioth.. Bot. 85: 269 (1915); *Dichanthium papillosum* (Hochst.) Stapf, in Prain, Fl. Trop. Afr. IX: 179 (1917); *Dichanthium fecundum* S. T. Blake, in Univ. Queensl. Papers, Dept. Biol. II No.3: 51 (1944); *Dichanthium annulatum* var. *decalvatum* (Hack.) Maire et Weiller, Fl. de L'Afr. du Nord 1: 282 (1952).

This species has three varieties keyed out as follows:

Some pedicellate spikelets on each raceme bisexual and often shortly awned.

var. ***fecundum****

Pedicellate spikelets always male or neuter.

Spikelets pilose, with a distinct subapical fringe of long tubercle-based cilia.

var. ***papillosum****

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* **fecundus**, fertile, alluding to the fertile pedicellate spikelets.

Spikelets less pilose, with tubercle-based cilia mainly along the margins of the lower glume. var. ***annulatum***

A tufted, decumbent or erect perennial of up to 2m tall with distinct short rhizomes. Culms woody and persistent, robust, geniculate ascending, simple or branched; culm nodes exposed and with a ring of hairs; culm internodes glabrous. Leaf blades linear-lanceolate, 4-4.5mm wide and up to 30cm long, glabrous along most of their length with long hairs in the ligule area; leaf sheaths glabrous, or sparsely hairy all over; ligule an unfringed membrane, about 2mm long.

Inflorescence consists of subdigitate 2-to-many racemes arranged on a short primary axis; rachis internodes and pedicels solid, usually hairy. Sessile spikelets imbricate, oblanceolate, 2-6mm long, the lowest 1-6 usually homogamous, male or neuter, the upper bisexual; lower glume slightly concave, pubescent below the middle, with long tubercle-based cilia above the middle, along the margins and across the apex; upper glume slightly shorter than the lower, glabrous except for the keel and apex which are often shortly ciliate. Florets 2: lower floret empty, lemma ovate, 3.8mm long, hyaline; upper floret bisexual, lemma stipiform, about 3mm long; awn 25mm long, both column and bristle minutely hispidulous; lodicules 2, fleshy, cuneate, highly vascularised; anthers 3, 1.5mm long; caryopsis elliptic-oblong. Pedicellate spikelets equal or subequal in size and shape to the sessile ones, male or neuter or bisexual. When bisexual, the pedicellate spikelet was found to be larger than the sessile one in all its parts.

Chromosome number(s): 2n = 20 (De Wet & Harlan, 1966; De Wet, Borgaonkar & Richardson, 1963); 40 (De Wet, Borgaonkar & Richardson, 1963).

Diagnostic characters and affinities: The three varieties are distinguished mainly on the basis of the glume characteristics and the sexuality of the pedicellate spikelets. *D.*

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[*] **papillosus**, referring to the tubercles (pimples, papillae) from which the cilia arise.

annulatum var. *fecundum* is the only other member of the subtribe (in addition to *Sorghastrum fuscescens* and *S. pogonostachyum*) which has bisexual pedicellate spikelets.

Habitat: Dry open places subject to overgrazing or disturbance. Also in swampy depressions.

Type: Egypt, *Forsskål* (C).

Representative specimens:

var. ***annulatum***:

Africa:

Somalia: Bosaso, 29.xi.1971, *Lavranos* 9049 (E).

Middle East:

Iran: S. Lorestan-Sheshom, 32°40'N 48°15'E, altitude 300-350m, 25.iv.1963, *Jacobs* 6411 (E).

Iraq: Baghdad, 7km on Hillah road, 29.ix.1954, *Wheeler Haines* 36 (E).

Israel: Lower Galilee, between Tabigha and Rosh Pinna, altitude 0m, 18.iv.1957, *Lorch & Grizi* 714 (E).

Oman: Wadi Bani Khalid, Shangiyah, 22°34'N 59°06'E, altitude 550m, 14.iv.1983, *Gallagher* 6733/7 (E).

Saudi Arabia: Sandia city compound, Jiddah, altitude 20ft, 27.ix.1983, *Collenette* 4584 (E).

Turkey: Hatay, Dörtyol to Iskenderun, altitude 100m, 06.v.1965, *Coode & Jones* 565 (E).

Yemen Arab Republic: Taiz Province, Bani Sheba, west of Turbah, altitude 1200m, 18.iii.1984, *Miller & King* 5261 (E); near Shemlaan near Sanạ's, altitude 2300m, 15.viii.1977, *Wood* 1806 (E).

South East Asia:

Pakistan: Harara, Abbttabad, Nasrav Valley in hills east of town, altitude 4200ft, 22.v.1958, *Burt* 664 (E); Baluchistan, Bela, Diwana to Hab., 01.v.1965, *Lamond* 798 (E).

Nepal: Mayangdi Khola (BENI), altitude 8200ft, 22.iv.1954, *Stainton, Sykes & Williams* 111 (E).

var. ***papillosum***:

Botswana: North-east District, altitude 1000m, 19.iv.1987, *Long & Rae* 802 (K); North-west District, 28.i.1980, *Smith* 3498 (K).

Zambia: Livingstone Game Park, 14.ii.1961, *Mitchell* 5/78 (K).

Zimbabwe: Belingwe, altitude 3000ft, 01.xi.1973, *Gosden* 10 (K); Gokwe District, Sengwa Research Station, 10.i.1975, *Guy* 2256 (K).

var. ***fecundum***:

Australia:

Northern Territory: Q. T. Station, 16°37'S 135°3'E, altitude 177m, 09.v.1947, *Blake* 17685 (K); Timber Creek, 19.v.1971, *Byrnes* 2208 (K); 1 mile north of Wollogorang Station, 02.vi.1948, *Perry* 1158 (K); 2 miles south of McArthur River Station, 25.vii.1948, *Perry* 1738 (K); Brunette Downs, 13.i.1972, *Redhead* Mck B282 (K).

Queensland: Forest Home Station, Gilbert river, 01.I.1931, Brass 1817 (K); North Kennedy District, Lansdown Pasture Research Station, 35 miles south of Townsville, 06.iv.1965, *Lazarides* 7176 (E); Burke District, "Sutherland", 45 miles north-west of Maxwelton, 26.i.1966, *Pedley* 1944 (K).

Distribution: This species is the widely distributed of *Dichanthium* species. Var. *annulatum* extends from western North Africa to Indonesia. Introduced to central Africa and Australia (De Wet & Harlan, 1966). Var. *papillosum* occurs in the tropics and subtropics of Africa, and var. *fecundum* is Australian in distribution (widely distributed in the more tropical regions of Western Australia, Northern Territory and Queensland).

4. ***Dichanthium aristatum**** (Poir.) C. E. Hubbard, in Kew Bull. 1939: 654 (1939).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 10 (1954).-Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 481 (1955).-Bor, Grasses Burma Ceylon India & Pakistan: 134 (1960).-Clayton, in Polhill (ed.), Fl. Trop. East. Afr., Gramineae (3): 723 (1982).-Gibbs Russell et al, Grasses of Southern Africa: 105 (1991).

Synonyms: *Dichanthium nodosum* Willem., in Usteri, Ann. Bot. 18: 11 (1796); *Andropogon aristatus* Poir, in Lamk., Encycl. Met. Bot. Suppl. 1: 585 (1810); *Andropogon mollicomus* Kunth, Rev. Gram. 1: 365 (1830); *Diplasanthum lanosum* Desv., Opusc.: 67 (1831); *Lepiocercis mollicoma* (Kunth.) Nees, Edinb. New. Philom. Journ. 18: 185 (1835); *Andropogon caricosus* subsp. *mollicomus* Hack. var. *mollicomus* (Kunth.) Hack., in DC., Monogr. Phan. 6: 569 (1889); *Andropogon nodosus* (Wilem.) Nash, N. Amer. Fl. 17: 122 (1912); *Dichanthium caricosum* var. *mollicomus* (Hack.) Haines, Bot. Bihar & Orissa 5: 1039 (1924).

A tufted perennial of up to 1.1m tall, shortly stoloniferous. Culms robust, erect, sometimes decumbent; culm nodes exposed and glabrous. Leaf blades linear-lanceolate, up to 25cm long and 3mm wide, glabrous except at the base in the ligule vicinity where there are long tubercle-based cilia; leaf sheaths glabrous; ligule a scarious membrane.

Inflorescence of 1-5 racemes arranged subdigitately on a short primary axis; raceme peduncles and culm below the inflorescence pubescent; rachis internodes and pedicels solid; rachis joints hairy; rachis internodes glabrous and pedicels hairy on one side (glabrous on the side facing the sessile spikelet); lowest 1-6 spikelet pairs homogamous, male or neuter. Sessile spikelet obovate, 2-5mm long; lower glume 5mm long, pilose below the middle, glabrous or shortly ciliate above the middle

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* **aristatus**, awned, abruptly terminated in a hard, straight, subulate point of various lengths.

along the margins and near apex, narrowly winged towards the apex; upper glume as long as the lower, glabrous or ciliate along the margins and keel. Florets 2: lower floret empty, lemma hyaline; upper floret bisexual, lemma stipiform; awn 22mm long, minutely pubescent; callus short, blunt; lodicules 2, fleshy; anthers 3, 2mm long; ovary ovate. Pedicellate spikelet male or neuter, subequal in size and shape to the sessile one.

Chromosome number(s): 2n = 20, 40 (De Wet, Borgaonkar & Richardson, 1963); 60 (Fedorov, 1974).

Diagnostic characters and affinities: Characterised by robust, suberect plants having the peduncles to the racemes villous, and the culm below the inflorescence strongly pilose. The species is related to and sometimes regarded as conspecific with *D. caricosum.*

Habitat: Damp places in disturbed ground.

Uses: Fodder grass.

Type: Mauritius, *Commerson* (FI).

Representative specimens:

South Africa: Transvaal: Pretoria, 13.i.1935, *Chippindal* 21 (K); Pretoria, Prinshof Experiment Station, iii.1943, *Codd* 2226 (K); Bon Accord Dam picnic area, 07.xii.1980, *Crook* 2347 (K); Ubombi District, Pongolo Poort dam site, altitude 200-250ft, *Ward* 3808 (E).

Zambia: Luangwa Valley, near the Lunda Plain, altitude 2500ft, 04.v.1966, *Astle* 4865 (K); Mpika District, Luangwa Game Reserve, 27.iv.1965, *Mitchell* 2689 (K).

Zimbabwe: Harare District, Harare, university campus on southern slope, 14.iii.1985, *Bennett s.n.* (K).

Distribution: India, introduced to Australia, Africa and America.

5. ***Dichanthium caricosum*** (L.) A. Camus, Bull. Mus. Hist. Nat. Paris 27: 519 (1921).-Bor, Flora of Assam 5: 370 (1940).-Bor, Grasses Burma Ceylon India & Pakistan: 134 (1960).-Napper, Grasses of Tanganyika: 100 (1965).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 725 (1982).

Synonyms: *Andropogon caricosus* L., Sp. Pl. ed. 2: 1480 (1763); *Andropogon serratum* Retz., Obs. Bot. 5: 21 (1789); *Andropogon filiformis* Pers., Syn. Pl. Glum. 1: 103 (1854); *Heteropogon concinuus* Thw., Enum. Pl. Zeyl.: 368 (1864); *Andropogon caricosus* subsp. *genuinis* Hack., in DC., Monogr. Phan. 6: 568 (1889); *Apocepis pallida* Hook.f.. Fl. Brit. Ind. 7: 143 (1896); *Dichanthium caricosum* (L.) Stapf, in Ridley, Fl. Malay Penins. 5: 210 (1925); *Dichanthium pallidum* (Hook.f.) Stapf ex Fischer, in Gamble, Fl. Pres. Madras 10: 1740, 1741 (1934); *Dichanthium theinlwinii* Bor, in Kew Bull. 1949: 223 (1949).

Perennial. Culms usually robust, ascending from a creeping base, often forming tufts at the rooted nodes. Leaf blades linear-lanceolate, up to 20cm long and 5mm wide, glabrous or sparingly hairy; leaf sheaths hairy along the margins and at the node, more rarely completely glabrous; ligule a ciliate membrane.

Inflorescence subdigitate; raceme peduncles and culm below inflorescence glabrous; racemes solitary, paired or more often 3-10, arranged along a short primary axis, with 15-20 spikelet pairs. Sessile spikelet 3-4mm long, obovate, lowest 1-3 homogamous, male or neuter, the upper ones bisexual; glumes subequal; lower glume ciliate below the middle, glabrous above or with scattered longer hairs near the apex and along the margins, rarely with scattered long hairs all over; upper glume often slightly longer than the lower one, ciliate along the keel. Florets 2: lower floret empty, lemma hyaline; upper floret bisexual, lemma stipiform, entire; awn 25mm long, glabrous; no anthers seen; ovary elliptic, tiny. Pedicellate spikelet male or neuter, subequal in shape and size to the sessile one.

Chromosome number(s): 2n = 20 (De Wet & Harlan, 1966); 40 (De Wet, Borgaonkar & Richardson, 1963).

Diagnostic characters and affinities: Morphologically *D. caricosum* and *D. aristatum* are easily distinguishable on the basis of the peduncle pubescence, which is glabrous in *D. caricosum*. On the basis of other characters, however, many specimens may equally well be included with either of the species. The plant is much more robust than *D. aristatum*. The spikelets seem to be bigger and markedly obovate.

Habitat: Swampy places, open humid woodland, black cotton soils.

Uses: Native pasture species.

Type: India, *Burmann* (LINN).

Representative specimens:

Singapore: Nelson road, Tanjong Pagar, railway goods yard, 08.v.1965, *Sinclair* 10784 (BM; E; K;).

Thailand: Payap, Fang, wayside, altitude 350m, 28.ii.1958, *Sørensen, Larsen & Hansen* 1785 (E).

Distribution: India, Burma, Sri Lanka, Malay Peninsula, China, New Guinea and Fiji.

6. ***Dichanthium sericeum***[*] (R. Br.) A. Camus, in Bull. Mus. Hist. Nat. Paris 27: 549 (1921).-Burbidge, Australian grasses 1: 146 (1966).-Burbidge, Australian grasses: 146 (1968).-Lazarides, The grasses of Central Australia: 70 (1970).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 163 (1982).-Simon, A key to Australian grasses (ed.2): 98 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 26 (1994).

Synonyms: *Andropogon sericeus* R. Br., Prodr. Fl. Nov. Holl. 1: 201 (1810); *Andropogon affine* R. Br., Prodr. Fl. Nov. Holl. 1: 201 (1810); *Andropogon*

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[*] **sericeus**, silky, with long straight close-pressed hairs.

chrysantherus F. Muell., Linnnaea 25: 443 (1852); *Andropogon jubatus* Balansa, Bull. Soc. Bot. Fr. 19: 322 (1872); *Andropogon acutiusculus* Hack., in DC., Monogr. Phan. 6: 575 (1889); *Andropogon sericeus* var. *mollis* F. M. Bailey, Queensl. Agric. Journ. 30: 316 (1913); *Dichanthium acutiusculum* (Hack.) A. Camus, Bull. Mus. Hist. Nat. 27: 549 (1921).

A perennial of about 1m tall, shortly rhizomatous, erect or slightly decumbent; culm nodes exposed and bearded. Leaf blades linear-lanceolate, up to 15cm long, glabrous to pilose all over; leaf sheaths glabrous to pilose; ligule an unfringed membrane of up to 1.5mm long.

Inflorescence of 1-15 sessile to subsessile white villous digitate racemes; lowest 1-6 spikelet pairs homogamous, male or neuter. Sessile spikelet elliptic-oblong, truncate at the apex; lower glume obtuse, pilose or rarely glabrous on the back below the middle, always with tubercle-based cilia (up to 6mm long) along the margins and forming a transverse subapical fringe; upper glume slightly longer than the lower, glabrous, ovate, carinate. Florets 2: lower floret empty, lemma hyaline; upper floret bisexual, lemma 2mm long, stipiform; awn 30mm long; epaleate; anthers 2 or 3, 2mm long; ovary obovate. Pedicellate spikelet obovate-oblong, 4mm long, male or neuter; lower glume obovate, linear to narrowly ovate, with a transverse subapical fringe of cilia; anthers 2.

Chromosome number: 2n = 20 (De Wet, Borgaonkar & Richardson, 1963; Gould, 1975).

Diagnostic characters and affinities: Racemes are densely covered with long, white silky hairs, sessile or very shortly pedunculate; lower glume of the sessile spikelet covered with long, silvery hairs with an arch of extremely long hairs at apex, many of which arise from tubercles.

Habitat: Occurs mainly in open grassland on heavy blackish soil and somewhat arid places.

Uses: Native pasture species.

Type: Australia, Port Jackson, *Brown* 6178 (BM!)..

Representative specimens:

Australia: Leichhardt District, vi.1956, *Bissett* 1 (E); Keppel Bay, 1802-1805, *Brown* 6178 (sheet 1) & Paterson river (sheet 2) (isolectotypes of *Andropogon sericeus* R. Br.(labelled A on the sheet) and *Andropogon affinis* (R. Br.) A. Camus (labelled B on the sheet); E); Upper Murray District, v.1913, *Peck s.n.* (E).

Kenya: Kabete Experimental Farm, 27.ix.1915, *Dowson* 203 (K).

Distribution: Widely distributed in Australia, and introduced to tropical East Africa.

Chapter 9. Distribution and ecogeography of the *Andropogoneae* and the *Sorghinae*.

9.1. The *Andropogoneae*.

The *Paniceae* and *Andropogoneae* both appear to be 'natural' tribes, which probably originated from a common panicoid stock in the warmer parts of the eastern hemisphere, possibly in the East Africa-Madagascar region (Hartley, 1958). It is thought that the *Panicoideae* then spread throughout the tropical and subtropical parts of both hemispheres. In this spread the tribe *Paniceae* formed the advance guard, reaching the western hemisphere at an early stage, and developing rapidly there under favourable conditions. The *Andropogoneae*, possibly formed at a later stage from the panicoid stock, spread rather towards the Indo-Malaysian region, and reached the American continent only comparatively recently (Hartley, 1958).

There is evidence that climatic factors, including winter temperature and possibly rainfall, are of importance in relation to the distribution of the *Andropogoneae* (Hartley, 1950). The effect of temperature is reflected in the predominantly tropical and subtropical distribution of the tribe, while its abundance in different parts of the tropical zone appears to be influenced by rainfall. The *Andropogoneae* reach their highest relative development in monsoonal climates, with a short season of heavy rainfall (Hartley, 1958). He lists the most conspicuous factors in the distribution of the *Andropogoneae* as:

(i) the concentration of the tribe in the tropical and subtropical parts of the world;

(ii) the region of maximum abundance in Indo-Malaysia;

and

(iii) the relatively lower concentration in the western hemisphere than in the eastern hemisphere.

The general distribution of the *Andropogoneae* throughout the whole world is shown in Figure 9.1 (adapted from Hartley, (1958)). The percentages indicate the proportion of the species of the *Andropogoneae* in the total grass flora of the region. The main centre of specific differentiation is in southern Asia. This region is also rich in taxa which have been regarded as being the most primitive members of the tribe. These include the subtribe *Saccharinae*, and especially the genus *Miscanthus,* which not only has a generalised type of inflorescence from which the more specialised forms within the tribe may have been derived, but which also shows relationships to other tribes of grasses (Hartley, 1958).

While the percentage of the species of the *Andropogoneae* in the flora of Africa does not in anyway approach the high levels reached in some parts of southern Asia, this may be due to the absence in Africa of comparable levels of summer rainfall and is not necessarily to be accepted as evidence that the tribe has spread to Africa from a centre of origin in Asia. The presence in tropical Africa of the genus *Miscanthidium*, closely related to, or perhaps congeneric with *Miscanthus*, indicates that the primitive forms of the tribe reached Africa at a very early stage, if they did not, indeed, originate there (Hartley, 1958). This has brought in the probability of a somewhat parallel evolution and spread occurring in Africa and Asia, with the tribe throughout retaining its tendency to develop maximum differentiation in regions of high winter temperature and abundant summer moisture.

Distribution of the *Andropogoneae* in the western hemisphere is quite different compared with the eastern hemisphere. Species of the tribe form a very small percentage of the grass flora. Also the more primitive taxa of the tribe are absent from the American continent. It is noteworthy that only one of the 87 genera (*Agenium*) is recorded as endemic there (Hartley, 1958). This strongly suggests that the tribe has not reached its full potential development in this region and that it has spread to America from a centre or centres of origin in the old world.

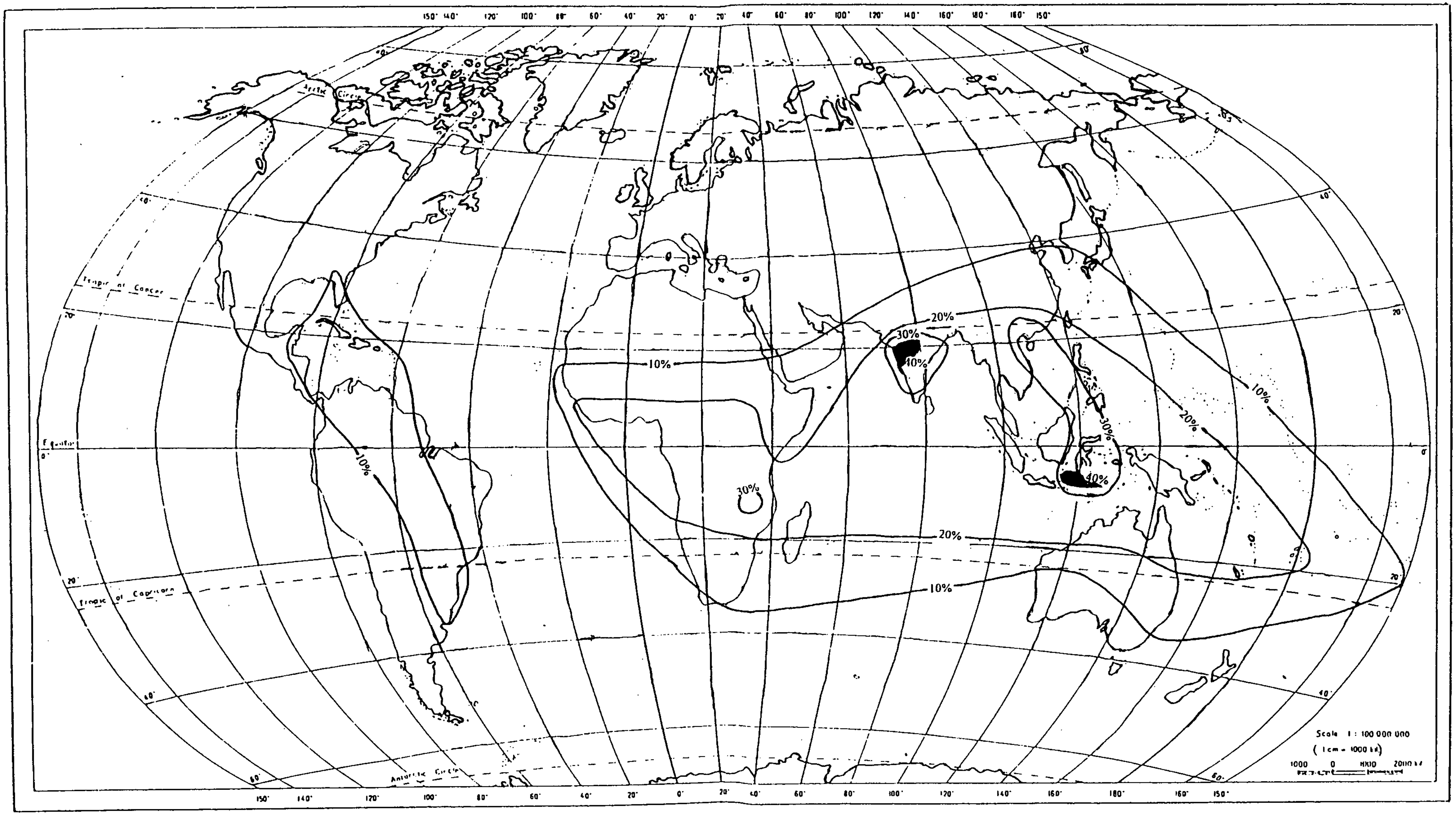

Figure 9.1. World distribution of the *Andropogoneae*. [ ] - regions of maximum abundance (>40%). The percentages indicate the proportion of the species of the *Andropogoneae* in the total grass flora of the region (after Hartley, 1958).

9.2. The *Sorghinae*.

From a geographical point of view, the genus is the most important and illuminating of all categories. The species is, generally speaking, too small a unit to be of much use in the consideration of world-wide plant distribution problems. The family, on the other hand, is more often than not too large a category for convenient handling. The genus on the contrary, tends to possess the advantages of both the family and species without their disadvantages. Genera are mostly of convenient size, both taxonomically and geographically.

The genera of the subtribe are distributed mainly in the Paleotropical floristic kingdom, with a few spreading into the Holoarctic, Neotropical and Australian kingdoms (Table 9.1). The monotypic genera and those with few species have restricted distributions and to some extent endemic. At specific level, the distribution discussed is those of species sampled. All the distribution data (maps and tables) are based on the information obtained from herbarium sheets, unless otherwise stated. The floristic nomenclature is based on Takhtajan (1986) (Figure 9.2).

9.2.1. Cosmopolitan genera.

These are genera which naturally extend somewhat beyond the limits of the region in which the bulk of their range and the majority of their species occur. In the *Sorghinae*, these genera are represented by *Bothriochloa* Kuntze, *Chrysopogon* Trin. and *Sorghum* Moench.

Bothriochloa: Other than *Sorghum*, this is the widely distributed of *Sorghinae* genera. It is found throughout the tropics of the world (Figure 9.3). To the south, its range reaches the sub-Antarctic, while to the north it goes as far as the North American Atlantic region. The genus has its origins in the Old World but was introduced into the Western Hemisphere (Celarier & Harlan, 1955). These are grasses of open grassy places.

Table 9.1. Distribution of *Sorghinae* genera.

Abbreviations:

Ast. - *Asthenochloa*

Bot. - *Bothriochloa*

Cap. - *Capillipedium*

Euc. - *Euclasta*

Psd. - *Pseudodichanthium*

Sor. - *Sorghastrum*

Vet. - *Vetiveria*

\+ - present

Chr. - *Chrysopogon*

Cle. - *Cleistachne*

Dic - *Dichanthium*

Hem. - *Hemisorghum*

Pss. - *Pseudosorghum*

Soru. - *Sorghum*

				Genera													
Floristic Kingdom	Subkingdom	Subkingdom regions	Subregions	Ast.	Bot.	Cap.	Chr.	Cle.	Dic.	Euc.	Hem.	Psd.	Pss.	Sor.	Soru.	Spa.	Vet.
Holoarctic	Boreal	Euro-Siberian	European				+								+		
		Eastern Asian					+								+		
		Atlantic North American	Canadian-Appalachians											+	+		
			Southern Atlantic North American		+									+			
			Central Grasslands		+									+			
	Tethyan	Macaronesian							+								
		Meditarranean					+		+						+		
		Irano-Turanian			+	+	+		+						+		
	Madrean													+	+		
Paleotropical	African	Saharo-Sidian			+	+	+		+						+		+
		Sudano-Angolan	Sahelo-Sudanian		+		+							+	+		+
			Somalo-Ethiopian		+	+	+								+		+
			South Tropical African		+	+	+	+		+				+	+		+
			Kalaharian				+							+	+		+
		West African Rainforest			+		+			+				+	+		+
		Namib-Karoo			+				+					+	+		+
	Madagascan						+		+	+				+	+		+
	Indomalesian	Indian			+	+	+	+	+	+		+	+		+		+
		Indo-Chinese			+	+	+		+		+		+		+		+
		Malesian		+	+	+	+		+				+		+		+
		Papuan			+	+	+		+						+		+
	Polynesian	Hawaiian					+										
		Fijian			+												
Neotropical			Caribbean		+		+							+	+		
			Central Brazilian		+									+	+		
			Andean											+	+		
Cape									+								
Australian		North and East Australian	Tropical North and East Australian		+	+	+		+						+	+	+
		Central Australian	Temprate and South-Eastern Australian		+		+		+						+		
Antarctic		Patagonian			+										+		

Figure 9.2. Floristic regions of the World (after Takhtajan (1986)).

1. Circumboreal Region. 2. Eastern Asiatic Region. 3. North American Atlantic Region. 4. Rocky Mountain Region. 5. Macaronesian Region. 6. Mediterranean Region. 7. Saharo-Arabian Region. 8. Irano-Turanian Region. 9. Madrean Region. 10. Guineo-Congolan Region. 11. Uzambara-Zululand Region. 12. Sudano-Zambesian Region. 13. Karoo-Namib Region. 14.St. Helena and Ascension Region. 15. Madagascan Region. 16. Indian Region. 17. Indo-Chinese Region. 18. Malesian Region. 19. Fijian Region. 20. Polynesian Region. 21. Hawaiian Region. 22. Neocaledonian Region. 23. Caribbean Region. 24. Region of the Guyana Highlands. 25. Amazonian Region. 26. Brazilian Region. 27. Andean Region. 28. Cape Region. 29. North East Australian Region. 30. Southwest Australian Region. 31. Central Australian or Eremaean Region. 32. Fernändezian Region. 33. Chile-Patagonian Region. 34. Region of the South Suantarctic Islands. 35. Neozylandic Region.

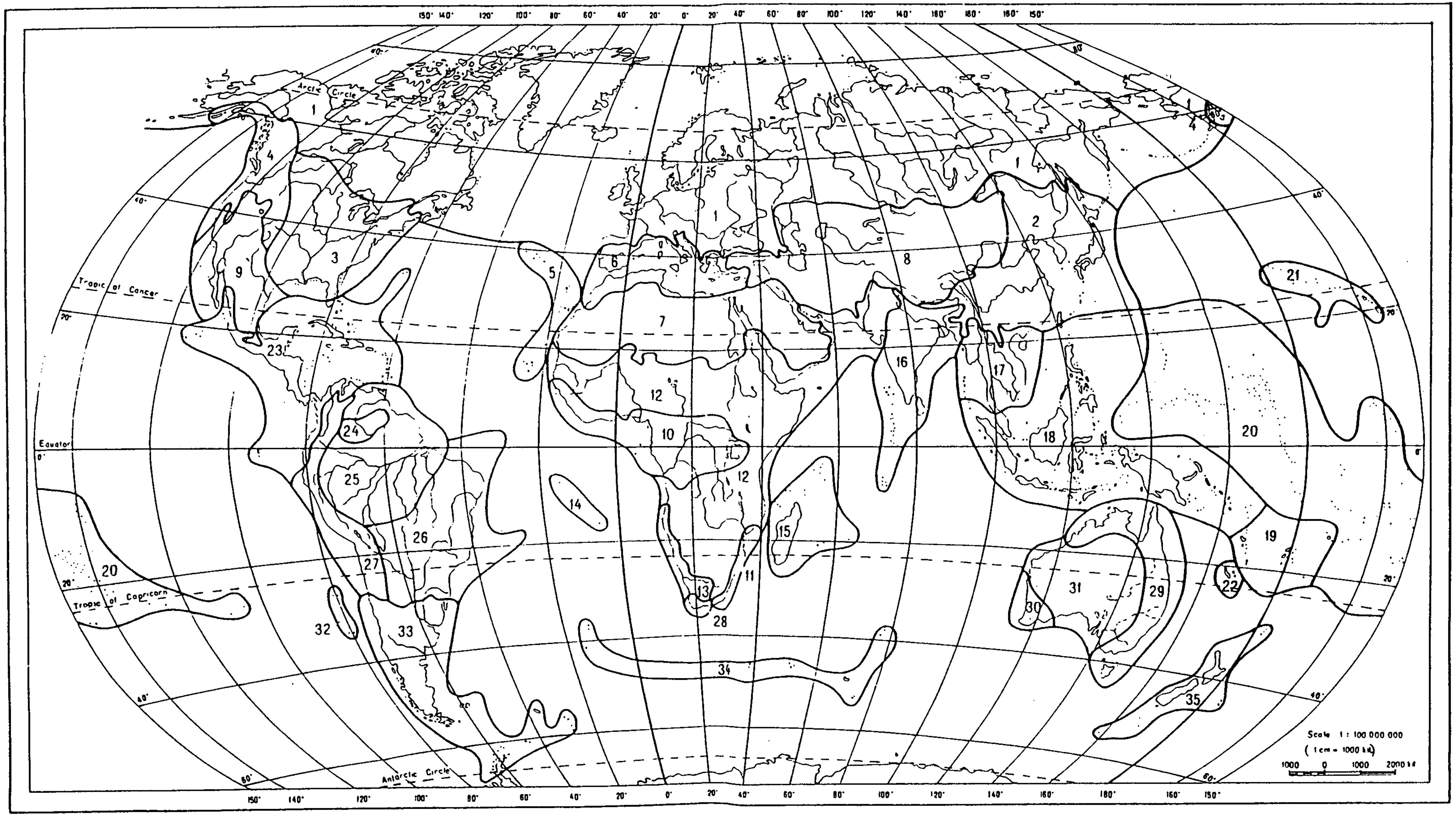

Figure 9.2. Floristic regions of the World (after Takhtajan (1986)).

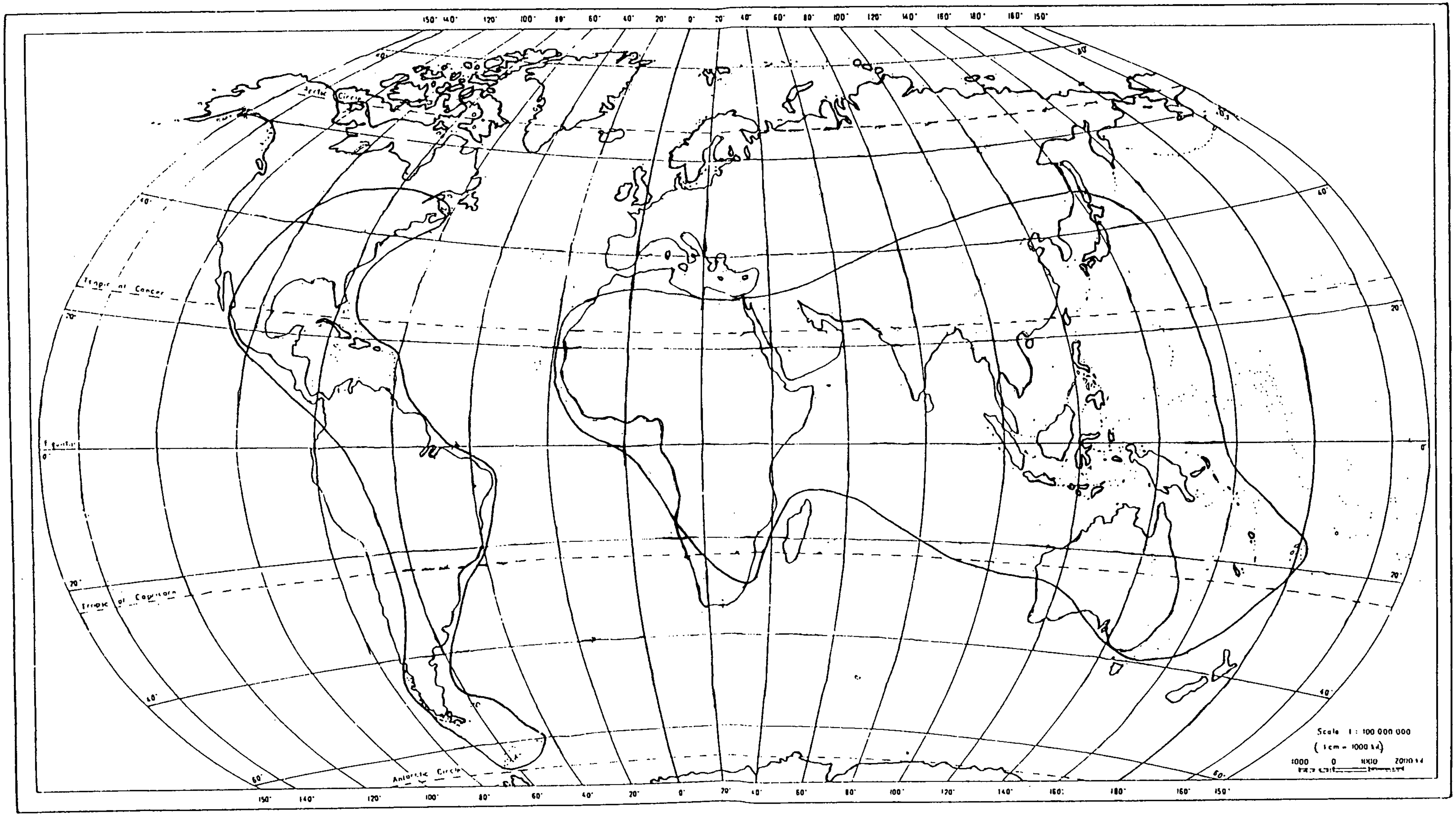

Figure 9.3. World distribution of the genus *Bothriochloa* (———).

Several species of *Bothriochloa* are of value in rangelands. *B. ischaemum* has been utilised as a sown forage grass for many years on the southern Great Plains of the USA (Hacker & Loch, 1995). The distribution of this species is widespread throughout the subtropical and temperate regions of Eurasia. It is found occasionally in the Atlas mountains of North Africa, throughout southern Europe, western Siberia, and central Asia, Mongolia and North China. Its northern limit in Europe is Belgium and Germany. Its southern boundaries extend from Syria and Lebanon, and then east through Iraq, Iran, Afghanistan, the Himalayas of North India, and into South China.

In the tropics, only *B. insculpta* (creeping bluegrass) and *B. pertusa* (Indian bluegrass) have been developed as species for sown pastures. *B. insculpta* is a stoloniferous perennial species native to tropical Africa, Arabia and Southeast Asia. It grows on a range of soils, including clays. This species was introduced in Australia in the 1930's (Hacker & Loch, 1995). *B. pertusa* is also stoloniferous and closely related to *B. insculpta* though generally smaller in stature. *B. pertusa* is essentially an Asian species. It also occurs in eastern Africa, but it is uncertain whether it is native to that continent or introduced. It is also naturalised in tropical America and Australia.

B. bladhii has a very extensive distribution in the Old World tropics. It is widely distributed throughout Africa, is found in India, Pakistan and Sri Lanka. It is also present in Burma, Malay Peninsula, China and Australia. It is also found in abundance in most of the Pacific islands. *B. radicans* is a native of the tropics and subtropics of eastern and southern Africa. It has also been introduced to tropical America. *B. macera*, *B. biloba* and *B. decipiens* occur only in Australia. According to Blake (1944), *B. macera* and *B. biloba* are particularly abundant in New South Wales and some neighbouring parts of Victoria, but extends to Queensland and South Australia. The species *B. decipiens* has two varieties. Both these varieties are endemic to Australia. *B. decipiens* var. *decipiens* is very abundant in the *Eucalyptus* forests of Queensland, particularly towards the south and east and extending into northern New South Wales (Blake, 1944). *B. decipiens* var. *cloncurrensis* occurs only in Queensland. *B. kuntzeana* is a species restricted to the Indian subcontinent. *B. saccharoides* is found in tropical America and the Caribbean islands. It is not clear whether this species is native there or has been introduced.

Chrysopogon: This genus is found mainly in the tropics of the Old World with a large concentration of species in the Indian subcontinent (Figure 9.4). Only one species, *C. aciculatus*, also occurs in temperate southern Europe, where it is commonly used in lawns. This species is also found in the tropics of Asia, Africa, Polynesia and Australia. Four species, *C. sylvaticus*, *C. fallax*, *C. latifolius* and *C. pallidus* are all endemic to Australia. They occur in abundance in Queensland, the Northern Territory and Western Australia. They are found in varied habitats, from stony hillsides through savannah woodlands to roadsides and ledges. One species, *C. orientalis*, occurs in the Indian subcontinent. The remaining species, *C. aucheri*, *C. gryllus*, *C. plumulosus*, *C. fulvus* and *C. serrulatus* are distributed in the Arabian Peninsula, tropical Africa and the Indian subcontinent. *C. serrulatus* is the only one in the group whose range extends to southern Africa.

Sorghum: The genus *Sorghum* is largely indigenous to the Old World tropics and subtropics (Figure 9.5). Of the five subgenera of the genus, only *(Eu)Sorghum* and *Parasorghum* have representatives in the Western Hemisphere. The other subgenera are restricted to the Old World tropics.

Parasorghum spreads from southern and eastern Africa through India and south-east Asia to Australia, and also to western Guatemala and Mexico. In this subgenus was sampled the species *S. nitidum* and *S. versicolor*. *S. nitidum* is found in Australia (eastern Queensland), China, Japan, India and most of the Indonesian islands. *S. versicolor* is characteristic of deciduous bushland or wooded grasslands of eastern, central and southern Africa.

Heterosorghum is restricted to Papua New Guinea, the Philippines, and Australia. Both *Chaetosorghum* and *Stiposorghum* are confined to Australia. *Stiposorghum* is represented by species *S. plumosum* and *S. stipoideum* in the sample. *S. plumosum* is distributed in Western Australia, the Northern Territory and

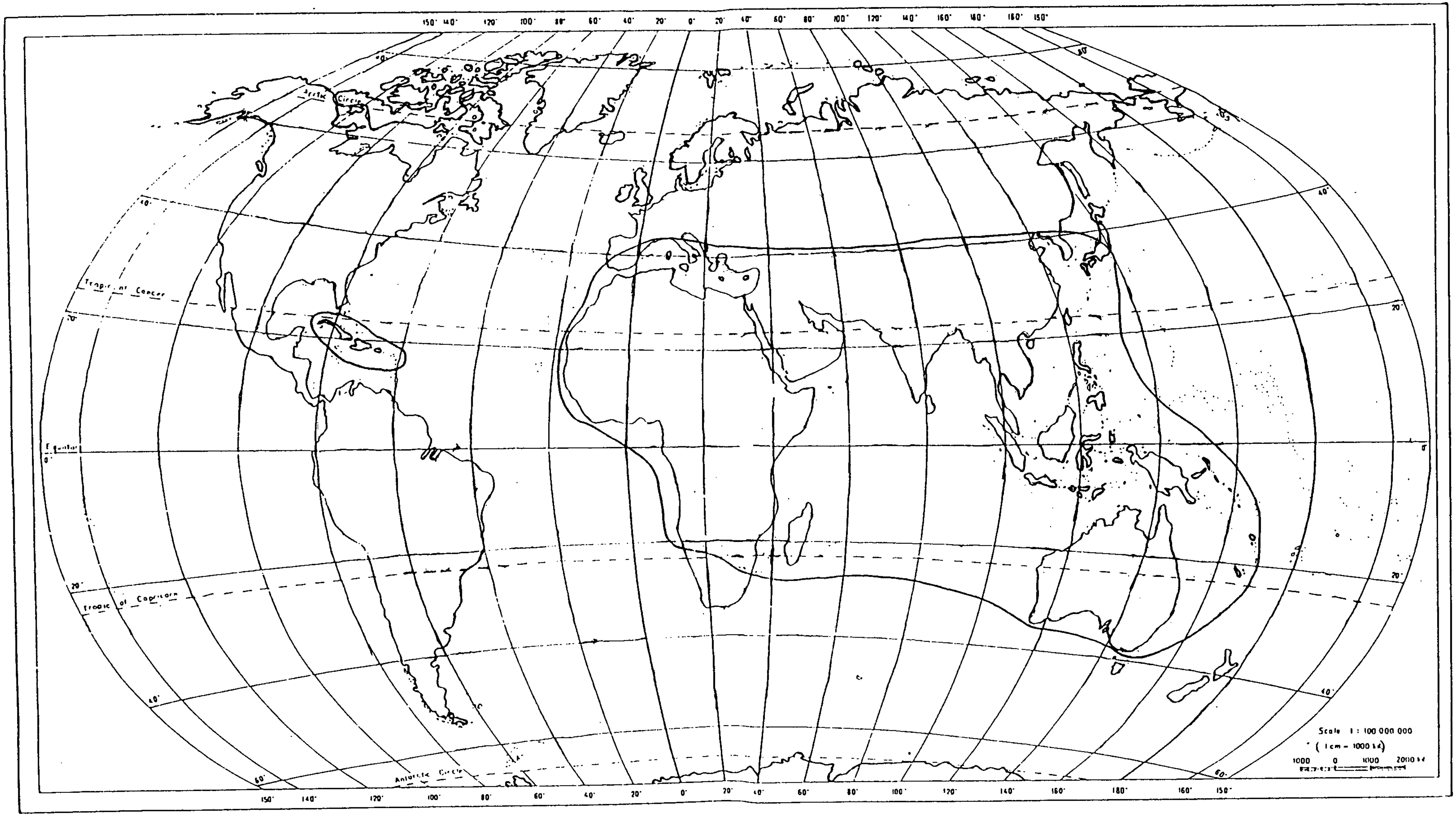

Figure 9.4. World distribution of the genus *Chrysopogon* (———).

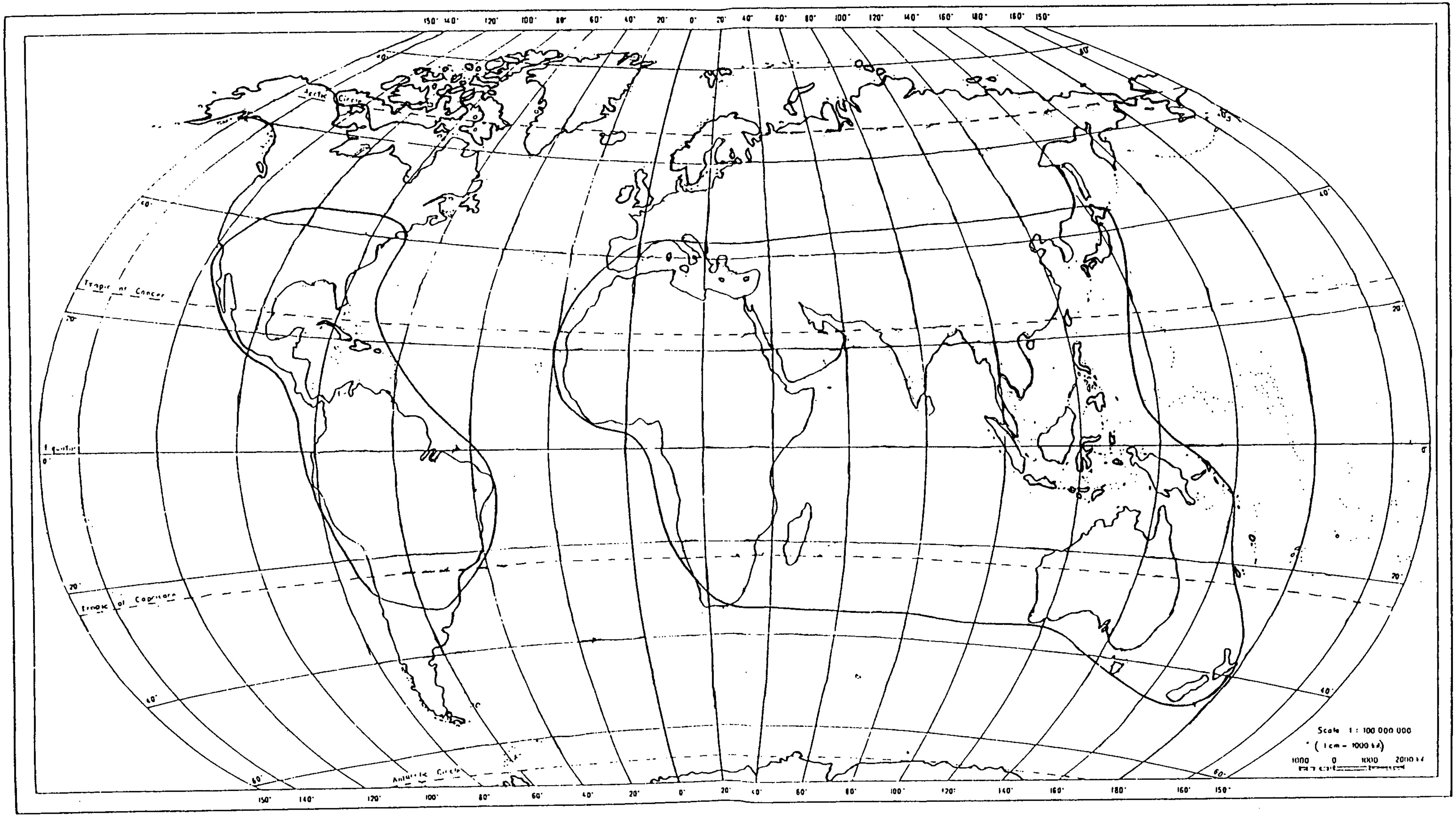

Figure 9.5. World distribution of the genus *Sorghum* (————).

Queensland chiefly north of latitude 21°, but extending further south in Queensland (Lazarides et al, 1991). A new record of the presence of this species in the Indonesian island of Sumba was made in this study. *S. stipoideum* is distributed in Western Australia and the Northern Territory.

(Eu)Sorghum is distributed through southern Africa to India, south-east Asia and the Philippines, "but did not reach either Australia or America until carried there by man in the past few centuries"(Doggett, 1970). All taxa of significance as crops or sown pastures are in this subgenus. A detailed comparative morphological study of grain sorghums, *S. bicolor* subsp. *bicolor*, led Harlan and De Wet (1972) to recognise five basic races, and ten hybrid races that combine characteristics of any two or more basic races. Race *bicolor* sorghums are grown across the range of *Sorghum* cultivation in Africa and Asia. Race *kafir* sorghums are important staples across the eastern and southern savannah from Tanzania to South Africa. Race *caudatum* is widely grown in Chad, Sudan, north-eastern Nigeria and Uganda. Race *durra* is widely grown along the fringes of the southern Sahara, across arid West Africa, the Near East and parts of India. Finally race *guinea* is grown in the high rainfall areas of West Africa and the savannah of Malawi. *S. bicolor* subsp. *drummondii* occurs as a weed in Africa wherever grain sorghums and their closest relatives are sympatric (De Wet, 1978). *S. bicolor* subsp. *arundinaceum* extends across the African savannah. De Wet (1978) reports that it was introduced to tropical Australia, parts of India and the New World. Four races are recognised in this subspecies: race *aethiopicum* of the arid African Sahel; race *virgatum* of north-eastern Africa; race *arundinaceum* of the African tropical forest; and race *verticilliflorum* of the African savannah.

S. halepense (Johnson grass) is a perennial with stout, creeping rhizomes. It is a native of the Mediterranean regions and common in all warm countries, including the southern United States. It is often a troublesome weed but reckoned an excellent forage grass. It is said to cross easily with *S. bicolor* in Argentina, and the hybrid thus formed is called *S. almum* Parodi (Hacker & Loch, 1995).

9.2.2. Discontinuous genera.

Discontinuity is the occurrence of a species or other unit in two or more separated regions. When one plant group is found distributed over two or more widely separated regions, its discontinuity is significant, only if it can be assumed that its range was formerly continuous and the subsequent disjunction has resulted from natural causes. This therefore means that the group is of monophyletic origin and has therefore not only had a common ancestry but also a single point of origin.

Capillipedium Stapf: *Capillipedium* occurs in the tropics of the Old World with a high concentration of the species in the Indomalesian region (Figure 9.6). Of the 14 or so species of the genus, it is only *C. parviflorum* and *C. spicigerum* that occur outside the region in Africa and Australia, with *C. spicigerum* endemic to Australia. *C. filiculme* and *C. huegelii* are endemic to India. *C. assimile* has a much wider distribution than the two species mentioned above, for it covers most of Southeast Asia. *C. parviflorum* is the widely distributed of *Capillipedium* species. In addition to the Indian subcontinent, its range extends westwards to eastern and southern Africa, and southwards to Australia.

Cleistachne Benth.: The genus consists of a single species, *C. sorghoides*. It is restricted in distribution to eastern and southern tropical Africa and western India (Figure 9.7).

Dichanthium Willemet: *Dichanthium* is widespread throughout the tropics and subtropics of the Old World (Figure 9.8). Most of the species occur in Africa, Arabia and the Indian subcontinent. *D. annulatum* is native through most of Africa, east China and Southeast Asia and south to tropical eastern Australia. It has also been introduced to the southern parts of the USA (Hacker & Loch, 1995). This species has three varieties. These are var. *annulatum*, var. *fecundum* and var. *papillosum*. Var. *annulatum* occurs in all the places where the species is known to exist. Var. *fecundum* occurs only in Australia, while var. *papillosum* is native to the tropics and subtropics of Africa. *D. aristatum* is indigenous to regions from tropical India

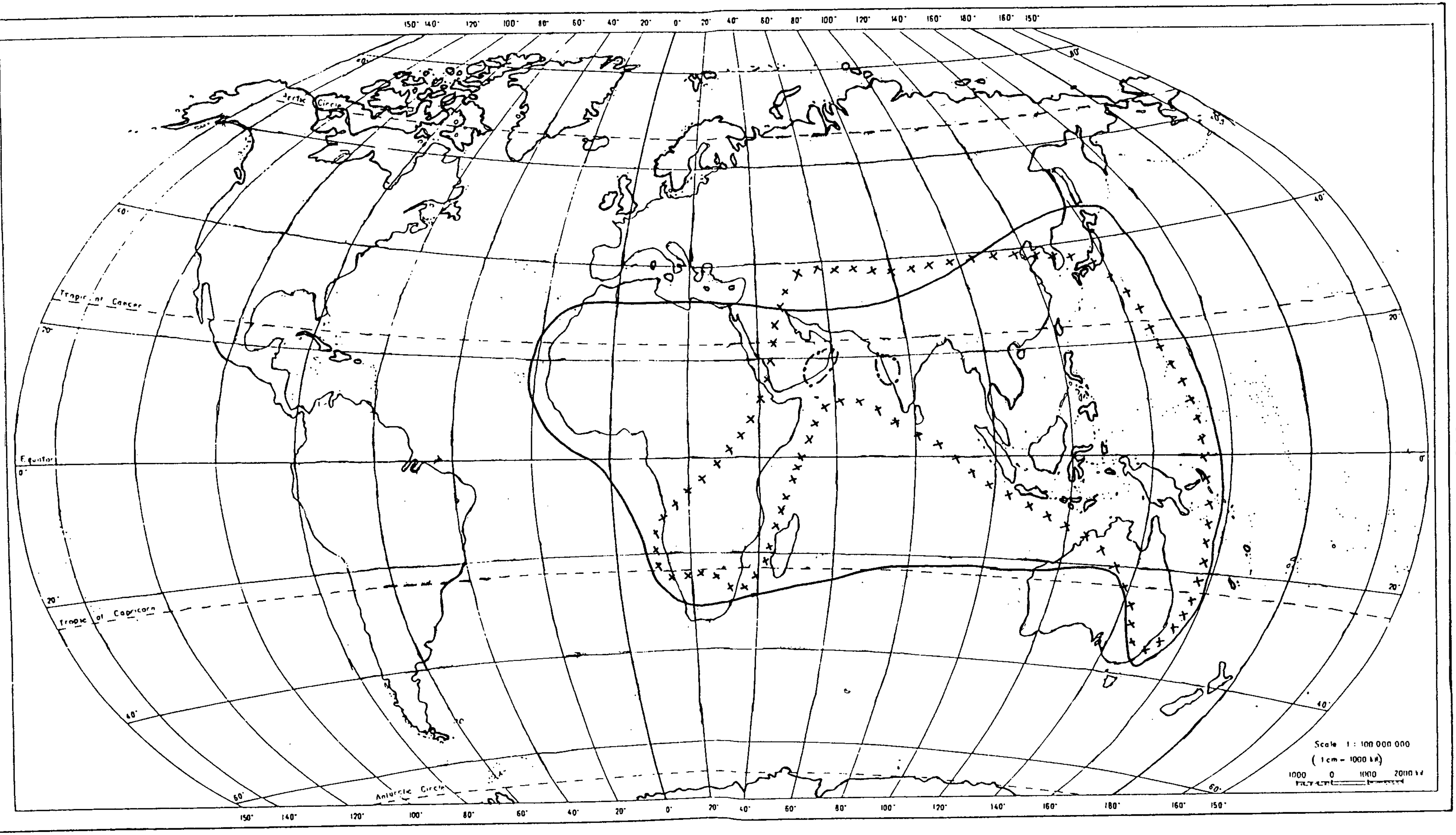

Figure 9.6. World distribution of the genera *Capillipedium* (x x x), *Pseudodichanthium* (-•--•-) and *Vetiveria* (————).

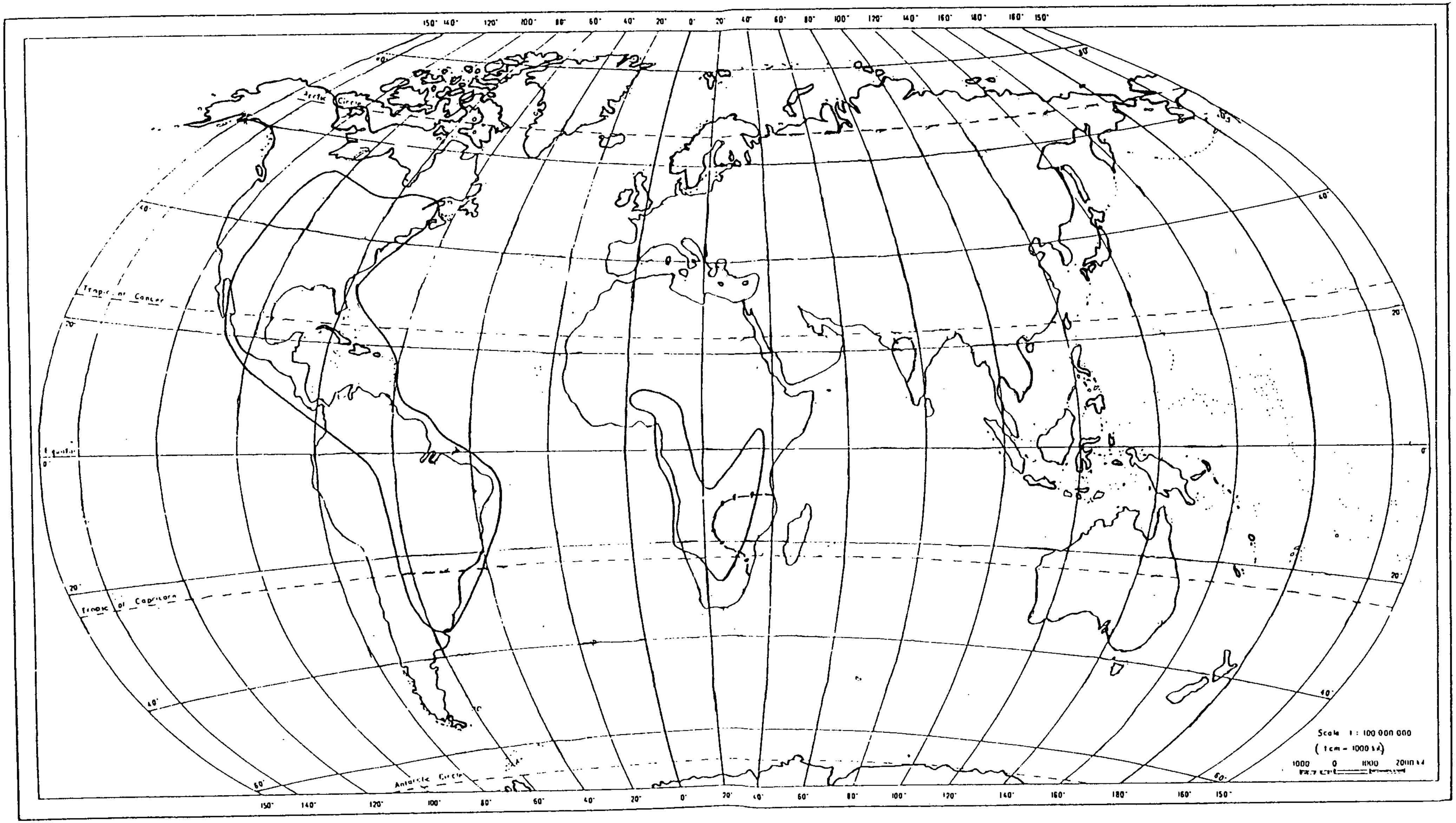

Figure 9.7. World distribution of the genera *Cleistachne* (-•-•-) and *Sorghastrum* (———).

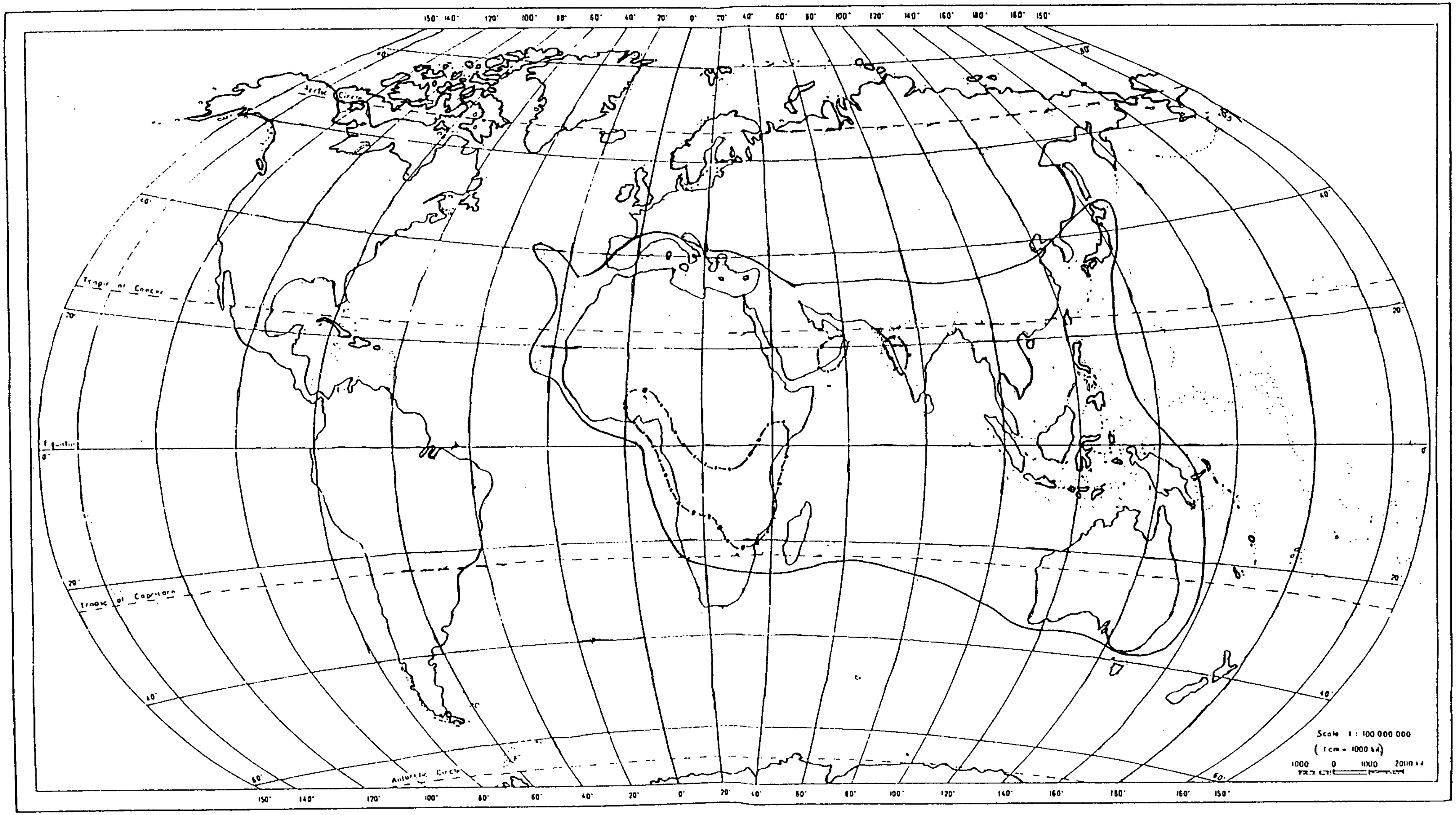

Figure 9.8. World distribution of the genera *Dichanthium* (———) and *Euclasta* (-•-•-).

eastwards to Indonesia, "... but has become naturalised in the Philippines, Fiji, Australia, Africa and the Americas " (Hacker & Loch, 1995). *D. caricosum* is a tropical species native to southern Asia from India to Malaysia and China. It also occurs in the West Indies, Cuba and Fiji, where it probably has been introduced. *D. sericeum* (Queensland bluegrass) is native to subtropical and tropical eastern Australia, Papua New Guinea and the Philippines. In Queensland, the species often dominates in open grasslands. The species *D. micranthum* and *D. foveolatum* occur mainly in the Arabian Peninsula, with the latter species extending southwards to tropical east Africa. These are species of low lying coastal areas.

Euclasta Franch.: This is one genus that shows a striking discontinuity. It is found only in east tropical Africa and western India (Figure 9.8). Of the three species in the genus, two, *E. clarkei* and *E. oligantha*, are found only in western India, and only *E. condylotricha*, extends to Madagascar and tropical east Africa.

Pseudodichanthium Bor: This genus was once thought to be endemic to India (Mehrota & Jain, 1980), but recent collections have shown that it also occurs in the Saharo-Arabian region, in the country of Oman (Figure 9.6). The single species, *P. serrafalcoides*, is found in monsoon forests. Oman tends to have affinities with India in terms of climate in contrast to most of the Arabian Peninsula whose affinities are closer to continental Africa (Cope, personal communication).

Sorghastrum Nash: Species of the genus are found in central and western Africa and north, central, and south America, including the Caribbean (Figure 9.7). In the Western Hemisphere, *Sorghastrum* appears to be restricted to the regions of the two continents facing the Atlantic ocean. The range of distribution of this genus would be continuous, in a sense, if the ocean barrier did not exist. In fact, two species, *S. incompletum* and *S. stipoides*, have been reported from both hemispheres. The species *S. pogonostachyum*, *S. fuscescens*, *S. friesii* and *S. incompletum* var. *bipennatum* are all African in distribution. *S. elliottii* and *S. nutans* occur mainly in the USA. In fact, *S. nutans* is said to be one of the important grasses of the prairies and an indicator of fodder in good condition (Gould, 1975). *S. minarum* and *S. setosum* are found in South America and extend northward to the Caribbean islands.

Vetiveria Bory: This is a small genus, probably with fewer that ten species, but is widespread throughout the Old World tropics (Figure 9.6). One species, *V. zizanioides*, is a native of tropical Asia. It has been extensively cultivated for its aromatic roots, and is now widely distributed throughout the tropics of world. It is 'Khas-Khas' or 'Khus-Khus', the source of 'Vetiver' oil. *V. fulvibarbis* and *V. nigritana* are African species. *V. fulvibarbis* is mainly West African in distribution, while *V. nigritana*, occurs in both west, east and southern Africa. *V. filipes* and *V. elongata* are restricted to Australia, where they tend to favour habitats near watercourses.

9.2.3. Endemic genera.

Endemism, in botanical terms, refers to the naturally growing taxa (species, genus, or family) confined to a particular area (Mehrota & Jain, 1980). In this account of the distribution of genera, endemic genera are those which are confined to only one of the floristic regions of the world, or whose ranges are not much greater than the average size of the continental ranges therein mentioned. Generic endemism is here therefore interpreted broadly in terms of Takhtajan's floristic regions (Figure 9.2). Four genera in the *Sorghinae* are endemic to certain regions. These are *Asthenochloa* Büse, *Hemisorghum* C. E. Hubbard, *Pseudosorghum* A. Camus and *Spathia* Ewart (Figure 9.9).

Asthenochloa: This genus is found in the south-east Asian islands of Java and the Philippines of the Malesian region. Even though it has been poorly collected, it seems to be found only in this part of the world. It occurs in damp and shaded places, rarely on banks of terraces, and of roads.

Hemisorghum: *Hemisorghum* is distributed in the Indian region, from Burma to Indo-China. *H. venustum* is apparently restricted to the island of Sri-Lanka. It is occasionally met with in southern India. The species of this genus tend to prefer shallow soils, mainly along river banks and disused roadsides.

Pseudosorghum: The genus occurs in tropical south-east Asia. Collections have mainly been made from the Indian sub-continent, and most of the Indonesian islands. The species are found in fairly grassy places.

Spathia: This is an Australian genus. So far, collections indicate that it occurs in the Northern Territory and Queensland. It is common in grasslands.

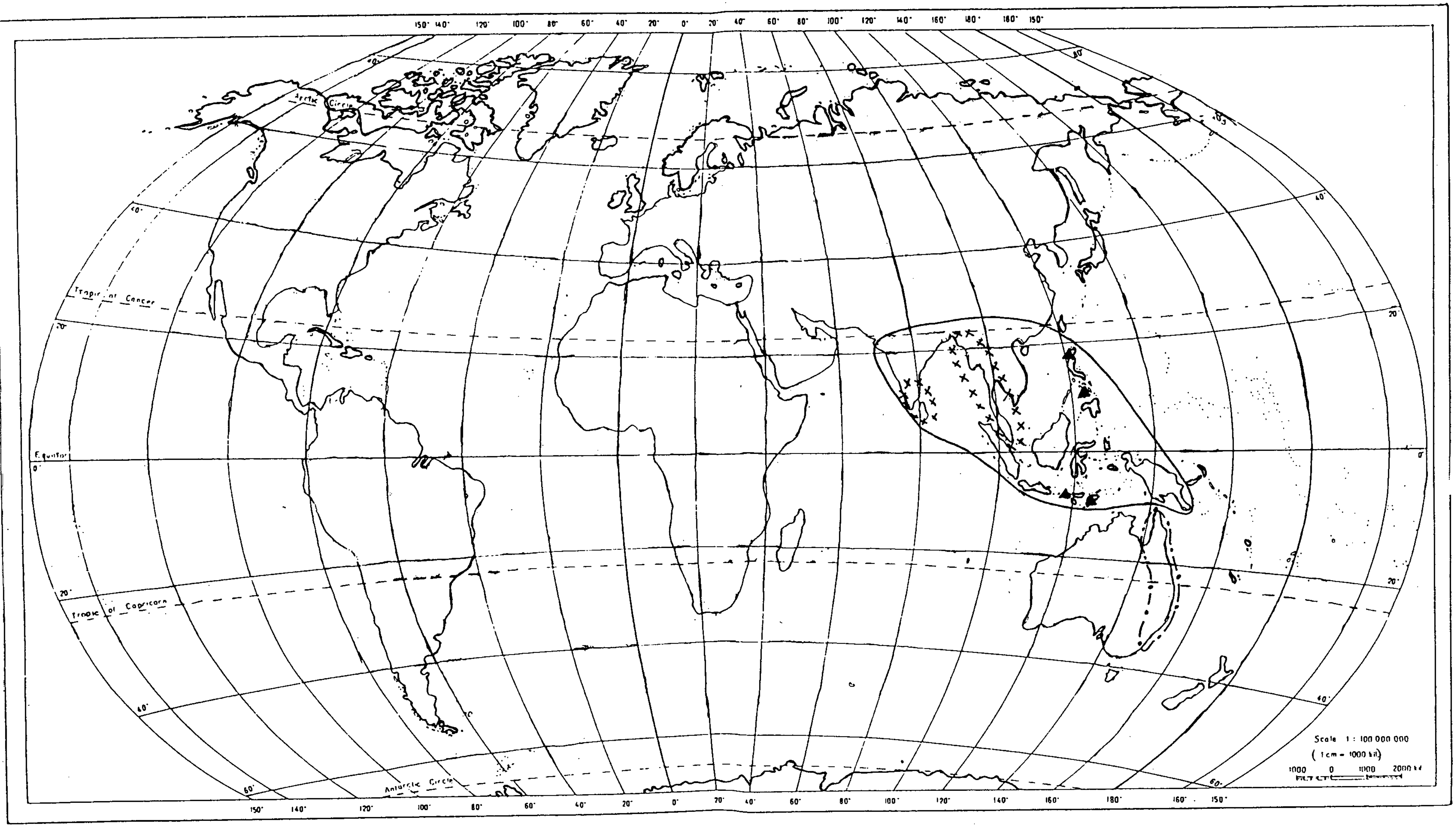

Figure 9.9. World distribution of the genera *Asthenochloa* (▲), *Hemisorghum* (x x x), *Pseudosorghum* (———) and *Spathia* (-•-•-).

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Chapter 11. Appendices.

Appendix 11.1. A manuscript sent to the Flora Zambesiaca Editorial Committee at Kew for publication.

Sorghinae of Flora Zambesiaca.

M.P. Setshogo*

Sorghinae Bluff, Nees & Schauer, Comp. Fl. Germ. ed. 2, 1: 46 (1836).

Bothriochloinae Keng, in Sinensia 10: 282 (1939).

Inflorescence terminal or rarely axillary, of single or digitate or paniculate racemes, the latter often in whorls; racemes with fragile rachis and slender internodes, sometimes reduced to triads or single spikelets, occasionally with homogamous pairs. Spikelets paired, dissimilar, seldom plumose. Sessile spikelet bisexual, usually dorsally compressed, the callus usually obtuse with cupuliform or truncate articulation but the latter sometimes oblique (always so when callus pungent); lower glume usually firm, more or less convex on the back and abruptly rounded on the flanks (except *Hemisorghum*); lower floret reduced to a barren lemma; upper lemma linear to oblong, entire or bilobed, sometimes stipiform, in which case it is reduced to a hyaline base of the awn, usually with a glabrous awn. Pedicellate spikelet male, barren, or (rarely) bisexual, sometimes much reduced, rarely with a small callus.

Genera 14. Only 9 of these genera occur in FZ.

A key to FZ *Sorghinae* genera:

- Spikelets in racemes which are solitary at ends of branches; the racemes collected into whorled panicles; rachis internodes and pedicels not furrowed.
    - Spikelets solitary at the ends of branches.
        - Pedicels entirely absent. 1. **Cleistachne**
        - Pedicels present; pedicellate spikelets absent. 2. **Sorghastrum**
    - Spikelets in pairs or threes; pedicellate spikelets often more or less reduced.

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Spikelets dorsally compressed, in panicles of many pairs or in threes of which one is hermaphrodite; racemes very much less than 30 cm. long, readily disarticulating; rachis nodes and pedicels ciliate; lower glume of sessile spikelet rounded on the sides, 2-keeled at tip; lodicules hairy. 3. **Sorghum**

Spikelets laterally compressed.

Spikelets in groups each consisting of a sessile and two more or less reduced pedicellate spikelets or a raceme of several pairs; lower glume smooth, not tuberculate. 4. **Chrysopogon**

Spikelets with many pairs of spikelets arranged in whorled racemes; lower glume tuberculate. 5. **Vetiveria**

Spikelets in racemes which are digitate or in pairs or solitary and terminal; the racemes not collected into whorled panicles; sometimes the rachis internodes and pedicels with a translucent median furrow.

Spikelets arranged in false racemes terminating the branches and branchlets of a true panicle; rachis internodes and pedicels with a median translucent furrow. 6. **Capillipedium**

Spikelets arranged in false racemes which are either solitary and terminal or subsessile, arranged along a central axis but not at the tips of capillary branches.

Racemes several to many, if solitary then the sessile spikelets imbricate; rachis internodes and pedicels with a translucent longitudinal furrow.

All pairs of spikelets heterogamous, rarely homogamous; racemes ascending; glumes sometimes pitted. 7. **Bothriochloa**

The lowest 1-3 pairs of spikelets homogamous; racemes nodding; glumes never pitted. 8. **Euclasta**

Rachis internodes and pedicels without a translucent furrow; lowest 1-6 pairs of spikelets homogamous; all spikelets, both sessile and pedicellate, in the racemes more or less alike; glumes herbaceous, greenish. 9. **Dichanthium**

1. **Cleistachne** Benth., in Hook. Ic. Pl. 14: t 1379 (1882). Type species: *Cleistachne sorghoides* Benth.

Coarse annual. Inflorescence a panicle, its primary branches bearing racemes at regular intervals along their length, each raceme reduced to a single sessile spikelet (whose apparent pedicel is homologous to the raceme peduncle); spikelets solitary, sessile; female fertile florets one; upper lemma bilobed, stipiform; lodicules 2, ciliate; pedicellate spikelet and pedicel completely suppressed.

Species 1.

1. **Cleistachne sorghoides** Benth., in Hook. Ic. Pl. 14: t 1379 (1882).-Hack., in DC., Monogr. Phan. 6: 653 (1889).-Stapf, in Prain, Flora of Trop. Africa IX: 154 (1917).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 8 (1954).-Chipindall, in Meredith, The grasses and pastures of South Africa: 468 (1955).-Bogdan, A revised list of Kenya grasses: 56 (1958).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 33 (1958).-Bor, Grasses of Burma Ceylon India & Pakistan: 119 (1960).-Napper, Grasses of Tanganyika: 98 (1965).-Hood, A guide to the grasses of Zambia: 58 (1967).-Clayton, in Polhill (ed.), Flora of Tropical East Africa, Gramineae (3): 734 (1982).-Gibbs Russell et al, Grasses of Southern Africa: 87 (1991). Type: Mozambique, Shupanga, *Kirk* (K).

Tall erect stilt rooted annual up to 3m. tall. Culms slender, culm nodes and internodes glabrous. Leaf blades linear-lanceolate, variable in width but often expanded to greater than 2 cm. wide, hairy on both surfaces, but less so on the abaxial surface, with prominent midribs; leaf sheaths hairy or glabrous, when hairy, the hairs just forward of the horizontal; leaf ligule an unfringed membrane.

Inflorescence a very compact panicle; racemes markedly reduced to single sessile spikelets (the raceme peduncle equivalent to the spikelet pedicel); raceme peduncles and rachis internodes covered with hair; spikelet colour variable but ranges from straw coloured to chestnut brown. Spikelets oblong; lower and upper glumes the same size, slightly coriaceous; lower glume minutely truncate, finely 7-nerved, covered with uniform short and dense hairs; upper glume glabrous below, hispid towards the apex, clasped lengthwise by the lower; callus obscure, shortly bearded. Florets 2: lower floret empty, lemma hyaline, oblong, ciliate, 2-nerved; upper floret bisexual, lemma stipiform, finely 3-nerved, awned; awn about 5-8 times the length of the lemma, geniculate, with a twisted column hairy along the spiral and a serrated bristle; palea shorter than the lodicules; lodicules 2, ciliate; anthers not seen; caryopsis obovate oblong, truncate, brown. Pedicellate spikelet and pedicel absent.

Zambia. (no locality given) dambo, 06.vi.1931, *Fraser* 14 (K). **Zimbabwe**. N: Gokwe District, 19.iii.1984, *Mahlangu* 981 (K); Henderson Research Station, 10.iii.1964, *West* 4743 (BM); Banket District, 15.iv.1947, *Wild* 1891 (K). C: Harare (Salisbury), Teviotdale, 20.iii.1965, *Bingham* 1429 (BM). E: Chimanimani (Melsetter) District, Muchira river, Tarka Forest Reserve, altitude 1100 m., iii.1971, *Goldsmith* 12/71 (BM). **Malawi**. C: Dedza District, Mua-Livulezi Forest, 09.iv.1964, *Adlard* 607 (MAL); Lilongwe District, Agricultural Research Station, 07.iv.1951, *Jackson* 457 (MAL). S: Chiradzulu, altitude 1250 m., 1970, *Brummitt & Banda* 9831 (K); Zomba District, lower slopes of Zomba Plateau, above Salisbury bridge, Zomba, altitude 1140 m., 26.iv.1980, *Brummitt, Masiye & Tawakali* 15560 (MAL). **Mozambique**. N: Niassa District, altitude 1000 m., 23. iii. 1964, *Torre & Paiva* 11359 (K).

Tropical Africa and India. Grassland or savannah woodland.

2. **Sorghastrum** Nash, in Britton, Fl. North. States: 71 (1901). Type species: *Sorghastrum nutans* (L.) Nash.

Poranthera Raf., in Bull. Bot. Geneve 1: 221 (1830).

Dipogon Steud., Nom. Bot. ed. 2, 1: 518 (1840).

Annuals or perennials. Inflorescence a panicle, the subdivided primary branches bearing short racemes, these sometimes reduced to triads. Sessile spikelet callus obtuse or pungent (with involucral hairs in *S. pogonostachyum*); lower glume coriaceous, convex, keeled at the tip; upper glume broadly convex; upper lemma mostly entire, sometimes bilobed, awned; lodicules glabrous. Pedicellate spikelet usually reduced to a barren pedicel, but present and bisexual in *S. fuscescens* and *S. pogonostachyum.*

Species ± 16.

Pedicellate spikelet bisexual, some pedicels barren.

Culm nodes glabrous; racemes up to 7-jointed; spikelet surrounded by an involucre of silvery hairs to ¾ the length of the sessile spikelet; awn 4 mm. long; upper lemma entire. 1. **pogonostachyum**

Culm nodes hairy; racemes 3-15-jointed; callus with a short beard of hairs only; awn 25 mm. long; upper lemma bilobed. 2. **fuscescens**

Pedicellate spikelet absent, all pedicels barren.

Racemes single-jointed; sessile spikelet 4-5.5 mm. long; upper lemma entire; awn 25-40 mm. long. 3. **incompletum** var. **bipennatum**

Racemes 2-many-jointed.

Leaf sheaths not produced into auricles; spikelets 5-7(-8) mm. long; awn 3-8(-10) mm. long, straight or bent and twisted. 4. **friesii**

Leaf sheaths with auricles; spikelets 4-7(-8) mm. long; awns 8-16 mm. long, never straight, always bent and twisted. 5. **stipoides**

1. **Sorghastrum pogonostachyum** (Stapf) Chippind. & Pole Evans, in Bot. Surv. S. Afr., Mem.: 247 (1948). Type: Angola, country of the Ganguellas and Ambuellas, *Gossweiler* 2225 (K).

Sorghum pogonostachyum Stapf, in Prain, Flor. Trop. Afr. IX: 144 (1917).

Mischanthidium gracilius Napper, in Kirkia 3: 120 (1963).

Perennial grass with a creeping rhizome, sending up a small tuft of culms from the base. Culms about 1 m. tall; culm nodes glabrous. Leaf blades narrow, glabrous, smooth except at the slightly rough tips; leaf sheaths firm, tight, glabrous, smooth, striate; ligule short, stout, pubescent.

Inflorescence a narrow panicle up to 15 cm. long; racemes loose, containing spikelet pairs, i.e., sessile and pedicellate spikelets. Sessile spikelet lanceolate; lower glume chartaceous, sparsely pilose on the back, 5.5 mm. long; upper glume glabrous; callus short, round, with hairs 4 mm. long. Florets 2: lower floret empty, lemma oblong, ciliate on the margins; upper floret bisexual, lemma entire, 3-nerved, awned from the tip; awn bristle-like, 4 mm. long; epaleate; lodicules 2, minute, fleshy, glabrous; anthers 3, 3 mm. long; ovary oblong. Pedicellate spikelet lanceolate, also with two florets of which the upper is bisexual; anthers 3, 3 mm. long, pedicel pilose, some barren while others bear the bisexual pedicellate spikelets.

Zambia. C: Central Province, Chakwenga Headwaters, 100-129 km. east of Lusaka, 27.x.1963, *Robinson* 5770 (PRE); Mkushi District, Mkushi river dambo, 27.x.1967, *Simon & Williamson* 1222 (PRE).

East and central Africa. Wet places, especially along water courses.

Note: Many, if not most, of the pedicels bear perfect spikelets.

2. **Sorghastrum fuscescens** (Pilger) Clayton, in Kew Bull. 30(3): 509 (1975). Type: Tanzania, Njombe District, Msima, *Schlieben* 1010 (K).

Miscanthidium fuscescens Pilger, in Notizdbl. Bot. Bart. Berlin II: 806 (1933).

Tufted perennial of up to 2 m. tall. Culm nodes shortly hairy. Leaf blades linear, 10-60 cm. long, 2-7 mm. wide, densely and coarsely pubescent; leaf sheaths also pubescent; ligule a short unfringed membrane.

Inflorescence a panicle of about 20-30 cm. long; the internodes of the main inflorescence axis pilose in the upper third, the rest glabrous, the joints pilose; racemes loose, 3-10 cm. long, with 3-15 spikelet pairs; raceme peduncles pilose on the upper third of their length; raceme internodes and pedicels pilose along their whole lengths; both pedicellate and sessile spikelets alike with a developed brown awn. Sessile spikelet 6 mm. long, lanceolate; lower glume coriaceous, pilose on the back, lanceolate, 5.5 mm. long, brown; upper glume keeled in the middle, pilose on the keel only, the rest of the body glabrous, slightly longer than the lower, 6 mm. long, ciliate on the margins. Florets 2: lower floret empty, lemma ovate, ciliate on the margins; upper floret bisexual, lemma bilobed, ciliate on the margins, awned; awn 25 mm. long, bigeniculate, glabrous; lodicules 2, opaque, fleshy; epaleate; callus 1 mm. long, rounded with short hair; anthers 3, 4 mm. long; ovary oblong. Pedicellate spikelet similar to the sessile, also with a bisexual upper floret; glumes coriaceous; anthers 2 or 3, 4 mm. long; pedicels pilose, some barren while others bear the spikelet.

Zambia. N: Mporokoso District, near Muzombwe, western side of Mweru-wa-Ntipa, altitude 3500 ft., 15.iv.1961, *Phipps & Vesey-Fitzgerald* 3218 (BM); Abercorn District, Kawimbe, altitude 5600 ft., 26.iii.1959, *Webster* A239 (K). **Malawi**. C: Dedza, Linthipe river, 10.iii.1951, *Jackson* 426 (K).

East and central Africa. Grassy hillsides and lake margins.

Note: Many, if not most, of the pedicels bear perfect spikelets. This species together with *S. pogonostachyum* differ with other members of *Sorghastrum* in this respect, but otherwise conform in most other characters.

3. **Sorghastrum incompletum** (Presl.) Nash var. **bipennatum** (Hackel) P. D. Davila, Systematic revision of the genus *Sorghastrum* (1988). Type: Sudan, Seriba Ghattas, *Schweinfurth* 2486 (K).

Andropogon bipennatus Hackel, Androp. Nov. Fl. 68 (8): 142 (1883).

Sorghum bipennatum (Hackel) Kuntze, Re. Gen. Pl. 2: 791 (1891), based on *Andropogon bipennatus* Hackel.

Sorghum bipennatum (Hackel) Stapf, Fl. Top. Afr. IX: 144 (1917), based on *Andropogon bipennatus* Hackel.

Sorghastrum bipennatum (Hackel) Pilger, in Notizdbl. Bot. Gart. Berlin XIV: 96 (1938).

A weak annual up to 1.5 m. tall (rarely more than 2 m.), often decumbent and rooting at the nodes below and with short stilt roots. Culms unbranched; culm nodes with short shiny hairs. Leaf blades up to 30 cm. long, linear-lanceolate, 3-10 mm. wide; leaf sheaths striate; ligule a tough membrane.

Inflorescence a loose, narrowly lanceolate panicle; raceme peduncles capillary, glabrous; racemes reduced to a single sessile spikelet, always accompanied by 2 barren pedicels; spikelets golden in colour, narrowly ovate, 4-5.5 mm. long, with a rounded base; lower glume coriaceous, dark brown, ovate, pilose with white hairs on the back, 5.5 mm. long; upper glume smooth on the back, also dark brown, boat-shaped. Florets 2: lower floret empty, lemma hyaline, ciliate along the margins; upper floret bisexual, lemma entire, awned; awn 40 mm. long, smooth, scabrid along the spiral, bigeniculate; palea single-nerved, small; lodicules 2, fleshy; anthers not seen; ovary ovate. Pedicellate spikelet absent; pedicels 2, 4 mm. long, barren, pilose with white hairs.

Zambia. C: Luangwa valley, Mfuwe Camp, altitude 2000 ft., 01.iv.1966, *Astle* 4765 (K). E: Chipata District (no exact location given), 17.iii.1970, *Abel* 182 (SRGH). **Zimbabwe**. N: Gokwe District (no exact location given), 15.iii.1984, *Mahlangu* 975 (SRGH, K). **Malawi**. C: Dedza District, Mua-Livulezi forest, 09.iv.1964, *Adlard* 607 (SRGH); Lilongwe District, Kampini, 17.iv.1950, *Jackson* 761 (MAL). S: Zomba, Naisi road, altitude 3500 ft., 14.v.1949, *Wiehe* N/106 (K). **Mozambique**. N: Malema District, 09.iv.1962, *Lemos & Marrime* 330 (PRE, K); Cabo Delgado Province: Montepuez area, 21.iv.1984, *Timberlake* 3408 (SRGH); Montepuez, 09.iv.1964, *Torre & Paiva* 11.833 (K).

African variety of *Sorghastrum incompletum*: tropical areas of Africa; Sudano-Zambesian and Guineo-Congo regions. Wooded grasslands.

4. **Sorghastrum friesii** (Pilg.) Pilg., Notizdbl. Bot. Gart. Berlin XIV: 96 (1938). Type locality, Zimbabwe.

> *Andropogon friesii* Pilger, in R. E. Fries, Erg. Schwed. Rhod.-Kongo Exped. 1911-1912 I: 195 (1916).
>
> *Sorghum micratherum* Stapf, in Prain, Flor. Trop. Afr. 9: 142 (1917), based on *Andropogon nutans* var. *angolense* Rendle, Cat. Afr. Pl. Welw. 2(1): 152 (1899).
>
> *Sorghum friesii* (Pilger) Hubbard, in Kew Bull. Misc. Inf.: 109 (1934), based on *Andropogon friesii* Pilger.

Tufted, shortly rhizomatous perennial. Culms up to 120 cm. tall, often rooting from the lower nodes; culm nodes many (crowded) in the lower part, with inconspicuous velvety hairs; culm internodes terete, hollow. Leaf blades glabrous, to 20 cm. long and 2-6 mm. wide, linear to linear-lanceolate, usually reflexed, leaf base expanded; leaf sheaths non-auriculate, glabrous; ligule an unfringed membrane, 0.5-1.5 mm. long.

Inflorescence a loose open panicle; primary branches divided; raceme peduncles glabrous, sometimes hairy towards the apex; racemes (2-)4-7-jointed; rachis internodes and pedicels hairy. Sessile spikelet 5-7(-8) mm. long, lanceolate; callus obtuse, bearded; glumes papery; lower glume hirsute on the back, slightly depressed longitudinally; upper glume glabrous, boat-shaped. Florets 2: lower floret represented by a hyaline lemma, lemma ovate, 5 mm. long, finely 2-nerved, ciliate on the upper margins, apex emarginate; upper floret bisexual, lemma bilobed, 4 mm. long, lobes glabrous, awned; awn 3-8(-10) mm. long, straight, glabrous; epaleate; lodicules 2, tiny, fleshy, glabrous; anthers 3, 4-5 mm. long; ovary oblong; pedicel 5 mm. long, shorter than the sessile spikelet, hairy, curved towards the base.

Botswana. N: Ngamiland, Boro flood plain, altitude 940 m., *Biggs* M517 (SRGH); 11km south of Gumare on road to Nokaneng, 18.iii.1976, *Ellis* 2680 (K); Boro river at Buffalo fence north of Maun, altitude 920 m., 28.ii.1987, *Long & Rae* 464 (E); Lediba at Matsaudi aga Mmatalelo Island, 30.iii.1973, *Smith* 503 (K); Floodplain near Kwara Bochai river, 02.vi.1973, *Smith* 562 (E); Xudum Drainage, Okavango, altitude 3300 ft., 15.iii.1961, *Vesey-Fitzgerald* 3241 (BM); Okavango river, 19 km. north of Shakawe on Botswana (Bechuanaland) border, 16.iii.1965, *Wild & Drummond* 7091 (BM); Kwando, James Camp, 18°22'S 23°32'E, 11.iv.1975, *Williamson* 16 (K). **Zambia.** N: Abercorn District, Saisi river (near Jericho), 27.ii.1958, *Vesey-Fitzgerald* 1547 (K). C: Mushwishi Agricultural Station, Broken Hill, altitude 3800 ft., 08.xii.1953, *Hinds* 175 (K); roadside at Munshiwemba, 17.i.1942, *Stohr* 744 (PRE). **Zimbabwe.** N: Gokwe District, about ½ mile north of Gokwe, 11.ii.1963, *Bingham* 484 (SRGH); Sipolilo, Nyamunyeche Estate, Karoi vlei, 07.ii.1979, *Nyariri* 673 (PRE). W: Shangani, Gwampa vlei at Tunke pan, Gwampa Forest Reserve, altitude 3000 ft., ii.1956, *Goldsmith* 31/56 (K); Matobo District, Mtsheleli Dam, altitude 4400 ft., 20.ii.1965, *Simon* 160 (BM). C: Gwelo District, G.T.C. sand, altitude 4600 ft., 10.iii.1967, *Biegel* 1989 (BM). S: Victoria District, 30.iii.1973, *Chiparawasha* 665 (K).

A southern African species. Typically favours wet areas such as swamps, road drains and stream banks. Often on poor sandy soils.

5. **Sorghastrum stipoides** (Kunth) Nash, in N. Amer. Fl. 17: 129 (1912).-Clayton & Renvoize, in Polhill, Fl. Trop. E. Afr. Gramineae Part 3: 732, fig. 169 (1982). Type: Colombia, Popaya to Almaguer, *Humboldt & Bonpland* (P, K).

> *Andropogon stipoides* Kunth, in H.B.K., Nov. Gen. Sp. 1: 189 (1816).
>
> *Andropogon trichopus* Stapf, in Kew Bull. 1897: 287 (1897).

Sorghum trichopus (Stapf) Stapf, in Fl. Trop. Afr. 9: 141 (1917).

Sorghum rigidifolium Stapf, in Fl. Trop. Afr. 9: 143 (1917).

Sorghastrum trichopus (Stapf) Pilg., in Engl. & Prantl, Pflanzenfam., edn 2, 14e: 142 (1940); Clayton, in Hepper, Fl. West Trop. Afr., edn2, 3: 468 (1972).

Sorghastrum rigidifolium (Stapf) Chippindall & Pole Evans, in Mem. Bot. Surv. S. Afr. 22: 247 (1948); Chippindall, in Meredith, Grasses and pastures of South Africa: 468 (1955).

A robust tufted perennial up to 1.5 m. tall with a hard creeping rhizome. Culms erect, usually unbranched, the internodes glabrous, nodes with a ring of inconspicuous adpressed white hairs. Leaf blades usually glabrous, 15-45 cm. long and 3-6 mm. wide, usually inrolled, rigid and conspicuously narrowed towards the base; leaf sheaths auriculate; ligule an unfringed membrane, 1.5-4 mm. long.

Inflorescence a linear-lanceolate panicle, about 20 cm. long, primary branches subverticillate, with capillary peduncles; racemes 1-4-jointed; rachis internodes violet-hirsute. Spikelets all alike, lanceolate, 4-7(-8) mm. long, the laterals each accompanied by a single densely violet-hirsute pedicel, the terminal on each raceme by two such pedicels; callus rounded, hirsute; lower glume coriaceous, tawny, green-nerved, pale violet-hirsute, broadly convex across the back, emarginate; upper glume about the same length as the lower glume, paler, glabrous proximally, shortly hirsute distally, emarginate. Florets 2: lower floret reduced a hyaline lemma; upper floret bisexual, with a linear bilobed lemma, ciliate on the margins; awn geniculate, flattened distally, 8-16 mm. long, glabrous; palea hyaline, minute; lodicules 2, fleshy, glabrous; anthers 3; caryopsis oblong.

Zambia. N: Mbala District, Uninji pans, altitude 5000 ft., 16.v.1968, *Sanane s.n.* (K); wet pasture near Lunzuo river bridge, 20 miles from Abercorn, altitude 5000 ft., 5.iv.1959, *Webster* A283 (K). **Malawi**. N: Karonga, Mwemtete Dambo, 26.vi.1951, *Jackson* 552 (K). C: Nkhotakota District, Katimbira village, T.A. Kanyenda, 13.v.1986, *Patel & Kwatha* 3194 (MAL). S: Zomba, near Tongani, 20.iv.1950, *BW* N/492 (MAL); Mposa Dambo, 13.v.1952, *Jackson* 814 (K). **Mozambique**. MS: Beira District, Cheringoma Coastal Area, Zuni Drainage, 5 km. west of Nyamaruza Camp, v.1973, *Tinley* 2842 (K). M: Sul do Save, Maputo, 20.ii.1952, *Mrye & Carvalho* 1148 (K); Mahotas, Marracuene, xii.1945, *Pimenta* 52565 (PRE, SRGH).

Tropical America and Tropical Africa. Low lying areas subject to flooding.

3. **Sorghum** Moench, Meth.: 207 (1794) nom conserv; Hubbard, in Hook. Ic. Pl. 34: t 3364 (1938); Garber, in Univ. California Publ. Bot. 23: 283-361 (1950); Snowden, in J. Linn. Soc. Bot. 55: 191-260 (1955); Celarier, in Cytologia 23: 395-418 (1959); Ivanyukovich & Doronina, in Trudy Prikl. Bot. Genet. Selek. 69: 18-27 (1980). Type species: *Sorghum bicolor* (L.) Moench.

Blumenchia Koel., Decs. Gram.: 28 (1802).

Sarga Ewart & White, in Proc. Roy. Soc. Victoria 23: 296 (1911).

Annuals or perennials, tufted or sometimes rhizomatous, mostly robust. Inflorescence a large panicle, its primary branches simple or subdivided, bearing short dense racemes with hairy internodes. Sessile spikelet dorsally compressed; callus obtuse or pungent; lower glume cartilaginous, convex, rounded on the flanks but becoming 2-keeled near the tip, usually hairy; upper lemma awned or awnless; lodicules ciliate. Pedicellate spikelet male or neuter, or reduced to a lower glume.

Species ± 20.

Nodes glabrous or pubescent.

Racemes tough or tardily disarticulating; grain large, commonly exposed by the gaping glume; annuals; cultivated. 1. **bicolor**

Racemes fragile; grain enclosed by the glumes; perennials or annuals; weeds or wild.

Perennial with abundant creeping rhizomes; sessile spikelet epaleate; lodicules ciliate; weed. 2. **halepense**

Annual; palea 2 mm. long; lodicules glabrous; wild. 3. **arundinaceum**

Nodes bearded.

Racemes 3-7-jointed; spikelets variously coloured; sessile spikelet 5-7 mm. long; callus short and blunt; awn 25-40 mm. long, glabrous. 4. **versicolor**

Sorghum is the only genus of the *Sorghinae* for which an extensive infra-generic classification exists. The most comprehensive subgeneric treatment of the genus was initiated by Garber (in Univ. Cal. Pub. Bot. 23: 283-362 (1950)) who recognised six subgenera. His subgenus *Sorghastrum* has now been accorded a generic status, and therefore only five subgenera now remain in the genus and these are:

(i) *(Eu)Sorghum* (Stapf) Garber - Old World, e.g. *S. bicolor, S. halepense* (introduced to the Americas), etc.;

(ii) *Chaetosorghum* Garber - Australian; monotypic, e.g. *S. macrospermum*;

(iii*)* *Heterosorghum* Garber - Australian; monotypic, e.g. *S. laxiflorum*;

(iv) *Parasorghum* (Snowden) Garber - Old World; e.g. *S. nitidum, S. versicolor*, etc.;

(v) *Stiposorghum* Garber - Australian; *S. intrans, S. plumosum,* etc.

The genus is represented by species of subgenera *(Eu)Sorghum* and *Parasorghum* in FZ. As is often the case with genera which include domesticated taxa, the subgenus *(Eu)Sorghum* contains a lot of nomenclatural inconsistencies, which has resulted in the existence of an extensive synonymy. The subgenus consists of cultivated grain sorghums, a complex of closely related annual taxa from Africa, and a complex of perennial taxa from Southern Europe and Asia. The subgenus is usually divided into two groups, the *Halepensia* complex, and the *Arundinacea* complex (De Wet, in Amer. J. Bot. 65(4): 477-484 (1978)). The subgenus is now considered to consist of three species: two rhizomatous taxa, *S. halepense*, and *S. propinquin* (both in the *Halepensia*), and the large and complex *S. bicolor* to include all annual wild, weedy and cultivated taxa (in the *Arundinacea*). Snowden (The cultivated races of sorghum (1936)) recognised 24 'species' which are all now considered variants of *S. bicolor.*

The grain sorghums are artifacts of human selection and cultivation (De Wet & Huckabay, in Evolution 21: 787-802 (1967); De Wet, Harlan & Price, in Amer. J. Bot. 57(6): 704 (1970)), and the different cultivated kinds deserve at most racial status (Harlan & De Wet, in Crop Science 12: 172-176 (1972)). The species *S. bicolor* has three subspecies:

(a) *S. bicolor* subsp. *bicolor* (grain sorghums). Based on *S. bicolor* (L.) Moench. A detailed comparative morphological study of grain sorghums led Harlan & De Wet (1972) to recognise five basic races, and ten hybrid races that combine characteristics of any two or more basic races. The five basic races are Bicolor, Guinea, Caudatum, Kaffir, and Durra.

(b) *S. bicolor* subsp. *arundinaceum.* Based on *S. arundinaceum* (Desv.) Stapf. This subspecies incorporates all wild sorghums associated with the grain sorghums. It therefore represents the 'wild' component of *S. bicolor.* De Wet (in Amer. J. Bot. 65(4): 477-484 (1978)) recognises four races in this subspecies: Aethiopicum, Virgatum, Arundinaceum and Verticilliflorum.

(c) *S. bicolor* subsp. *drummondii.* Based on *S. drummondii* (Steud.) Millsp. et Chase. This subspecies incorporates derivatives from hybridisation between subspecies *bicolor* and *arundinaceum.* It occurs as a weed in Africa wherever cultivated grain sorghums and their closest wild relatives are sympatric (De Wet, in Amer. J. Bot. 65(4): 477-484 (1978)). This species is extremely variable, a variability undoubtedly enhanced by human selection of grain races, which then introgress with the wild species (Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 726 (1982)).

The races of *Sorghum bicolor* grade morphologically and ecologically so completely into one another that they do not deserve formal taxonomic status.

In the present treatment of the genus, only *S. bicolor* subsp. *arundinaceum* (as *S. arundinaceum*) has been investigated. There is no doubt that *S. bicolor* subsp. *bicolor* occurs in FZ, but no suitable material was seen to enable a thorough investigation of this subspecies.

2. **Sorghum halepense** (L.) Pers., Syn. Pl. 1: 101 (1805).-Bor, Flora of Assam 5: 352 (1940).-Sturgeon, A revised list of the grasses of Southern Rhodesia Part IV: 6 (1954).-Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 460 (1955).-Clayton, in Hepper (ed.), Fl. West Trop. Afr. ed.2(3): 467 (1972).-Gibbs Russell et al, Grasses of Southern Africa: 320 (1990).-Cope & Hosni, A key to Egyptian grasses: 54 (1991). Type locality, Syria.

Holcus halepensis L., Sp. Pl. ed. 1: 1047 (1753).

Andropogon arundinaceus Scop., Fl. Cam. ed. 2(ii): 274 (1772).

Milium halepense (L.) Cav., Descr. Pl.: 306 (1802).

Blumenbachia halepensis (L.) Koel., Descr. Gram.: 29 (1802).

Andropogon halepensis (L.) Brot., Fl. Lusit. I: 89 (1804).

Andropogon Sorghum (L.) Brot. subsp. *halepensis* (L.) Hack. var. *halepensis* (L.) Hack. subvar. *genuinus* Hack., in DC., Monogr. Phan. 6: 502 (1889).

Andropogon halepensis (L.) Brot. var. *genuinus* (Hack.) Stapf, in Hook., Fl. Brit. Ind. 7: 183 (1896).

Andropogon halepensis (L.) Brot. *typicus* Asch. et Graebn., Syn. Mitteleur. Fl. II Abt. I: 47 (1898).

Sorghum miliaceum (Roxb.) Snowden, in J. Linn. Soc. (Bot.) 55: 205 (1955).

Sorghum miliaceum var. *parvispiculum* Snowden, in J. Linn. Soc. (Bot.) 55: 209 (1955).

Perennial with abundant creeping rhizomes. Culms slender to robust, mostly simple but sometimes branched, 0.5-3.5 m. tall, up to 2 cm. wide; culm nodes exposed, glabrous. Leaf blades linear, narrowed to a point at the apex, 20-90 cm. long, 0.5-4 cm. wide; leaf sheaths glabrous; ligule an unfringed membrane.

Inflorescence a panicle; lower primary branches naked for about 2-5 cm., glabrous; racemes 1 to 5-jointed; rachis internodes and pedicels slender, densely ciliate with whitish hairs, hairs up to 1 mm. long. Sessile spikelet elliptic, 4-6.5 mm. long, almost glabrous to densely hairy, awned or awnless; glumes coriaceous; lower glume 2-keeled, keel wings ending in minute teeth, forming with the pointed apex a 3-toothed tip, hairy on the back, dorsally compressed, broadly lanceolate; upper glume sparsely hairy on the back, boat-shaped; callus short and blunt, shortly bearded. Florets 2: lower floret empty, lemma lanceolate, ciliate; upper floret bisexual, lemma bilobed, ciliate, awned or awnless; awn (when present) 12 mm. long, glabrous, untwisted; epaleate; lodicules 2, fleshy, ciliate on the apical corners; anthers not seen; ovary ovate, small. Pedicellate spikelet male, narrower than the sessile, 5.5 mm. long; glumes papery; lower glume lanceolate, ciliate on the lateral keels, glabrous, 5.5 mm. long; upper glume sharply carinate, glabrous, 5.5 mm. long; lower lemma broadly lanceolate, ciliate on the margins, with a truncate apex, 4 mm. long; upper lemma ovate, ciliate on margins, 3 mm. long; lodicules 2, fleshy, glabrous; anthers 3, 2.5 mm. long; pedicels hairy on the margins.

Zimbabwe. N: Lomagundi District, altitude 3500 ft., 8.vii.1921, NO. 3149 (K). W: Insiza, altitude 4500 ft., iii.1920, *Capstick* 2328 (K); Wankie District, Victoria Falls National Park, pathside in *Hyparrhenia* zone near Chimunzi, altitude 2800 ft., 21.iv.1970, *Simon & Hill* 2129 (K). C: Harare (Salisbury) District, Harare (Salisbury) Experiment Station, 5.vii.1921, *Mundy* 50b (K); cultivated at Department of Agriculture Experimental Station, altitude 4800 ft., 28.xi.1931, Trapuds s.n. (K). E: Chipinga District, East Sabi, upper Rupembe, altitude 1300 ft., 22.I.1957, *Phipps* 86 (K). **Malawi**. S: Port Herald District, between Muone & Shire river, altitude 260 ft., 20.iii.1960, *Phipps* 2586 (K). **Mozambique**. T: Boruma (Zambezi), v.1891, *Menyharth* 1046 (K).

Tropics of Old and New Worlds. In moist areas on river banks, in clay soils and wet sandy soils.

Cultivated fodder.

Note: The distinguishing features of this species are the abundant slender wide-spreading rhizomes, narrow leaf blades, and the somewhat small contracted panicles. A frequent variation of the spikelets is the presence or absence of an awn to the upper lemma. The majority of the plants have awned spikelets, but sometimes in specimens of the same gathering and number, the spikelets of one panicle are awned and those of the other awnless. It is also not uncommon to find most of the spikelets in a panicle awnless but accompanied by a few that are distinctly awned. It is on this basis that some authors have recognised two forms or varieties, *S. halepense* subsp. *halepense* (the typical awned form), and *S. halepense* subsp. *muticus* (the awnless form).

3. **Sorghum arundinaceum** (Desv.) Stapf, in Prain, Fl. Trop. Afr. IX: 114 (1917).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 6 (1954).-Clayton, in Hepper (ed.), Fl. West Trop. Afr. ed.2(3): 467 (1972).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 727 (1982).-Lowe, Flora of Nigeria, Grasses: 277 (1989).-Cope & Hosni, A key to Egyptian grasses: 54 (1991). Type: Ghana, *Isert* (B).

Andropogon arundinaceus Willd, Sp. Pl. 4: 906 (1805).

Rhaphis arundinacea Desv., Opusc.: 69 (1831).

Andropogon sorghum var. *effusus* Hack., in DC., Monogr. Phan. 6: 503 (1889).

Andropogon sorghum effusus Piper, in Proc. Biol. Soc. Wash. 28: 35 (1915).

Sorghum verticilliflorum (Steud.) Stapf, in Prain, Flor. Trop. Afr. IX: 114 (1917).

Sorghum stapfii (Hook.f.) Fischer, in Gamble, F.P.I. 10: 1735 (1934).

Sorghum pugionifolium Snowden, in J. Linn. Soc. (Bot.) 5: 240 (1955).

Short-lived perennial or an annual. Culms 0.3-4 m. tall, often robust, branched; culm nodes mostly glabrous, sometimes pubescent. Leaf blades variable, often large, 5-75 cm. long, 5-7 mm. wide, flat, broadly lanceolate, glabrous on both surfaces, with a prominent whitish midrib, tapering to a fine point; leaf sheaths glabrous, not keeled; leaf ligule a fringed membrane, edged with a fringe of fine hairs and hairy on the back.

Inflorescence a broadly spreading panicle, 10-60 cm. long; main inflorescence axis angular, glabrous; primary branches divided, pubescent at the nodes; raceme peduncles glabrous; racemes 2-7-jointed; rachis internodes and pedicels hairy. Sessile spikelet (4-)7(-9) mm. long, lanceolate to narrowly ovate; glumes coriaceous; lower glume white pubescent, sometimes tomentose or fulvously pubescent, slightly depressed longitudinally on the back; upper glume glabrescent or with sparse hairs on the back. Florets 2: lower floret empty, lemma lanceolate, 5.5 mm. long, ciliate on the margins; upper floret bisexual, lemma deeply lobed, ciliate on the lobes and margins, 3 mm. long; awn 20 mm. long, glabrous; palea present, 2 mm. long, ciliate on margins and apex; lodicules 2, fleshy, glabrous; no anthers seen; caryopsis obovate, 3 mm. long. Pedicellate spikelet neuter, linear to lanceolate, 6.5 mm.

long; glumes papery; lower glume glabrous; upper slightly shorter than the lower, glabrous; lower lemma glabrous, with a truncate apex; pedicel hairy.

Botswana. N: Tati river, south-east of Francistown, altitude 980 m., 04.iii.1985, *Long* 12242 (E); Chadum valley, South-west African border, 16 km. west of Knau Knau, 14.iii.1965, *Wild & Drummond* 7024 (BM, SRGH). **Zambia**. N: Mpika District, Mfuwe, 26.iv.1965, *Mitchell* 2683 (BM, SRGH); 04.i.1963, *Rensburg* 1161 (WAG). **Zimbabwe**. N: Urungwe District, Mana pools floodplain, 31.iii.1981, *Dunham* 73 (SRGH). C: Harare (Salisbury): Crowborough Sewage farm, Mufakose township, 06.ii.1974, *Lenton s.n.* (WAG); Harare (Salisbury) Research Station, cultivated, 22.ii.1974, *Simon* 2386 (PRE). **Malawi**. C: Nkhota Kota, altitude 490 m., 17.vi.1970, *Brummitt* 11519 (MAL); Dedza District, Masasa controlled area, 22.v.1989, *Chikuni, Patel & Nachamba* 79 (MAL); Salima District, Lifidzi Breeding Centre, 21.v.1985, *Patel & Nachamba* 2192 (MAL); Salima District, Chipoka, 25.v.1972, *Salubeni* 1811 (MAL). S: Tanga District, Palombe river, 06.v.1952, *Jackson* 802 (MAL); Njanje District, Mwanalundu Hills, 11.i.1990, *Salubeni & Nachamba* 5615 (MAL). **Mozambique**. Z: Namagoa, Mocuba, (no date), *Faulkner* 37 (PRE). T: Baroma Province, Msusa, Zambesi valley, 25.vii.1950, *Chase* 2805 (BM); Tete, Cabora Bassa, altitude 215-220 m., 09.v.1972, *Pereira & Correia* 2469 (WAG). GI: Gaza Province, Chibute, Miniquenique, Estação Experimental do C.I.C.A., 13.vi.1960, *Lemos & Balsinhas* 98 (PRE). M: Maputo Province, Umbeluzi State farm, near Boane, 19.ii.1985, *Timberlake* 3386 (SRGH).

Throughout Africa, extending eastwards to Australia. Swampy soils, streamsides, disturbed places and old farmland.

Note: This species is assumed to be the wild progenitor of the grain sorghum, *S. bicolor*. The variability in the species can be attributed to human selection of grain races, and introgression with the wild species.

4. **Sorghum versicolor** Anderss., in Peters, Reise Mossamb.: 563 (1863).-Stapf, Fl. Trop. Afr. IX: 138 (1917).-Sturgeon, A revised list of the grasses of Southern Rhodesia Part IV: 6 (1954).-Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 459 (1955).-Bogdan, A revised list of Kenya grasses: 55 (1958).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 60 (1958).-Napper, Grasses of Tanganyika: 96 (1965).-Hood, A guide to the grasses of Zambia: 58 (1967).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 729 (1982).-Gibbs Russell et al, Grasses of Southern Africa: 302 (1990). Type: Mozambique, Boror, *Peters* (whereabouts uncertain).

Andropogon serratus var. *versicolor* Hack., in DC., Monogr. Phan. 6: 522 (1889).

Sorghum purpureo-sericeum (A. Rich.) Aschers. & Shweinf. var. *trinervatum* Chiov., Fl. Somal 2: 439 (1932).

An annual of up to 2.5 m. tall. Culms slender, with a very conspicuous ring of long, silky white hairs spreading round the culm from each node. Leaf blades hairy on both surfaces, occasionally glabrous on the upper surface, 10-30 cm. long, up to 15 mm. wide; leaf sheaths glabrous, bearded with long cilia at the mouth; ligule an unfringed membrane, to 3 mm. long.

Inflorescence an open panicle to 25 cm. long; branches simple; main inflorescence axis glabrous, smooth, bearded at the nodes; raceme peduncles glabrous, smooth, with prominent pulvini; racemes 3-7-jointed; rachis internodes and pedicels long hairy. Sessile spikelet elliptic-oblong, (5-)5.5(-7) mm. long; lower glume coriaceous, glossy, reddish brown to black, pilose on the back, bearded from the callus with pallid to reddish hairs; upper glume also coriaceous and same colour as lower, tapers to a fine apex, pilose above the middle, glabrous and shiny below. Florets 2: lower floret empty, lemma 4 mm. long, ciliate on the margins; upper floret bisexual, lemma 3 mm. long, deeply lobed, ciliate on the lobes and margins, awned; epaleate; awn (25-)40 mm. long, twisted, scabrid along the spiral; lodicules 2, fleshy, densely ciliate from the apical corners; anthers 3, 2.5 mm. long; ovary oblong. Pedicellate spikelet neuter, smaller than sessile [(3-)4(-5) mm. long], lanceolate, greenish; lower glume membranous, hirsute on the back; upper glume also membranous, glabrous to scabrid, enclosed by the lower; pedicel hairy.

Botswana. N: 6 km. south-east of Tsau, 18.iii.1965, *Wild & Drummond* 7132 (BM, SRGH). **Zambia**. C: Mumbwa District, Sala Reserve, Cheta river, 26.iii.1963, *Vesey-Fitzgerald* 4019 (SRGH). S: Kalomo District, Siantambo, 07.ii.1963, *Mitchell* 17/63 (BM). **Zimbabwe**. W: Bubi District, Gwampa Forest Reserve, ii.1956, *Goldsmith* 6/56 (PRE). C: Gwelo District, Base, Gwelo kop., altitude 4700 ft., 05.iii.1967, *Biegel* 1959 (BM). E: Chimanimani (Melsetter) District: Mutambara Tribal Trust Land on main road near Lisnacloon farm, altitude 1000 m., 26.iii.1969, *Crook* 850 (PRE); Sabi Valley, Nyanyadzi, 26.iii.1956, *Whellan* 1009 (WAG). S: Victoria District: Fort Victoria, Victoria Reserve Zone, 19.iii.1956, *Cleghorn* 185 (BM); Fort Victoria area, 02.i.1949, *Robinson* 336 (SRGH). **Malawi**. N: Northern Province, Nzimba District, 25 miles south of Rumphi on M1, altitude 4000 ft., 04.v.1974, *Pawek* 8571 (PRE, WAG); Zomba District, near Macheleni hill, Tembenu village, 05.iii.1978, *Seyani & Patel* 800 (MAL). **Mozambique**. N: Malema, Mutuáli, Estação Experimental do Instituto do Algodão, 05.iv.1962, *Lemos & Marrime* 318 (PRE). T: Tete, Cabora Bassa, altitude 230-330 m., 02.v.1972, *Pereira & Correia* 2328 (WAG). M: Maputo (Laurenço Marques), Macaéne-Magude, 22.i.1948, *Torre* 7179 (BM).

Eastern, central and southern Africa. In deciduous bushland or wooded grassland, commonly on waterlogged soils or black clays.

Note: This species and *S. purpureo-sericeum* (A. Rich.) Aschers. & Schweinf, are so very similar that they may just represent a variation in one species. Differences between them mainly comes from their spikelet length (shorter in *S. versicolor)*, their apparent inability to hybridise (Garber, 1950), and their differing geographical distributions.

4. **Chrysopogon** Trin., Fund. Agrost.: 187 (1820); nom. conserv. Type species: *Chrysopogon gryllus* (L.) Trin.

Rhaphis Lour., Fl. Cochin.: 552 (1790).

Pollinia Spren., Pl. Pugill. 2: 10 (1815).

Centrophorum Trin., Fund. Agrost.: 106 (1822).

Trianthium Desv., Opusc.: 69 (1831).

Chalcelytrum Lunell, in Amer. Midl. Nat. 4: 212 (1915).

Tufted perennials; ligule a short membrane or a line of hairs. Inflorescence a panicle, its primary branches whorled, simple, each bearing a raceme reduced to a triplet of spikelets (rarely racemes with 2 sessile spikelets, e.g. *C. sylvaticus*); spikelets in triplets, or in triplets and pairs; the triplet consists of a sessile spikelet and two pedicellate spikelets; pedicels linear filiform, never longitudinally grooved. Sessile spikelet laterally compressed, its callus elongated, acute to pungent; glumes subequal, unequally awned or aristate or awnless; lower glume cartilaginous to coriaceous, often spinulose on the keels and muricate on the back; upper lemma entire or bilobed, awned; awn glabrous to pubescent and usually prominent. Pedicellate spikelet male or neuter; glumes awned or aristate or awnless.

Species 26.

1. **Chrysopogon serrulatus** Trin., in Mem. Acad. Sci. Petersb. Ser. 6(2): 318 (1832).-Bor, Grasses Burma Ceylon India & Pakistan: 118 (1960).-Clayton & Renvoize, in Polhill (ed.), Flor. Trop. East

Africa: 736 (1982).-Gibbs Russell et al, Grasses of Southern Africa: 85 (1991). Type: Nepal, *Wallich* (LE).

Andropogon trinii Steud., Syn. Pl. Glum. 1: 395 (1854).

Andropogon ciliolatus Steud., Syn. Pl. Glum. 1: 396 (1854).

Andropogon caerulens Steud., Syn. Pl. Glum. 1: 395 (1854).

Chrysopogon ciliolatus (Steud.) Boiss., Fl. Orient. 5: 458 (1884).

Andropogon trinii Steud. var. *increscens* Hack., in DC., Monogr. Phan. 6: 558 (1889).

Andropogon monticola Schult. var. *trinii* Hook.f., Fl. Brit. Ind. 7: 193 (1896).

Chrysopogon montanus Trin. var. *serrulatus* (Trin.) Stapf, in Prain, Fl. Trop. Afr. IX: 160 (1917).

Chrysopogon montanus Trin var. *tremulus* (Hack.) Stapf, in Prain, Flora of Tropical Africa IX: 160 (1917).

Chrysopogon fulvus (Spreng.) Chiov. var. *tremulus* (Hack.) Chiov., Rac. Bot. Miss. Consol. Kenya: 325 (1935).

Chrysopogon fulvus (Spreng.) Chiov. var. *serrulatus* (Trin.) R. B. Stewart, in Brittonia 5: 446 (1945).

Perennial. Culms up to 150 cm. tall, sometimes robust. Leaf blades glabrous except in the ligule area where there are sparse tubercle-based hairs on the margins on both surfaces, linear-lanceolate, 2-10 mm. wide; leaf sheath glabrous, rarely hairy at the top; leaf ligule a ciliolate rim.

Inflorescence paniculate, up to 15 cm. long; consists of racemes with peduncles fulvously bearded at the tips. Sessile spikelet narrowly oblong, 6 mm. long; lower glume awnless, slightly hispid at the tip, 6 mm. long; upper glume with few white hairs on the back, with a glabrous awn about 12 mm. long, obscurely hispidulous. Florets 2: lower floret empty, lemma hyaline, single-nerved with sparsely ciliolate margins; upper floret bisexual, lemma hyaline, bilobed, awn 2.5 cm. long, slightly puberulous, ovary about 1 mm. long, completely enclosed by 2 fleshy lodicules, anthers 3, 3 mm. long. Pedicellate spikelet male or neuter, glumes awned; lower glume 6 mm. long with white short hairs on the back, awn 5 mm. long, hispidulous; upper glume glabrous, 6.5 mm. long, awn 2.5 mm. long, obscurely hispidulous, lemma hyaline, sparsely ciliolate on the margins; anthers 3, 3 mm. long; pedicel 2.5 mm. long, fulvously villous unilaterally.

Botswana. SE: Gaborone, Aedume Park, altitude 1050 m., 09.xi.1977, *Hansen* 3276 (K). **Zimbabwe**. N: Urungwe District, altitude 1700 ft., 16.x.1957, *Phipps* 797 (K). W: Nyamandhlovu District (no exact location), 21.ix.1956, *Plowes* 1880 (K). S: Nuanetsi District, Sengwe Tribal Trust Land, 15.xi.1973, *Cleghorn* 2910 (K); Gwanda District, Tuli Pasture Research Sub-Station, altitude 2500 ft., 5.i.1955, *Oates* 1742 (E).

Tropical Africa; Northwest India. Common in shallow sandy soils and rocky landscape.

Note: This species is very similar to *C. plumulosus* except that it has a longer callus (up to 1.5 mm. long), longer upper glume of sessile spikelet (4-7 mm. long) and the glabrous or obscurely hispidulous (not plumose) awns of the glumes of both the sessile and pedicellate spikelets. Also the upper lemma apex is bilobed in *C. serrulatus* and entire in *C. plumulosus.*

5. **Vetiveria** Bory, in Lem.-Lisanc., Bull. Sci. Soc. Philom: 42 (1822). Type species: *Vetiveria zizanioides* (L.) Nash.

Lernomandia Steud., in Flora 33: 229 (1850).

Mandelorna Steud., Syn. Pl. Glum. 1: 359 (1854).

Tufted perennials with tough rhizomes; lower leaf sheaths much compressed, flabellate-imbricate; conduplicate leaf blades that do not bend away from the culm at the collar region but just a lateral indentation marks the end of the sheath and the beginning of the blade; leaf sheaths keeled. Inflorescence a panicle, its primary branches whorled, simple or each bearing a raceme; racemes (2-)3 to many-jointed, pedunculate; spikelets paired, compressed laterally, differing in sex, one sessile, the other pedicellate; rachis internodes and pedicels slender and gradually thickened upwards. Sessile spikelet laterally compressed, its callus obtuse to pungent, often large and conical; lower glume papery to coriaceous, muticus, spinulose on the keels and muricate or mammilate on the back; upper glume aristate; upper lemma entire or bilobed, awned or awnless. Pedicellate spikelet male or neuter.

Species 10.

Sessile spikelet mucronate or awnless.	1. **zizanioides**
Sessile spikelet awned; awn 5 mm. long.	2. **nigritana**

1. **Vetiveria zizanioides** (L.) Nash, in Small, Fl. Southeast U. S.: 67 (1903).-Stapf, in Kew Bull. 1906: 346-349, 362 & in Prain, Flor. Trop. Africa IX: 157 (1917).-Sturgeon, A revised list of the grasses of Southern Rhodesia Part IV: 8 (1954).-Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 470 (1955).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 70 (1958).-Bor, Grasses Burma Ceylon India & Pakistan: 258 (1960).-Napper, Grasses of Tanganyika: 99 (1965).-Clayton, in Hepper (ed.), Flor. West Trop. Africa ed.2 (3), Gramineae: 470 (1972).-Lowe, The flora of Nigeria, Grasses: 291 (1989). Type: India, *Koenig* (LINN).

Phalaris zizanioides L., Mant. Pl. 2: 183 (1771).

Andropogon muricatus Retz., Obs. Bot. 3: 43 (1783).

Agrostis verticillata Lamk., Ecycl. Meth. Bot. 1: 59 (1783).

Anatherum muricatum (Retz.) P. Beauv., Ess. Agrost.: 150 (1812).

Vetiveria odoratissima Lem.-Lisanc., in Bull. Soc. Philom. (Paris): 43 (1822).

Vetiveria odorata Vivey, J. Pharm. 13: 501 (1827).

Andropogon festucoides J. S. Presl ex C. B. Presl, Rel. Haenk. 1: 340 (1830).

Vetiveria muricata (Retz.) Griseb., Fl. Brit. West Ind.: 560 (1864).

Vetiveria arundinacea Griseb., Fl. Brit. West. Ind.: 559 (1864).

Sorghum zizanioides (L.) O. Ktze., Rev. Gen. Pl. 2: 791 (1891).

Andropogon zizanioides (L.) Urban, Symb. Antill. 4: 79 (1903).

Holcus zizanioides (L.) O. Ktze. ex Stuck., in Ann. Mus. Nac. Buenos Aires 11: 48 (1904).

Anatherum zizanioides (L.) Hitchc. et Chase, in U.S. Natl. Herb. Contrib. 18: 285 (1917).

Perennial grass of up to or greater than 2 m. tall; culms erect, usually sheathed all along. Leaf blades linear, acute, up to 90 cm. long, 4-20 mm. wide, erect, rigid, firm or somewhat spongy, striate; leaf sheaths compressed, particularly the lower ones, sharply keeled, fan shaped, imbricate, very smooth; ligule a scarious rim.

Inflorescence a long oblong panicle of up to and over 30 cm. long, contracted; the main inflorescence axis stout, glabrous, smooth; whorls 6-10 with up to 20 pedunculate racemes; peduncles filiform, slightly scabrous; racemes very slender; rachis internodes about the same length as spikelets or slightly longer, glabrous; pedicels shorter than the sessile spikelets, glabrous. Sessile spikelet linear-lanceolate, variable in colour (yellowish, olive, violet brown, purplish); callus obtuse, 1 mm. long or less, glabrous; lower glume muricate on the back, spinulose on the keels; upper glume spinulose on the keel. Florets 2: lower floret empty, lemma as long as the glumes, acute, retrorsely ciliate; upper floret bisexual, lemma up to 3 mm. long, narrow, oblong-lanceolate, mucronate, glabrous; lodicules 2, fleshy, glabrous; anthers 3, 2-3 mm. long; ovary ovate, 3.5 mm. long. Pedicellate spikelet sparingly aculeolate or almost smooth, male; lower lemma same as for sessile spikelet; upper lemma acute, entire; anthers 3, 2.5 mm. long; pedicel glabrous.

Zimbabwe. N: Mazoe District, Makalanga, cultivated, 22.v.1950, *Pollitt* s.n. (K). E: Chipinga District, Newcastle Block, La Lucie Farm, introduced, cultivated, 19.iii.1981, *Nicoll* s.n. (K).

Southeast Asia to Tropical Africa; introduced to most parts of the world. Mostly in cultivated fields and basically in places associated with the function it is intended for, e.g., it might be grown as edging to roads. Principally used for thatching; not grazed except when young and tender. Its root is the scented *khas khas* which is used for *tattis* or grass screens which are kept wetted to cool rooms. Commercial oils are extracted from its roots and used in perfumery.

2. **Vetiveria nigritana** Stapf, in Prain, Fl. Trop. Afr. IX: 157 (1917).-Sturgeon, A revised list of the grasses of Southern Rhodesia Part IV: 8 (1954).-Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 469 (1955).-Napper, Grasses of Tanganyika: 99 (1965).-Hood, A guide to the grasses of Zambia: 58 (1967).-Clayton, in Hepper (ed.), Flor. West Trop. Africa ed.2 (3), Gramineae: 470 (1972).-Clayton, in Polhill (ed.), Flor. Trop. East Africa Gramineae (3): 739 (1982).-Lowe, The flora of Nigeria, Grasses: 291 (1989).-Gibbs Russell et al, Grasses of Southern Africa: 353 (1991). Type: Nigeria, Nun R., *Vogel* (K).

Andropogon nigritanus Benth., in Hook., Niger Fl.: 573 (1849).

Andropogon squarrosus var. *nigritanus* Hack., In DC., Monogr. Phan. 6: 544 (1889).

Mandelorna insignis Steud., Syn. Pl. Glum. 1: 359 (1854).

Vetiveria zizanioides (L.) Nash var. *nigritana* (Benth.) A. Camus, in Bull. Mus. Hist. Nat. Paris 25: 674 (1919).

Tufted perennial. Culms 1.5-3 m. tall, unbranched: upper culm nodes exposed, glabrous, lower ones hidden by leaf sheaths. Leaf blades narrow, up to 90 cm. long and 7 mm. wide, cauline; leaf sheaths sharply keeled; ligule a scarious rim.

Inflorescence a terminal panicle of whorled pedunculate racemes; racemes many-jointed; the main inflorescence axis and raceme peduncles minutely ciliolate towards the apex (upward facing cilia); whorls 8-10 and with up to 15 racemes; rachis internodes and pedicels gradually thickened upwards. Sessile spikelet: lower glume compressed laterally, coriaceous, spinulose on the back, narrowly linear-lanceolate, 7 mm. long; upper glume sharply keeled in the middle, spinulose along the keel, coriaceous to chartaceous, but with an inflexed margin, drawn to a short aristate tip, 7 mm. long. Florets 2: lower floret represented by a hyaline lemma, lemma ovate; upper floret bisexual, lemma hyaline, with a bilobed apex; awn 5 mm. long, slightly exserted from the glumes or enclosed, bristle-like, glabrous on the lower half (column) and minutely toothed on the bristle; lodicules 2, fleshy, glabrous; anthers not seen; ovary oblong-lanceolate. Pedicellate spikelet neuter, shorter than the sessile one; both glumes less coriaceous, and less spinulose; lower glume 5 mm. long, sparingly aculeolate along the keel towards the apex or almost smooth; upper glume smooth with flexible ciliate margins; lower lemma hyaline with ciliate margins; pedicel solid, glabrous, thickened upwards.

Botswana. N: Okavango river, Old Mohembo, 16 km. north of Shakawe on Botswana border, 19.iii.1965, *Wild & Drummond* 7074 (BM). **Zambia**. B: Mankoya District, near resthouse, Mankoya, 20.xi.1959, *Drummond & Cookson* 6644 (E, BM). C: Kafue District (no exact location), 09.ii.1963, *Van Rensberg* 1359 (BM). **Zimbabwe**. N: Gokwe District, Copper Queen N.R.A, near Morowa river, 21.xii.1963, *Bingham* 901b (BM). **Malawi**. S: Port Herald, Tengani, 28.xi.1950, *Jackson* 310 (MAL); Khonjeni Estate, Thyolo, altitude 2400 ft., 16.xii.1974, *Schwarz* 14 (MAL). **Mozambique**. T: Boroma Province, Ulere station, Zambezi river, 10.vii.1956, *Chase* 2671 (BM); Chitengo, 13 km. to Acampamento, 02.v.1978, *Diniz* 163 (WAG).

Tropical Africa. Occurs mainly on river banks, occasionally on roadsides and forested areas.

6. **Capillipedium** Stapf, in Prain, Fl. Trop. Afr. IX: 169 (1917). Type species: *Capillipedium parviflorum* (R. Br.) Stapf.

Filipedium Raiz. & Jain, in J. Bombay Nat. Hist. Soc. 49: 682 (1951).

Annuals or perennials; mostly rambling. Inflorescence a delicate, loose panicle, bearing short 1-5(-8)-jointed racemes at the ends of capillary primary and secondary branches; rachis internodes and pedicels finely filiform, with a translucent longitudinal groove. Sessile spikelet callus obtuse; lower glume cartilaginous, broadly convex to slightly concave, acute or obtuse; upper lemma hyaline base of the awn, entire; awn glabrous. Pedicellate spikelet male or neuter.

Species ± 14.

1. **Capillipedium parviflorum** (R. Br.) Stapf, in Prain, Fl. Trop. Afr. IX: 169 (1917).-Bor, Flora of Assam 5: 362 (1940).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 8 (1954).-Bogdan, A revised list of Kenya grasses: 56 (1958).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 32 (1958).-Bor, Grasses Burma Ceylon India & Pakistan: 112 (1960).-Napper, Grasses of Tanganyika: 99 (1965).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 718 (1982). Type: Australia, North Coast, *Brown* 6188 (BM!, K!).

Holcus parviflorus R. Br., Prodr.: 199 (1810).

Sorghum parviflorum Beauv., Agros: 132 (1812).

Anatherum parviflorum Spreng., Syst. 1: 290 (1825).

Holcus caerulescens Gaud., in Freycin. Voy. Bot.: 411 (1829).

Andropogon micranthus Kunth, Rev. Gram. I: 165 (1829); Steud., Syn. Pl. Glum. 1: 396 (1854); Hack., in DC., Monogr. Phan. 6: 488 (1889); Hook.f., Fl. Brit. Ind. VII: 178 (1896).

Andropogon alternans J. S. Presl., in C. B. Presl., Reliq. Haenk. 1: 342 (1830).

Rhaphis caerulescens Desv., Opusc.: 69 (1831).

Chrysopogon violascens Trin., in Mem. Ac. Petersb. 6 me ser. II: 319 (1832).

Andropogon quartianianus A. Rich., Tent. Fl. Abyss. II: 469 (1851).

Andropogon violascens Nees ex Steud., Syn. Pl. Glum. 1: 396 (1854).

Andropogon parvispicus Steud., Syn. Pl. Glum. 1: 397 (1854).

Andropogon capilliflorus Steud., Syn. Pl. Glum. 1: 397 (1854).

Rhaphis villosula Nees ex Steud., Syn. Pl. Glum. 1: 397 (1854).

Rhaphis microstachya Nees ex Steud., Syn. Pl. Glum. 1: 397 (1854).

Andropogon serratus Miq., Ann. Mus. Lugd.-Bat. II: 290 (1866).

Chrysopogon parviflorus Benth., Fl. Austr. VII: 537 (1878).

Chrysopogon parvispicus (Steud.) Wats., in Atkins., Gaz. N. W. Ind.: 392 (1882).

Tufted perennial, mostly 75-100 cm. tall. Culms with bearded nodes. Leaf blades glaucous, the blades expanded, erect and straight, linear from an often narrowed and slightly contracted base, 30 cm. long, 2.5 mm. wide, finely pointed, margins scabrid; leaf sheaths tight or at length slipping from the culms, the lowermost ones longer, the others usually shorter than the internodes, more or less with tubercle-based hairs and frequently villous on the collar; ligule a very short, truncate, ciliolate membrane.

Inflorescence a profusely divided delicate panicle; main inflorescence axis terete; primary branches alternate, opposite or semiverticillate, divided from low down and up to the third degree; raceme peduncles filiform, glabrous. Racemes 1-jointed, reduced to 1 sessile and two pedicellate spikelets, rarely 2-jointed with 2 sessile and 3 pedicellate spikelets; rachis internodes very similar to the raceme peduncles and glabrous. Sessile spikelet narrowly oblong, 2.8-5 mm. long; lower glume with short hairs on the back, shallowly concave in the middle, ciliate upwards on the keels, truncate, with 2 intracarinal nerves; upper glume single-keeled, scabrid on the keel, the median nerve drawn into a mucro. Florets 2: lower floret empty, lemma 2-2.5 mm. long, ovate; upper floret bisexual, lemma stipiform, linear, flattened, entire, single-nerved; awn 20 mm. long (including the upper lemma), minutely hispidulous; lodicules 2, fleshy, glabrous; anthers 3, 1.5 mm. long; caryopsis oblong, 2.1 mm. long. Pedicellate spikelet lanceolate, male or neuter, 2.5-3.5 mm. long; lower glume shortly hairy on the keels, truncate, with 3 intracarinal nerves, acute; upper glume glabrous, lanceolate, with 2 intracarinal nerves; lower lemma oblong, truncate; anthers 3, 1.5 mm. long; pedicels with a median translucent longitudinal groove, subequal, hairy on the raised margins.

Zambia. E: Fort Jameson, 25.v.1963, **Verboom* 761 (SRGH, BM). **Zimbabwe**. C: Gwelo District, 6 miles south from Gwelo, altitude 4600 ft., 18.iii.1967, *Biegel* 2000 (BM); C: Harare (Salisbury) District, Ballantyne Park, altitude 4950 ft., 26.iii.1965, *Crook* 730 (BM); Harare (Salisbury), university grounds near main entrance gate, altitude 1500 m., 01.i.1968, *Crook* P55 (PRE); Marlborough, ii.1954, *Kerr* 6 (PRE); wet ground bordering Gwebi river, Mazoe road, 22.ii.1974, *Simon* 2385 (SRGH, PRE). **Malawi**. C: Dowa District, Uperere Mission, Chankalamu Dambo, 02.xi.1950, *Jackson* 249 (MAL); Agricultural Research Station near Lilongwe, 30.ix.1952, *Kantikana* 4 (BM); Chipata mountain, altitude 6000 ft., 04.v.1963, **Verboom* 978 (SRGH).

* - racemes 2-jointed (i.e. with 2 sessile and 3 pedicellate spikelets).

Widely distributed throughout the tropics of the Old World, China and Japan. Grassland.

7. **Bothriochloa** Kuntze, Rev. Gen. Pl. 2: 762 (1891). Type species: *Bothriochloa bladhii* (Retz.) S. T. Blake.

Andropogon subgen. *Gymnoandropogon* Nees, Fl. Afr. Austr.: 103 (1841).

Gymnandropogon (Nees) Duthie, in Atkinson, Gaz. N.W. Prov. & Oude 10: 638 (1882).

Amphilophis Nash, in Britton, Man. Fl. North. States: 71 (1901).

Perennials. Inflorescence of few to many-jointed pedunculate digitate or subdigitate racemes, the branches undivided or the lower ones sparsely branched; racemes without homogamous spikelet pairs, always terminate in a triad; spikelets paired, one sessile, the other pedicellate, similar in shape or the pedicellate reduced and smaller, always differing in sex; rachis internodes and pedicels linear-filiform, with a translucent longitudinal groove. Sessile spikelet callus obtuse; lower glume mostly cartilaginous, broadly convex to slightly concave, sometimes with 1-3 circular pits on the back, acute; upper lemma hyaline base of the awn, entire (bilobed in *B. biloba* and *B. erianthoides*). Pedicellate spikelet much like the sessile or smaller, male or neuter.

Species ± 35.

Lower glume of the sessile spikelet not pitted. 1. **radicans**

Lower glume of the sessile spikelet pitted.

Inflorescence paniculate; lower glume of pedicellate spikelet not pitted 2. **bladhii**

Inflorescence subdigitate; lower glume of pedicellate spikelet with 0-4 slit-like pits. 3. **insculpta**

1. **Bothriochloa radicans** (Lehm.) A. Camus, in Ann. Soc. Linn. Lyon 1930 n.s. LXXVI: 164 (1931).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 9 (1954).-Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 48 (1955).-Bogdan, A revised list of Kenya grasses: 56 (1958).-Napper, Grasses of Tanganyika: 100 (1965).-Hood, A guide to the grasses of Zambia: 57 (1967).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 721 (1982).-Müller, Grasses of South West Africa/Namibia: 86 (1984).-Chaudhary, Grasses of Saudi Arabia: 420 (1989).-Gibbs Russell et al, Grasses of Southern Africa: 63 (1991). Type: cultivated in Hamburg, seed from South Africa (whereabouts uncertain).

Andropogon radicans Lehm., in Ind. Sem. Hort. Hamb. (1828).

Andropogon ischaemum var. *radicans* Hackel, in DC., Monogr. Phan. 6: 476 (1889).

Amphilophis radicans Stapf, in Prain, Fl. Trop. Afr. IX: 172 (1917).

A tufted, often stoloniferous perennial of up to 70 cm. tall; has a shrubby growth form and or can be decumbent (including rooting at the nodes). Culms herbaceous and branching from the lower nodes to form cushions; culm nodes exposed and bearded, the lower ones with small velvety hairs and the upper glabrous; culm internodes terete. Leaf blades linear-lanceolate, 6-20 cm. long, 2-6 mm. wide, gradually tapering to a fine point; sheaths glabrous except at the usually bearded mouth, those of the basal leaves loose and open, others closely clasping the culms; leaf ligule a ring of white hairs.

The inflorescence is of clustered 5-16 hairy subdigitate racemes up to 70 mm. long; the main inflorescence axis is slender and shorter than the lower racemes; racemes 10-20-jointed, shortly pedunculate; rachis internodes and pedicels linear, with a longitudinal translucent groove in the middle; rachis joints densely long hairy. Sessile spikelet lanceolate, 2.5-4 mm. long; lower glume slightly concave on the back and hairy on the lower half, firmly membranous; upper glume with an acute apex, with a single keel, minutely hispid along this keel towards the apex. Florets 2: lower floret empty, lemma oblong-linear, 3 mm. long, ciliolate at the apex; upper floret bisexual, lemma stipiform, glabrous, 1.5 mm. long, awned; awn twisted, geniculate, 25 mm. long; epaleate; lodicules 2, fleshy and glabrous; callus short and blunt; anthers 3, 1.5 mm. long; ovary oblong. Pedicellate spikelet neuter; lower glume 3.5 mm. long, oblong, with sparse long white hairs along the lateral keels and ciliolate towards the apex on these keels; upper glume flimsy, ciliate on margins, lanceolate, 3 mm. long; lower lemma oblong, obtuse, truncate, 2 mm. long; pedicels linear.

Botswana. N: Sigara Pan, 30 miles west of Nata river, altitude 896 m., 26.iv.1957, *Drummond & Seagrief* 5240 (K, SRGH); Nxai Pan National Park, 14.iii.1976, *Smith* 1654 (K). **Zimbabwe**. W:

Hlekwani, approximately 10 km. south-west of Bulawayo, altitude 1350 m., 19.xii.1990, *Laegaard* 1528 (K). S: Nuanetsi District, Nuanetsi Ranch, Bubi Section, 23.ii.1967, *Cleghorn* 1421 (K).

Tropical Africa; introduced to tropical America. Open deciduous bushland.

Native pasture species.

2. **Bothriochloa bladhii** (Retz.) S. T. Blake, in Proc. Roy. Soc. Queensl. LXXX: 62 (1969).-Clayton, in Hepper (ed.), Fl. West Trop. Afr. ed.2(3): 470 (1972).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 719 (1982).-Lowe, The flora of Nigeria, Grasses: 225 (1989).- Gibbs Russell et al, Grasses of Southern Africa: 62 (1991). Type: China, *Bladh* (LD, K).

Andropogon bladhii Retz., Obs. Bot. 2: 27 (1781).

Andropogon intermedius R. Br., Prdr.: 202 (1810). Hack., in DC., Monogr. Phan. 6: 485 (1889).

Andropogon punctatus Roxb., Hort. Beng.: 7 (1814) and Fl. Ind. 1: 268 (1820).

Andropogon haenkei J. S. Presl, in C. B. Presl, Reliq. Haenk. 1: 340 (1830).

Rhaphis stricta Nees, in Hook. J. Bot. Kew. Misc. 2: 99 (1850).

Andropogon inundatus F. Muell., Linnaea 25: 444 (1853).

Andropogon leptanthus Steud., Syn. Pl. Glum. 1: 391 (1854).

Andropogon perfosus Nees & Meyen ex Steud., Syn Pl. Glum. 1: 391 (1854).

Bothriochloa anamitica O. Kuntze, Rev. Gen. Pl. 2: 762 (1891).

Sorghum intermedium (R. Br.) O. Kuntze, Rev. Gen. Pl. 2: 792 (1891), based on *Andropogon intermedius.*

Sorghum intermedium (R. Br.) O. Kuntze var. *haenkei* (Presl) O. Kuntze, Rev. Gen. Pl. 2: 792 (1891), based on *Andropogon haenkei.*

Amphilophis intermedia (R. Br.) Stapf, in Agric. News W. Indies 15: 179 (1916), based on *Andropogon intermedius.*

Amphilophis glabra (Roxb.) Stapf var. *haenkei* (PresL) E. G. & A. Camus, in Lecomte, Fl. Gen. Indo-Chine 7: 311 (1922), based on *Andropogon haenkei.*

Amphilophis haenkei (Presl) Haines, Bot. Bihar & Orissa: 1029 (1924), based on *Andropogon haenkei.*

Bothriochloa intermedia (R. Br.) A. Camus, Ann. Soc. Linn. Lyon n.s. 76: 164 (1931); S. T. Blake, in Univ. Queensl. Papers, Dept. Biol. II No.3: 37 (1944), based on *Andropogon intermedius.*

Bothriochloa glabra (Roxb.) A. Camus, in Ann. Soc. Linn. Lyon n.s. 76: 164 (1931); Bor, Grasses Burma Ceylon India & Pakistan: 107 (1960).

Bothriochloa inundata (F. Muell.) J.M. Black, Trans. & Proc. Roy. Soc. S. Aust. 60: 163 (1936), based on *Andropogon inundatus.*

Bothriochloa caucasica (Trin.) Hubbard, in Kew Bull. 1939: 101 (1939); Bor, Grasses Burma Ceylon India Pakistan: 106 (1960)

Bothriochloa glabra (Roxb.) A. Camus subsp. *haenkei* (Presl) Henr., Blumea 3: 456 (1940), based on *Andropogon haenkei.*

Bothriochloa haenkei (Presl) Ohwi, Acta Phytotax. & Geobot. 11: 168 (1942), based on *Andropogon haenkei.*

Dichanthium bladhii (Retz.) Clayton, in Kew Bull. 32: 3 (1977).

A variable and tufted perennial. Culms rather straggling, up to 1 m. tall, culm nodes glabrous, rarely bearded; culm internodes terete or channelled on one side. Leaf blades to 30 cm. long and 10 mm. wide, tapering gradually to a slender tip, almost glabrous; leaf sheaths bearded at the nodes; ligule a ring of white hairs.

Inflorescence a panicle, with numerous slender branches 2-5 cm. long, along a common axis 3-10 cm. long; lower branches sometimes rebranched; rachis internodes and pedicels with a translucent longitudinal groove, hairy, hairs up to 2.5 mm. long. Spikelets usually dark purple or strongly flushed with purple; sessile spikelet 3-4 mm. long, with a ring of short white hairs at the base; lower glume hairy below the middle on the back, rarely glabrous, rigidly ciliate on the margins in the upper part, depressed along the middle, with a deep or shallow pit in the upper part, the pit sometimes not occurring in all spikelets, rarely absent altogether; upper glume lanceolate, margins sparsely ciliate in the upper part or glabrous, depressed longitudinally on both sides of the median keel, keel scabrid in the upper part. Florets 2: lower floret empty, lemma oblong, obtuse, glabrous; upper floret bisexual, lemma stipiform; awn 10-18 mm. long, geniculate, weakly twisted, glabrous; epaleate; ovary oblong; lodicules 2, tiny, fleshy, glabrous; anthers 3, 1.5 mm. long; ovary oblong. Pedicellate spikelet usually smaller than the sessile and reduced to 1 or 2 glumes, rarely well developed and with the lower glume pitted.

Botswana. N: Tubu Island, east of Gumare, 15.i.1983, *Astle* 8228 (SRGH)); Tati river, south-east of Francistown, altitude 980 m., *Long* 12246 (E). SE: Mahalapye, Madibeng, altitude 3200 ft., 11.xii.1959, *De Beer* 870 (BM). **Zambia**. C: Lusaka District, Mount Makulu, 30.i.1973, *Delmotte* 949 (SRGH). E: Ngomi area, Fort Jameson, iii.1962, *Verboom* 588 (WAG). S: Namwala District, Kafue river at Kialala, Kafue National Park, 08.xii.1963, *Mitchell* 24/29 (BM; SRGH). **Zimbabwe**. N: Lomagundi District, Saroi-Sinaia road, altitude 3500 ft., ii.1972, *Davies* 3180 (SRGH); Alaska, General Office, altitude 3985 ft., 16.ii.1966, *Jacobsen* 2827 (PRE); Sipolilo, Nyamunyeche Estate, Gwenzi dam, 20.iii.1979, *Nyariri* 772 (PRE). W: Bubi District, Gwampa vlei, altitude 3000 ft., i.1956, *Goldsmith* 45/56 (PRE); Wankie District, Matetsi Safari Area LK 82096, altitude 3200 ft., 14.iii.1978, *Gonde* 131 (PRE). **Malawi**. C: Kasungu Game Reserve, altitude 3300 ft., 18.ii.1970, *Hall-Martin* 563 (PRE); Lilongwe District, Diampwe river, 18.iv.1952, *Jackson* 764 (MAL). S: Blantyre District, Chichiri Campus, University of Malawi, Limbe, 04.vii.1971, *Banda* 1160 (MAL); Ruo-Tuchila plain, Mulanje, altitude 2000 ft., 22.v.1934, *Lawrence* 143 (MAL). **Mozambique**. T: Chitengo, 13 km. to Acampamento, 02.v.1978, *Diniz* 164 (WAG). M: Sul do Save, Ilha Mariana, 07.iv.1954, *Myre & Cavalho* 1776 (PRE).

Africa, India to Australia, and the Pacific; introduced to United States. Streamsides, swamp margins and cracking clays.

Note: *B. bladhii* is often confused with *Capillipedium* species because of the paniculate nature of the inflorescence and the somewhat capillaceous inflorescence branches. It has 10-25 jointed panicle branches compared to 1-10 jointed ones in *Capillipedium* species. Work on genetic barriers of *B. bladhii* (as *B. intermedia*) has established that this species is capable of crossing with other species of *Bothriochloa* and species of the related genera *Dichanthium* and *Capillipedium* (De Wet & Harlan, 1966; Faruqi, 1969). This led De Wet & Harlan (1966) to unite the three genera taxonomically using the biological species concept, and calling the species a compilospecies.

3. **Bothriochloa insculpta** (Hochst.) A. Camus, in Ann. Soc. Linn. Lyon 1930 n.s. LXXVI: 165 (1931).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 9 (1959).- Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 483 (1955).-Bogdan, A revised list of Kenya grasses: 56 (1958).-Jackson & Wiehe, An annotated check-list of Nyasaland grasses: 31 (1958).-Bor, Grasses of Burma Ceylon India & Pakistan: 107 (1960).-Napper, Grasses of Tanganyika: 100 (1965).-

Hood, A guide to the grasses of Zambia: 57 (1967).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 720 (1982).-Chaudhary, Grasses of Saudi Arabia: 419 (1989).-Gibbs Russell et al, Grasses of Southern Africa: 63 (1991). Type: Ethiopia, Mt. Sholoda (Selleuda), *Schimper* 80 (K).

Andropogon insculptus Hochst. ex A. Rich., Tent. Fl. Abyss. II: 458 (1851).

Andropogon pertusus (L.) Willd. var. *capensis* Hackel, in DC., Monogr. Phan 6: 482 (1889).

Andropogon pertusus (L.) Willd. var. *insculptus* subvar. *trifoveolatus* Hackel, in DC., Monogr. Phan. 6: 482 (1889).

Andropogon pertusus (L.) Willd. var. *capensis* Durand & Schinz, Consp. Fl. Afr. V: 718 (1895).

Andropogon pertusus (L.) Willd. var. *insculptus* Durand & Schinz, Consp. Fl. Afr. V: 718 (1895).

Andropogon pertusus (L.) Willd. var. *capensis* Stapf, in Dyer, Fl. Cap. VII: 345 (1897).

Amphilophis insculpta (Hochst.) Stapf, in Prain, Fl. Trop. Afr. IX: 176 (1917).

Tufted perennial. Culms up to 2 m. tall, either decumbent and rambling or developing into stout woody stolons, branching and rooting at the prostrate nodes; culm nodes bearded with a ring of white hairs; internodes channelled on one side. Leaf blades 4-30 cm. long, 2-8 mm. wide, glabrous on both surfaces, occasionally with sparse tubercle-based hairs on the lower surface, margins rough; leaf sheaths glabrous, striate, clasping the internodes tightly, bearded at the mouth; ligule an unfringed membrane, acute.

Inflorescence of 3-20 subdigitate pedunculate racemes; main inflorescence axis up to 3 cm. long, bearded at the joints; racemes 10-20-jointed; raceme peduncles glabrous; raceme length variable but up to 10 cm. long; lower racemes longer than the main inflorescence axis; rachis internodes and pedicels with a longitudinal translucent groove, hairy on the margins, hairs increasing upwards to 3 mm. long. Sessile spikelet narrowly elliptic, 4.5 mm. long; lower glume with a single deep pit on the back just above the middle, glabrous, shortly ciliate on the lateral keels towards the apex, 4 mm. long; callus bearded, obtuse, 0.5 mm. long; upper glume sharply carinate, minutely ciliate on this keel towards the apex, glabrous, narrowly lanceolate, 4.5 mm. long. Florets 2: lower floret empty, lemma 3.5 mm. long, broadly ovate; upper floret bisexual, lemma stipiform, tapers downwards, 2 mm. long, awned from the tip; awn 25 mm. long, glabrous; epaleate; lodicules 2, fleshy, cuneate; anthers 3, 1.8 mm. long; ovary ovate. Pedicellate spikelet neuter, glabrous; lower glume with 0-4 slit-like pits (shallow), glabrous, oblong, 5 mm. long, with an irregular apex, sharply ciliate along the lateral keels; upper glume lanceolate, 4.5 mm. long, flimsy with ciliate margins; lower lemma oblong, truncate, 3 mm. long; pedicel hairy, with a longitudinal translucent groove.

Botswana. N: Tubu Island, east of Gumare, 15.i.1983, *Astle* 8228 (SRGH); Ngamiland District, altitude 910 m., 31.iii.1987, *Long & Rae* 510 (E); Savuti-Selinda road, 26.ii.1983, *Smith* 4141 (SRGH). SE: South-east District, altitude 1000 m., 04.iii.1987, *Long & Rae* 34 (E). **Zambia**. C: Munibwa District, Lubungu Pontoon, Kafue river, Kafue National Park, 07.iv.1963, *Mataundi* 19/80 (SRGH). **Zimbabwe**. N: Gokwe District, 3 miles north of Gokwe, 30.v.1963, *Bingham* 674 (SRGH). W: Balulima-Mangwe District, Dombodema Mission Farm, Tjompani Store, altitude 1300 m., 29.iv.1972, *Norrgrann* 145 (WAG). E: Lower Sabi, altitude 1500 ft., 27.i - 2.ii.1948, *Rattray* 1262 (WAG). **Malawi**. C: Ncheu District, South Ncheu (Ntcheu), 20.iv.1956, *Jackson* 1851 (MAL). **Mozambique**. GI: Gaza District, Chibuto, Maniquenique, Estação Experimental do C.I.C.A., 13.vi.1950, *Lemos & Balsinhas* 100 (PRE, WAG); S'uldo S'ave, Licilo, 10.vii.1947, *Pedro & Pedrogão* 1404 (SRGH).

Tropical Africa, Arabia and India; introduced to Australia. Overgrazed grasslands and weedy places.

Cultivated fodder; native pasture species.

Note: This species may be confused with the east African *B. pertusa.* It differs in having the lower glume of the pedicellate spikelet always with 1-4 pits and that of the sessile spikelet always glabrous on the back.

8. **Euclasta** Franch., in Bull. Soc. Hist. Nat. Autun 8: 335 (1895). Type species: *Euclasta condylotricha* (Hochst.) Stapf.

Indochloa Bor, in Kew Bull. 9: 75 (1954).

Inflorescence terminal and axillary, of delicate solitary or subdigitate pedunculate racemes; racemes consist of spikelet pairs, one sessile, the other pedicellate; 1-3 large homogamous spikelet pairs at the base of the raceme; pedicellate spikelet larger than the sessile; rachis internodes and pedicels with a translucent longitudinal groove; lower glume papery, more or less flat; lower floret empty with a hyaline lemma; upper floret bisexual, lemma entire, stipiform; pedicellate spikelet male or neuter.

Species 3.

1. **Euclasta condylotricha** (Hochst.) Stapf, in Prain, Fl. Trop. Afr. IX: 181 (1917).- Jackson & Weihe, An annotated check-list of Nyasaland grasses: 41 (1958).-Napper, Grasses of Tanganyika: 100 (1965).-Hood, A guide to the grasses of Zambia: 65 (1967).-Clayton, in Hepper (ed.), Flora of West Tropical Africa, ed.2 (3): 471 (1972).-Clayton, in Polhill (ed.), Flora of Tropical East Africa, Gramineae(3): 722 (1982).-Lowe, Flora of Nigeria, Grasses: 237 (1989). Type: Ethiopia, Dscheladscheranne, *Schimper* 2011 (BM!).

Andropogon condylotrichus Hochst., in Steud., Syn. Pl. Glum. 1: 377(1854).

Andropogon piptatherus Hack., in Mart. et Eichl., Fl. Bras. 2: 3, 293 (1883).

Sorghum piptatherum (Hack.) O. Ktze., Rev. Gen. Pl. 2: 792 (1891).

Euclasta glumacea Franch., in Bull. Soc. Hist. Nat. Autun 8: 336 (1895).

Euclasta graminea Th. et Hel. Durand, Syll. Fl. Congol.: 649 (1909).

Amphilophis piptatherus (Hack.) Nash, in North Amer. Fl. 17: 127 (1912).

Annual. Culms up to 1.5 m. tall, ascending but geniculate at the base, always bearded at the nodes. Plant shallowly rooted and rooting at the nodes (stilt rooted). Leaf blades linear-lanceolate, somewhat flaccid, up to 25 cm. long, 2-10 mm. wide, contracted at the base and drawn to a setaceous tapering point, glabrous on both surfaces or with very short sharp hairs along the midrib and immediate adjacent veins; midrib slender, whitish and prominent; leaf sheaths striate, glabrous, closely clasping the internodes for about half their length, with long tubercle-based hairs at the mouth, in the collar region; ligule ciliolate.

Inflorescence of subdigitate racemes; rachis internodes and pedicels with a translucent longitudinal groove; lowest 1-3 spikelet pairs of each raceme homogamous, male or neuter. Sessile spikelet bisexual; lower glume pale to whitish, elliptic-oblong, minutely truncate, 4 mm. long, with 5 nerves ending below the hyaline apex, hairy on the margins and lower half, 2-keeled, the keels scaberulous; upper glume ovate, strongly carinate, opaque, glabrous, 4 mm. long. Florets 2: lower floret empty, lemma ovate, carinate and ciliate along this keel and the margins, glabrous; upper floret bisexual, lemma hyaline, stipiform; palea present, broadly ovate, hyaline: awn 37 mm. long, minutely hairy; lodicules 2, fleshy, glabrous; anthers 3, 0.75 mm. long; ovary ovate, 2 mm. long. Pedicellate spikelet male; lower glume oblanceolate, many nerved (7-10 nerved), hairy on the lower 1/3, 5.5 mm. long;

upper glume 4-nerved, 4-4.5 mm. long. Upper floret male, lemma slightly shorter than the glume; anthers 3, linear, 1.5 mm. long; lodicules 2, fleshy; pedicel grooved, hairy on the sides.

Zambia. E: Fort Jameson, Jumbe area, 24.iii.1963, *Verboom* 941 (BM). **Zimbabwe**. C: Gatooma District, Sanyati Reserve, 12.iii.1959, *Cleghorn* 451 (BM). S: Gokwe District, 10 miles from Gokwe, near top of basalt escarpment in Bonye Gorge, 25.iii.1963, *Bingham* 571 (BM).

Tropics of Africa. Occurs mainly on roadsides and shallow rock escarpments.

9. **Dichanthium** Willemet, in Usteri, Ann. Bot. 18: 11 (1796).-De Wet & Harlan, in Bol. Soc. Arg. Bot. 12: 206-227 (1968). Type species: *Dichanthium annulatum* (Forssk.) Stapf.

Lepeocercis Trin., Fund. Agrost.: 203 (1822).

Diplasanthum Desv., Opusc.: 66 (1831).

Eremopogon Stapf, in Prain, Fl. Trop. Afr. IX: 182 (1917).

Annuals or perennials. Inflorescence of single, digitate or subdigitate racemes; racemes rarely solitary but more often in pairs-to-many, arranged on a short primary axis; pedunculate or subsessile, sometimes with the lower branches divided; racemes always terminate in a triad of 1 sessile and 2 pedicellate spikelets; spikelets highly imbricate, paired, one sessile, the other pedicellate, subequal to equal in size and shape, usually differing in sex, except the lower 1-6 pairs, which are with rare exceptions homogamous male or neuter; rachis internodes and pedicels solid. Sessile spikelet callus obtuse; lower glume papery to cartilaginous, broadly convex to slightly concave, sometimes pitted, acute to broadly obtuse; upper lemma hyaline base of the awn, entire; awn glabrous. Pedicellate spikelet much like the sessile, male or neuter, awnless, rarely bisexual and awned (e.g. *D. annulatum* var. *fecundum*).

Species ± 20.

Inflorescence of 2-many digitate or subdigitate racemes:

Culm nodes bearded; rachis internodes hairy; lower glume of sessile spikelet concave, pubescent in the lower third, with long tubercle-based cilia above the middle, along the margins and forming a subapical fringe. 1. **annulatum**

Culm nodes glabrous; rachis internodes glabrous; lower glume of sessile spikelet narrowly winged on the lateral keels, without tubercle-based cilia. 2. **aristatum**

Inflorescence digitate with 1-15 sessile to subsessile white villous racemes. 3. **sericeum**

1. **Dichanthium annulatum** (Forssk.) Stapf, in Prain, Fl. Trop. Afr. IX: 178 (1917).-Bor, Flora of Assam 5: 371 (1940).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 10 (1954).-Bogdan, A revised list of Kenya grasses: 57 (1958).-Bor, Grasses Burma Ceylon India & Pakistan: 133 (1960).-Hood, A guide to the grasses of Zambia: 65 (1967).-Clayton, in Hepper (ed.), Fl. West Trop. Afr. (ed.2) 3: 471 (1972).-Clayton, in Polhill (ed.), Fl. Trop. East Afr., Gramineae (3): 725 (1982).-Chaudhary, Grasses of Saudi Arabia: 417 (1989).-Cope & Hosni, A key to Egyptian grasses: 54 (1989).-Gibbs Russell et al, Grasses of Southern Africa: 105 (1991). Type: Egypt, *Forsskål* (C).

Andropogon annulatus Forssk., Fl. Aegypt.- Arab.: 173 (1775).

Andropogon bladhii Retz., Obs. Bot. 2: 27 (1781).

Andropogon scandens Roxb., Hort. Beng.: 7 (1814).

Andropogon obtusus Nees, in Hook. et Arn., Bot. Beech Voy.: 243 (1838).

Lepiocercis annulata (Forssk.) Nees, Fl. Afr. Aust.: 98 (1841).

Andropogon papillosus Hochst., in Rich., Tent. Fl. Abyss. 2: 457 (1851).

Andropogon annulatus var. *monostachya* F. Muell. ex Benth., Fl. Austr. 7: 531 (1878).

Andropogon annulatus var. *bladhii* (Retz.) Hack., in DC., Monogr. Phan. 6: 572 (1889).

Andropogon annulatus var. *decalvatus* Hack., in DC., Monogr. Phan. 6: 572 (1889).

Andropogon grandispiculatus Domin, Biblioth.. Bot. 85: 269 (1915). Type: Australia, Queensland, Flinders river, ii.1910, *Domin s.n.* (K!).

Dichanthium papillosum (Hochst.) Stapf, in Prain, Fl. Trop. Afr. IX: 179 (1917).

Dichanthium fecundum S. T. Blake, in Univ. Queensl. Papers, Dept. Biol. II No.3: 51 (1944). Type: Australia, Queensland, North Kennedy District, Ayr, altitude 20ft, *Blake* 8337 (K!).

Dichanthium annulatum var. *decalvatum* (Hack.) Maire et Weiller, Fl. de L'Afr. du Nord 1: 282 (1952).

This species has three varieties keyed out as follows:

Some pedicellate spikelets on each raceme bisexual and often shortly awned. var. **fecundum**

Pedicellate spikelets always male or neuter.

Spikelets pilose, with a distinct subapical fringe of long tubercle-based cilia. var. **papillosum**

Spikelets less pilose, with the tubercle-based cilia mainly along the margins of the lower glume. var. **annulatum**

Var. **papillosum** is the only one that occurs in FZ.

A tufted, decumbent or erect perennial of up to 2 m. tall with distinct short rhizomes. Culms woody and persistent, robust, geniculate ascending, simple or branched; culm nodes exposed and with a ring of hairs; culm internodes glabrous. Leaf blades linear-lanceolate, 4-4.5 mm. wide and up to 30 cm. long, glabrous along most of their length with long hairs in the ligule area; leaf sheaths glabrous, or sparsely hairy all over; ligule an unfringed membrane, about 2 mm. long.

Inflorescence consists of subdigitate 2-to-many racemes arranged on a short primary axis; rachis internodes and pedicels solid, usually hairy. Sessile spikelets imbricate, oblanceolate, 2-6 mm. long, the lowest 1-6 usually homogamous, male or neuter, the upper bisexual; lower glume slightly concave, pubescent below the middle, with long tubercle-based cilia forming a subapical arch; upper glume slightly shorter than the lower, glabrous except for the keel and apex which are often shortly ciliate. Florets 2: lower floret empty, lemma ovate, 3.8 mm. long, hyaline; upper floret bisexual, lemma stipiform, about 3 mm. long; awn 25 mm. long, both column and bristle minutely hispidulous; lodicules 2, fleshy, cuneate, highly vascularised; anthers 3, 1.5 mm. long; caryopsis elliptic-oblong. Pedicellate spikelets equal or subequal in size and shape to the sessile ones, male or neuter.

var. **papillosum**:

Botswana. N: North-east District, altitude 1000 m., 19.iv.1987, *Long & Rae* 802 (K); North-west District, 28.i.1980, *Smith* 3498 (K). **Zambia**. S: Livingstone Game Park, 14.ii.1961, *Mitchell* 5/78 (K). **Zimbabwe**. N: Gokwe District, Sengwa Research Station, 10.i.1975, *Guy* 2256 (K). S: Belingwe, altitude 3000 ft., 01.xi.1973, *Gosden* 10 (K).

Occurs in the tropics and subtropics of Africa. Dry open places subject to overgrazing or disturbance. Also in swampy depressions.

2. **Dichanthium aristatum** (Poir.) C. E. Hubbard, in Kew Bull. 1939: 654 (1939).-Sturgeon, A revised list of grasses of Southern Rhodesia Part IV: 10 (1954).-Chippindall, in Meredith (ed.), The grasses and pastures of South Africa: 481 (1955).-Bor, Grasses Burma Ceylon India & Pakistan: 134 (1960).-Clayton, in Polhill (ed.), Fl. Trop. East. Afr., Gramineae (3): 723 (1982).-Gibbs Russell et al, Grasses of Southern Africa: 105 (1991). Type: Mauritius, *Commerson* (whereabouts uncertain).

Dichanthium nodosum Willem., in Usteri, Ann. Bot. 18: 11 (1796).

Andropogon aristatus Poir, In Lamk., Encycl. Met. Bot. Suppl. 1: 585 (1810).

Andropogon mollicomus Kunth, Rev. Gram. 1: 365 (1830).

Diplasanthum lanosum Desv., Opusc.: 67 (1831).

Lepiocercis mollicoma (Kunth.) Nees, Edinb. New. Philom. Journ. 18: 185 (1835).

Andropogon caricosus subsp. *mollicomus* Hack. var. *mollicomus* (Kunth.) Hack., in DC., Monogr. Phan. 6: 569 (1889).

Andropogon nodosus (Wilem.) Nash, N. Amer. Fl. 17: 122 (1912).

Dichanthium caricosum var. *mollicomus* (Hack.) Haines, Bot. Bihar & Orissa 5: 1039 (1924).

A tufted perennial of up to 1.1 m. tall, shortly stoloniferous. Culms robust, erect, sometimes decumbent; culm nodes exposed and glabrous. Leaf blades linear-lanceolate, up to 25 cm. long, glabrous except at the base in the ligule area where there are long tubercle-based cilia; leaf sheaths glabrous; ligule a scarious membrane.

Inflorescence of 1-5 racemes arranged subdigitately on a short primary axis; raceme peduncles and culm below the inflorescence pubescent; rachis internodes and pedicels solid; rachis joints hairy; rachis internodes glabrous and pedicels hairy on one side (glabrous on the side facing the sessile spikelet); lowest 1-6 spikelet pairs homogamous, male or neuter. Sessile spikelet obovate, 2-5 mm. long; lower glume 5 mm. long, pilose below the middle, glabrous or shortly ciliate above the middle along the margins and near apex, narrowly winged towards the apex; upper glume as long as the lower, glabrous or ciliate along the margins and keel; callus short, blunt. Florets 2: lower floret empty, lemma hyaline; upper floret bisexual, lemma hyaline, stipiform; awn 22 mm. long, minutely pubescent; lodicules 2, fleshy, glabrous; anthers 3, 2 mm. long; ovary ovate. Pedicellate spikelet male or neuter, subequal in size and shape to the sessile one.

Zambia. N: Mpika District, Luangwa Game Reserve, 27.iv.1965, *Mitchell* 2689 (K). C: Luangwa Valley, near the Lunda Plain, altitude 2500 ft., 04.v.1966, *Astle* 4865 (K). **Zimbabwe**. C: Harare District, Harare, university campus on southern slope, 14.iii.1985, *Bennett s.n.* (K).

India, introduced to Australia, Africa and America. Damp places in disturbed grounds.

Fodder grass.

Note: Characterised by robust, suberect plants having the peduncles to the racemes villous, and the culm below the inflorescence strongly pilose. The species is related to and sometimes regarded as conspecific with *D. caricosum.*

3. **Dichanthium sericeum** (R. Br.) A. Camus, in Bull. Mus. Hist. Nat. Paris XXVII: 549 (1921).-Burbidge, Australian grasses 1: 146 (1966).-Burbidge, Australian grasses: 146 (1968).-Lazarides, The

grasses of Central Australia: 70 (1970).-Wheeler, Jacobs & Norton, Grasses of New South Wales: 163 (1982).-Simon, A key to Australian grasses (ed.2): 98 (1993).-Simon & Latz, A key to the grasses of the Northern Territory, Australia: 26 (1994). Type locality, Australia.

Andropogon sericeus R. Br., Prodr. Fl. Nov. Holl. 1: 201 (1810).

Andropogon affine R. Br., Prodr. Fl. Nov. Holl. 1: 201 (1810).

Andropogon chrysantherus F. Muell., Linnnaea 25: 443 (1852).

Andropogon jubatus Balansa, Bull. Soc. Bot. Fr. 19: 322 (1872).

Andropogon acutiusculus Hack., in DC., Monogr. Phan. 6: 575 (1889).

Andropogon sericeus var. *mollis* F. M. Bailey, Queensl. Agric. Journ. 30: 316 (1913).

Dichanthium acutiusculum (Hack.) A. Camus, Bull. Mus. Hist. Nat. 27: 549 (1921).

A perennial of about 1 m. tall, shortly rhizomatous, erect or slightly decumbent; culm nodes exposed and bearded. Leaf blades linear-lanceolate, up to 15 cm. long, glabrous to pilose all over; leaf sheaths glabrous to pilose; ligule an unfringed membrane of up to 1.5 mm. long.

Inflorescence of 1-15 sessile to subsessile white villous digitate racemes; lowest 1-6 spikelet pairs homogamous, male or neuter. Sessile spikelet elliptic-oblong, truncate at the apex; lower glume obtuse, pilose or rarely glabrous on the back below the middle, always with tubercle-based cilia (up to 6 mm. long) along the margins and forming a transverse subapical fringe; upper glume slightly longer than the lower, glabrous, ovate, carinate. Florets 2: lower floret empty, lemma hyaline; upper floret bisexual, lemma 2 mm. long, stipiform; awn 30 mm. long; epaleate; lodicules 2, fleshy, glabrous; anthers 2 or 3, 2 mm. long; ovary obovate. Pedicellate spikelet obovate-oblong, 4 mm. long, male or neuter; lower glume obovate, linear to narrowly ovate, with a transverse subapical fringe of cilia; anthers 2, 2 mm. long; pedicel hairy.

Zimbabwe. C: Harare (Salisbury) District, cultivated, altitude 4800 ft., xii.1919, *Eyles* 1971 (K).

Widely distributed in Australia, and introduced to tropical East Africa. Cultivated

Note: Racemes are densely covered with long, white silky hairs, sessile or very shortly pedunculate; lower glume of the sessile spikelet covered with long, silvery hairs with an arch of extremely long hairs at apex, many of which arise from tubercles.

Appendix 11.2. A mauscript sent to Kew Bulletin for publication on the new combination recognised in the genus Euclasta Franch.

A NEW COMBINATION OF EUCLASTA (POACEAE) FROM INDIA.

M.P. SETSHOGO*

Summary. A new combination in the genus *Euclasta* Franch., *Euclasta oliganthus* (Hochst. ex Steud.) M.P. Setshogo, is made.

Euclasta oliganthus (Hochst. ex Steud.) M.P Setshogo comb. nov. **Type**: India, Nilgri Hills, *Hohenacker* 1288 (K! BM!).

Synonyms: *Andropogon oliganthus* Hochst. ex Steud, *Syn. Pl. Glum* 1: 368 (1854). *Heteropogon oliganthus* (Hochst. ex Steud.) Blatter & McCann, *in J. Bombay Nat. Hist. Soc.* 32: 623 (1928); *Indochloa oligantha* (Hochst. ex Steud.) Bor, in *Kew Bull.* 9: 79, t. 2 (1954); *Dichanthium oliganthum* (Hochst. ex Steud.) T.A. Cope, in *Kew Bull.* 35(3): 703 (1980).

Distribution: Southern India.

The genus, *Euclasta*, was described by Bor (1954) as a new genus *Indochloa* Bor. This description was based on *Dichanthium clarkei* (Hack.) Haines. This genus included the species, *D. clarkei* and *Heteropogon oliganthus* (Hochst. ex Steud.) Blatt. et McCann. Bor thought that these species had been misplaced in the genera *Dichanthium* and *Heteropogon*, for the similarities between the two far outweighed the differences. The name *Indochloa* Bor, however, was rejected because the genus had already been described as *Euclasta* by Franchet in 1895, who based his description on *E. glumacea* (=*E. condylotricha*). In conforming with this new generic circumscription, Cope (1980) transferred the

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species *Indochloa clarkei* (Hack.) Bor to *Euclasta*. He then transferred *Indochloa oligantha* (Hochst. ex Steud.) Bor to the genus *Dichanthium*.

As a result of a thorough revision of the genus *Euclasta* and other related *Sorghinae* genera (including *Dichanthium*), I propose a new combination, *Euclasta oliganthus* (Hochst. ex Steud.) M.P. Setshogo. This species has many features in common with *E. clarkei*, some of which are: (1) both are straggling annuals; (2) the structure of the raceme is the same; (3) the lower pairs of neuter spikelets are remarkably similar both in shape and in nervation; (4) the sessile bisexual spikelets are very similar in shape, texture and nervation; and (5) the callus is obtuse and bearded. It differs from *Dichanthium* species in the following: (1) the pedicellate spikelets are spreading rather than overlapping; (2) rachis internodes and pedicels have a translucent longitudinal groove; and (3) lower glume of the sessile spikelet is characteristically oblong-truncate.

It is quite clear that *Dichanthium* is not the genus in which this species can be placed. It clearly belongs in the genus *Euclasta*.

Key to the species of *Euclasta*:

Inflorescence of subdigitate pedunculate racemes; homogamous spikelet pairs male or neuter. 1. **condylotricha**

Inflorescence a delicate solitary raceme (rarely two); homogamous spikelet pairs neuter:

Raceme peduncle glabrous; sessile spikelet 3.5 mm long. 2. **clarkei**

Raceme peduncle pilose; sessile spikelet 5 mm long. 3. **oliganthus**

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References.

Bor, N. L. (1954). Notes on Asiatic Grasses: XVI. *Indochloa* Bor, a new genus of Indian grasses. *Kew Bull.* 9: 73-81.

Cope, T. A. (1980). New combinations in Asiatic Grasses. *Kew Bull.* 35(3): 701-704.

Appendix 11.3. Delta file for phenetic analysis.

*HEADING Species of *Sorghinae*

*NUMBER OF CHARACTERS

*KEY OPTIONS

*PRINT WIDTH

*DATA BUFFER SIZE

*MAXIMUM NUMBER OF STATES

*MAXIMUM NUMBER OF ITEMS

*CHARACTER TYPES

*NUMBERS OF STATES

*CHARACTER WEIGHTS

*KEY STATES

*CHARACTER DESCRIPTIONS

#1. Longevity/

1. annual/

2. perennial/

#2. Habit/

1. caespitose<tufted>/

2. spreading <decumbent>

#3. Culm orientation/

1. erect/

2. geniculate/

#4. Perennating organs/

1. rhizomes/

2. stolons/

3. other/

#5. Culm branching/

1. branched/

2. sparingly branched/

3. unbranched/

#6. Central culm nodes/

1. exposed/

2. hidden <by leaf sheath>/

#7. Culm node pubescence/

1. hairy/

2. glabrous/

#8. Culm node hair type/

1. short hairs/

2. pilose/

#9. Culm internode/

1. terete/

2. channelled on one side/

#10. Leaf sheath/

1. auriculate/

2. non auriculate/

#11. Leaves/

1. cauline/

2. basal/

#12. Leaf blade shape/

1. linear/

2. linear lanceolate/

3. lanceolate/

4. acicular <narrow and tapering>/

#13. Leaf blade folding/

1. flat/

2. folded <conduplicate>/

3. rolled/

#14. Leaf blade width <range (mm)>/

1. 1-5.9/

2. 6-10.9/

3. 11-20/

4. > 20/

#15. Ligule/

1. absent/

2. unfringed membrane/

3. fringed membrane/

#16. Fringed membrane type/

1. ciliate/

2. lacerate <shortly toothed>/

#17. Inflorescence type/

1. paniculate/

2. racemose/

#18. Spathe/

1. present/

2. absent/

#19. Paniculate inflorescence/

1. with simple branches/

2. with divided branches/

#20. Panicle internode/

1. long <panicle open or loose>/

2. short <panicle contracted>/

#21. Main inflorescence axis/

1. slender/

2. substantial<stout>/

#22. Racemose inflorescence/

1. digitate/

2. subdigitate/

3. single raceme/

#23. Racemes/

1. solitary/

2. paired/

3. fasciculate <clustered in groups of three or more>/

#24. Racemes <manner of disarticulation>/

1. falling entire/

2. disarticulating at the joint(s)/

#25. Number of spikelet pairs (nodes) on ultimate rachis axis/

1. 1/

2. 2-3/

3. 4-5/

4. 6-10/

5. > 10/

#26. Raceme nodes/

1. densely long-hairy/

2. glabrous/

#27. Rachis internodes/

1. with a translucent longitudinal groove/

2. without a translucent longitudinal groove/

#28. Rachis internodes pubescence/

1. hairy/
2. glabrous/
3. scabrous/

#29. Spikelets/

1. solitary/
2. consistently paired/
3. consistently in triplets/
4. sometimes in triplets and paired/

#30. Spikelet type/

1. sessile only/
2. in pedicellate/sessile combinations/
3. in a triad <1 sessile and 2 pedicellate>/
4. sessile and accompanied by (a) barren pedicel(s)/

#31. Spikelet disposition/

1. imbricate/
2. distant <not overlapping>/

#32. Sessile spikelet <in the heterogamous pairs>/

1. bisexual/
2. female-only/
3. male-only/
4. neuter/

#33. Pedicellate spikelet <in the heterogamous pairs>/

1. absent/
2. bisexual/
3. female-only/
4. male-only/

5. neuter/

#34. Lowest sessile spikelet <in the raceme>/

1. homogamous<male or neuter>/

2. heterogamous<bisexual>/

#35. Pedicel <development>/

1. well developed/

2. rudimentary/

3. absent/

#36. Pedicel pubescence/

1. hairy/

2. glabrous/

#37. Sessile spikelet/

1. compressed laterally/

2. not noticeably compressed/

3. compressed dorsiventrally/

#38. Callus/

1. absent/

2. long/

3. short/

#39. Callus point shape/

1. pungent/

2. blunt/

#40. Callus pubescence/

1. bearded/

2. not bearded/

#41. Lower glume<of sessile spikelet>/

1. two keeled/

2. not two keeled/

#42. Shape of the back of the lower glume/

1. convex/

2. concave/

3. flattened/

#43. Lower glume awns/

1. present/

2. absent/

#44. Lower glume wings/

1. present/

2. absent/

#45. Lower glume pitting/

1. with a conspicuous pit/

2. without a conspicuous pit/

#46. Lower glume/

1. hairy/

2. glabrous/

#47. Lower glume indumentum/

1. hairy all over/

2. hairy below the middle/

3. with a subapical fringe of hair/

4. with submarginal hairs/

#48. Lower glume back/

1. with aculeolate scales/

2. without aculeolate scales/

#49. Lower glume keels/

1. ciliate/

2. not ciliate/

#50. Upper glume/

1. awned/

2. awnless/

3. mucronate/

#51. Upper lemma <of upper floret>/

1. awned/

2. awnless/

3. mucronate/

#52. Upper lemma margins/

1. ciliate/

2. glabrous/

#53. Upper lemma width relative to awn base width/

1. wider than the awn base/

2. narrower than the awn base/

#54. Upper lemma apex/

1. entire/

2. bilobed/

#55. Upper lemma awn/

1. present/

2. absent/

#56. Upper lemma awn orientation/

1. geniculate/

2. not geniculate/

#57. Awn twisted/

1. yes/

2. no/

#58. Upper lemma awn pubescence/

1. hairless<glabrous or scabrous>/

2. hairy/

#59. Awn hairs/

1. long plumose/

2. not long plumose/

#60. Upper lemma awn length in relation to the upper lemma length/

1. much shorter/

2. about as long/

3. much longer/

#61. Palea <of upper floret>/

1. absent/

2. relatively long/

3. conspicuous but relatively short/

#62. Palea margin and apex/

1. entire/

2. ciliate/

#63. Lodicules/

1. absent/

2. fleshy/

3. membranous/

#64. Lodicules margins and apex/

1. ciliate/

2. glabrous/

*DEPENDENT CHARACTERS

1,1:4 6,2:7-8 7,2:8 15,1:16 15,2:16 17,1:22 17,2:19-21 25,1:27-28,34 35,3:36 41,2:49 46,2:47 51,2:53 55,2:56-60 58,1:59 61,1:62 63,1:64

*ITEM DESCRIPTIONS

#1. ***Asthenochloa tenera***/

1,2 2,2 3,1 4,3 5,2 6,1 7,2 9,1 10,2 11,1 12,3 13,1 14,2 15,3 16,1 17,1 18,2 19,2 20,2 21,1 23,1 24,2 25,1 26,1 29,2 30,4 31,2 32,1 33,1 35,2 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,3 51,1 52,1 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,1 63,1

#2. ***Cleistachne sorghoides***/

1,1 2,2 3,1 5,3 6,1 7,2 9,1 10,2 11,1 12,2 13,1 14,U 15,2 17,1 18,2 19,2 20,2 21,1 23,1 24,1 25,1 26,1 29,1 30,1 31,2 32,1 33,1 34,2 35,3 37,3 38,3 39,2 40,1 41,2 42,1 43,2 44,2 45,2 46,1 47,1 48,2 50,2 51,1 52,1 53,1 54,2 55,1 56,1 57,1 58,2 59,2 60,3 61,3 62,2 63,2 64,1

#3. ***Euclasta clarkei***/

1,1 2,2 3,2 5,1 6,1 7,1 8,1 9,1 10,2 11,1 12,2 13,1 14,2 15,3 16,1 17,2 18,2 22,3 23,1 24,2 25,4 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,2/3 43,2 44,1 45,2 46,1 47,1 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#4. ***Euclasta condylotricha***/

1,1 2,2 3,1/2 5,1 6,1 7,1 8,U 9,1 10,2 11,1 12,2 13,1 14,1/2 15,3 16,2 17,2 18,2 22,2 23,1 24,2 25,4 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,4 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,2 46,1 47,2/4 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,2 59,2 60,3 61,2 62,1 63,2 64,2

#5. ***Euclasta oligantha***/

1,1 2,2 3,1/2 5,1/2 6,1/2 7,1 8,2 9,1 10,2 11,1 12,1 13,1 14,1 15,2 17,2 18,2 22,3 23,1 24,2 25,4 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1/3 43,2 44,2 45,2 46,1 47,2/4 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,3 62,1 63,2 64,2

#6. ***Hemisorghum mekongense***/

1,2 2,1 3,1 4,3 5,2/3 6,1 7,2 9,1 10,2 11,1 12,2 13,1 14,4 15,3 16,2 17,1 18,2 19,1 20,1 21,2 23,3 24,2 25,5 26,2 27,2 28,2 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,2 37,3 38,3 39,2 40,2 41,1 42,1/3 43,2 44,2 45,2 46,2 48,2 49,2 50,2 51,2 52,1 54,1/2 55,2 61,2 62,1 63,2 64,2

#7. ***Hemisorghum venustum***/

1,2 2,1 3,1 4,3 17,1 18,2 19,2 20,1 21,1 23,U 24,2 25,5 26,U 27,2 28,2 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,2 37,3 38,3 39,2 40,2 41,1 42,3 43,2 44,2 45,2 46,2 48,2 49,2 50,2 51,1 52,2 53,1 54,2 55,1 56,2 57,2 58,1 60,3 61,1 63,2 64,2

#8. ***Pseudodichanthium serrafalcoides/***

1,1 2,2 3,2 5,1 6,1 7,2 9,1 10,2 11,1 12,1 13,1 14,1/2 15,2 17,2 18,2 22,1 23,1 24,2 25,U 26,1/2 27,2 28,1/2 29,2 30,2 31,1 32,1 33,5 34,1 35,1 36,1/2 37,3 38,3 39,2 40,2 41,1 42,1 43,2 44,1 45,2 46,2 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,2 59,2 60,3 61,1 63,2 64,2

#9. ***Pseudosorghum fasciculare/***

1,1 2,2 3,2 5,1 6,1 7,2 9,1 10,2 11,1 12,2 13,1 14,1/2 15,2 17,1 18,2 19,1/2 20,2 21,1 24,2 25,5 26,1 27,2 28,1 29,2 30,2 31,2 32,1 33,4/5 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,U 43,2 44,2 45,2 46,2 48,2 49,2 50,2 51,1 52,1 53,2 54,2 55,1 57,1 58,1 60,3 61,2 62,1 63,2 64,2

#10. ***Spathia neurosa/***

1,1 2,1 3,1 5,2/3 6,1 7,1 8,1 9,2 10,2 11,1 12,1 13,1 14,1 15,3 16,2 17,2 18,1 22,1 23,3 24,2 25,2/3 26,1 27,2 28,1 29,2 30,2 31,1 32,1 33,5 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,1 47,1/3 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,3 62,1 63,2 64,2

#11. ***Chrysopogon aciculatus/***

1,2 2,1 3,2 4,1 5,1 6,1 7,2 9,1 10,2 11,2 12,4 13,1 14,1 15,3 16,2 17,1 18,2 19,1 20,1/2 21,1 23,3 24,2 25,1 26,1 29,3 30,3 31,2 32,1 33,4 35,1 36,2 37,1 38,2 39,1 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,2 49,1 50,1 51,1 52,2 53,1 54,1 55,1 56,2 57,2 58,1 60,3 61,2 62,1 63,2 64,2

#12. ***Chrysopogon aucheri/***

1,2 2,1 3,1 4,3 5,3 6,1 7,1/2 8,1 9,1 10,2 11,2 12,2 13,1 14,1 15,3 16,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,1 26,1 29,3 30,3 31,2 32,1 33,4 35,1 36,1 37,1 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,2 49,2 50,1 51,1 52,1 53,1 54,2 55,1 56,2 57,1 58,1 60,3 61,1 63,2 64,2

#13. ***Chrysopogon fallax/***

1,2 2,1 3,1 4,3 5,3 6,1 7,2 9,2 10,2 11,1 12,1 13,1 14,1 15,3 16,2 17,1 18,2 19,1 20,2 21,1 23,3 24,2 25,1 26,1 29,3 30,3 31,2 32,1 33,4 35,1 36,2 37,1 38,2 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,1 49,1 50,1 51,1 52,2 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,2 62,2 63,2 64,2

#14. ***Chrysopogon fulvus/***

1,2 2,1 3,1 4,3 5,1 6,1 7,2 9,1 10,2 11,1 12,1 13,1 14,U 15,3 16,1 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,1 26,1 29,3 30,3 31,2 32,1 33,4/5 35,1 36,1 37,1 38,3 39,2 40,1 41,2 42,1 43,2 44,2 45,2 46,2 48,2 50,1 51,1 52,2 53,1 54,2 55,1 56,1 57,1 58,U 59,U 60,3 61,1 63,2 64,2

#15. ***Chrysopogon gryllus/***

1,2 2,1 3,1 4,3 5,3 6,1 7,2 9,1 10,2 11,2 12,1/2 13,1 14,2 15,3 16,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,1/2 26,1 27,2 28,2 29,3/4 30,2 31,2 32,1 33,4/5 34,2 35,1 36,1/2 37,1 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,2 49,1 50,1 51,1 52,1/2 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,2 62,1 63,2 64,2

#16. ***Chrysopogon latifolius/***

1,2 2,1 3,1 4,3 5,1 6,1 7,2 9,2 10,2 11,1 12,1 13,1/2 14,2/3/4 15,3 16,1 17,1 18,2 19,1 20,2 21,2 23,3 24,2 25,1 26,1 29,3 30,3 31,2 32,1 33,4 35,1 36,2 37,1 38,2 39,1 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,1 49,1 50,1 51,1 52,2 53,1 54,1 55,1 56,1 57,1 58,2 59,2 60,3 61,2 62,1 63,2 64,2

#17. ***Chrysopogon orientalis/***

1,2 2,1 3,1 4,3 5,1 6,1 7,2 9,1 10,2 11,2 12,1 13,1/3 14,1 15,3 16,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,1 26,1 29,3 30,3 31,2 32,1 33,4 35,1 36,2 37,1 38,3 39,2 40,1 41,1 42,3 43,1 44,2 45,2 46,2 48,2 49,2 50,1 51,1 52,2 53,1 54,1 55,1 56,2 57,2 58,1 60,3 61,1 63,2 64,2

#18. ***Chrysopogon pallidus/***

1,2 2,1 3,1 4,2 5,2 6,1 7,2 9,2 10,2 11,1 12,U 13,2 14,2 15,3 16,1 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,1 26,1 29,3 30,3 31,2 32,1 33,4 35,1 36,2 37,1 38,2 39,1 40,1 41,1 42,1 43,1/2 44,2 45,2 46,2 48,1 49,1 50,1 51,1 52,1 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,2 62,2 63,2 64,2

#19. ***Chrysopogon plumulosus/***

1,2 2,1 3,1 4,3 5,3 6,1 7,2 9,1 10,2 11,1 12,2 13,1 14,1 15,3 16,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,1 26,1 29,3 30,3 31,2 32,1 33,4/5 35,1 36,1 37,1 38,3 39,1 40,1 41,2 42,1 43,2 44,2 45,2 46,2 48,2 50,1 51,1 52,2 53,1 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#20. ***Chrysopogon serrulatus/***

1,2 2,1 3,1 4,3 5,3 6,1 7,2 9,1 10,2 11,1 12,U 13,1 14,1/2 15,3 16,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,1 26,1 29,3 30,3 31,2 32,1 33,4/5 35,1 36,1 37,1 38,3 39,1 40,1 41,2 42,1 43,2 44,2 45,2 46,2 48,2 50,1 51,1 52,2 53,1 54,2 55,1 56,1 57,1 58,1/2 59,2 60,3 61,1 63,2 64,2

#21. ***Chrysopogon sylvaticus/***

1,2 2,1 3,1 4,3 5,1 6,1 7,2 9,1 10,2 11,2 12,1 13,2 14,2 15,3 16,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,1/2 26,1 27,2 28,2 29,3/4 30,2/3 31,2 32,1 33,5 34,2 35,1 36,2 37,1 38,3 39,1 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,2 49,1 50,1 51,1 52,2 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,2 62,1 63,2 64,2

#22. ***Vetiveria elongata/***

1,2 2,1 3,1 4,3 5,3 6,2 9,1 10,2 11,1 12,1 13,2 14,2 15,3 16,2 17,1 18,2 19,1 20,2 21,1 23,3 24,2 25,1/2/3/4 26,2 27,2 28,2 29,2 30,2 31,2 32,1 33,4 34,2 35,1 36,2 37,1 38,2 39,1 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,2 49,1 50,1/3 51,1 52,2 53,1 54,2 55,1 56,2 57,2 58,1 60,3 61,3 62,1 63,2 64,2

#23. ***Vetiveria filipes*/**

1,2 2,1 3,1 4,3 5,2/3 6,1 7,2 9,1 10,2 11,1 12,3 13,2 14,1/2 15,3 16,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,2/3/4 26,1 27,2 28,2 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,2 37,1 38,2 39,1 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,1 49,1 50,3 51,1 52,2 53,1 54,1/2 55,1 56,2 57,1 58,1 60,3 61,1 63,2 64,2

#24. ***Vetiveria fulvibarbis*/**

1,2 2,1 3,1 4,3 5,2 6,1 7,2 9,1 10,2 11,1 12,1 13,2 14,U 15,3 16,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,4 26,1 27,2 28,2 29,2 30,2 31,2 32,1 33,4 34,2 35,1 36,2 37,1 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,2 49,1 50,3 51,1 52,1 53,1 54,2 55,1 56,2 57,2 58,1 60,3 61,2 62,1 63,2 64,2

#25. ***Vetiveria nigritana*/**

1,2 2,1 3,1 4,3 5,3 6,1 7,2 9,1 10,2 11,1 12,1 13,2 14,2 15,3 16,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,5 26,1 27,2 28,2 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,2 37,1 38,3 39,2 40,1 41,2 42,1 43,2 44,2 45,2 46,2 48,1 50,3 51,1 52,2 53,1 54,2 55,1 56,2 57,2 58,1 60,2 61,1 63,2 64,2

#26. ***Vetiveria zizanioides*/**

1,2 2,1 3,1 4,3 5,3 6,2 9,1 10,2 11,1 12,1 13,2 14,1/2/3 15,3 16,2 17,1 18,2 19,1 20,2 21,2 23,3 24,2 25,5 26,2 27,2 28,2 29,2 30,2 31,2 32,1 33,4 34,2 35,1 36,2 37,1 38,3 39,2 40,2 41,1 42,1 43,2 44,2 45,2 46,2 48,1 49,1 50,2 51,2/3 52,2 53,1 54,1 55,2 61,1 63,2 64,2

#27. ***Bothriochloa biloba*/**

1,2 2,1 3,1/2 4,3 5,2/3 6,1 7,2 9,2 10,2 11,1 12,1 13,1 14,1 15,2 17,2 18,2 22,2 23,1 24,2 25,U 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,2 43,2 44,2 45,2 46,1 47,2 48,2 49,1 50,3 51,1 52,2 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,3 62,2 63,2 64,2

#28. ***Bothriochloa decipiens*/**

1,2 2,2 3,1/2 4,3 5,1 6,1 7,2 9,2 10,2 11,1 12,2 13,1/3 14,1 15,2 17,2 18,2 22,2 23,1/2 24,2 25,U 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,1 46,1 47,2 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#29. ***Bothriochloa insculpta*/**

1,2 2,1 3,2 4,2 5,1 6,1 7,1 8,2 9,2 10,2 11,1 12,3 13,1 14,1/2 15,2 17,2 18,2 22,2 23,1/2/3 24,2 25,U 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,1 46,2 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#30. ***Bothriochloa ischaemum*/**

1,2 2,1 3,2 4,1 5,1/3 6,1 7,1/2 8,1 9,1 10,2 11,2 12,1 13,1 14,1 15,3 16,1 17,2 18,2 22,1/2 23,1/3 24,2 25,U 26,2 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,1 47,2 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#31. ***Bothriochloa kuntzeana*/**

1,2 2,2 3,1 4,3 5,3 6,1 7,1 8,2 9,1 10,2 11,1 12,1 13,1 14,U 15,2 17,2 18,2 22,2 23,1/3 24,2 25,U 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,4 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,1 46,2 48,2 49,1 50,3 51,1 52,2 53,2 54,1 55,1 56,2 57,2 58,1 60,3 61,1 63,2 64,2

#32. ***Bothriochloa macera*/**

1,2 2,1 3,1/2 4,3 5,1 6,1 7,2 9,2 10,2 11,1 12,1 13,1 14,1 15,3 16,1 17,2 18,2 22,2 23,1/2 24,2 25,U 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,U 43,2 44,2 45,1/2 46,1 47,2 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#33. ***Bothriochloa pertusa*/**

1,2 2,2 3,1/2 4,1 5,1 6,1 7,1 8,2 9,1 10,2 11,2 12,3 13,1 14,1 15,2 17,2 18,2 22,1 23,3 24,2 25,U 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,4 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,1 46,1 47,2 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,2 59,2 60,3 61,1 63,2 64,2

#34. ***Bothriochloa radicans*/**

1,2 2,1 3,2 4,2 5,1 6,1 7,1 8,1 9,1 10,2 11,1 12,2 13,1 14,1/2 15,3 16,1 17,2 18,2 22,1/2 23,3 24,2 25,U 26,1 27,1 28,U 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,U 37,3 38,3 39,2 40,1 41,1 42,2 43,2 44,2 45,2 46,1 47,2 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#35. ***Bothriochloa saccharoides*/**

1,2 2,1 3,1/2 4,3 5,U 6,U 7,U 8,U 9,U 10,2 11,1 12,1 13,1/2 14,1/2 15,2 17,2 18,2 22,2 23,1/2/3 24,2 25,U 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,2 58,2 59,2 60,3 61,1 63,2 64,2

#36. ***Capillipedium assimile*/**

1,2 2,2 3,2 4,3 5,1 6,1 7,1/2 8,1 9,1 10,2 11,1 12,2 13,1 14,1/2 15,3 16,2 17,1 18,2 19,2 20,1 21,1 23,U 24,2 25,2 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,2 43,2 44,2 45,2 46,2 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,2 57,2 58,1 60,3 61,1 63,2 64,2

#37. ***Capillipedium filiculme*/**

1,1 2,2 3,2 5,1 6,1 7,1 8,1 9,1 10,2 11,1 12,3 13,1 14,2/3 15,2 17,1 18,2 19,2 20,1 21,1 23,U 24,2 25,U 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,4 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#38. ***Capillipedium huegelii/***

1,2 2,2 3,1 4,3 5,1 6,1 7,1 8,1 9,1 10,2 11,1 12,1 13,1 14,U 15,3 16,2 17,1 18,2 19,2 20,2 21,1 23,U 24,2 25,U 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,2 46,2 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,2 57,2 58,1 60,3 61,1 63,2 64,2

#39. ***Capillipedium parviflorum/***

1,2 2,1 3,1 4,3 5,3 6,1 7,1 8,1 9,1 10,2 11,1 12,1 13,1 14,1 15,3 16,2 17,1 18,2 19,2 20,1 21,1 23,1/2/3 24,1 25,1 26,1 29,3 30,3 31,2 32,1 33,4/5 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,2 43,2 44,2 45,2 46,1 47,1 48,2 49,1 50,3 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#40. ***Capillipedium spicigerum/***

1,2 2,1 3,1 4,3 5,3 6,1 7,1/2 8,1 9,1 10,2 11,1 12,1 13,1 14,1/2 15,3 16,2 17,1 18,2 19,2 20,1 21,1 23,1/2/3 24,2 25,2/3/4 26,1 27,1 28,1 29,2 30,2 31,2 32,1 33,4 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,2 43,2 44,2 45,2 46,1 47,1 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#41. ***Dichanthium annulatum/***

1,2 2,1/2 3,1 4,1 5,1/3 6,1 7,1 8,2 9,1 10,2 11,1 12,2 13,1 14,1 15,2 17,2 18,2 22,2 23,1/2 24,2 25,5 26,1 27,2 28,1 29,2 30,2 31,1 32,1 33,2/4/5 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,2 43,2 44,2 45,2 46,1 47,2/3/4 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#42. ***Dichanthium aristatum/***

1,2 2,1 3,1 4,2 5,3 6,1 7,2 9,1 10,2 11,1 12,2 13,1 14,U 15,3 16,2 17,2 18,2 22,2/3 23,1/3 24,2 25,5 26,1 27,2 28,2 29,2 30,2 31,1 32,1 33,4/5 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,1 45,2 46,1 47,2 48,2 49,1 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,2 59,2 60,3 61,1 63,2 64,2

#43. ***Dichanthium caricosum/***

1,2 2,2 3,2 4,3 5,3 6,1 7,2 9,1 10,2 11,1 12,2 13,1 14,U 15,3 16,1 17,2 18,2 22,2 23,1/2/3 24,2 25,U 26,1 27,2 28,1 29,2 30,2 31,1 32,1 33,4/5 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,1 47,2/3/4 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#44. ***Dichanthium foveolatum/***

1,2 2,1 3,2 4,1 5,3 6,1 7,1 8,1 9,1 10,2 11,1 12,1 13,1 14,U 15,3 16,1 17,2 18,2 22,3 23,1 24,2 25,5 26,1 27,2 28,1 29,2 30,2 31,1 32,1 33,5 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,2 43,2 44,2 45,1 46,2 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#45. ***Dichanthium micranthum***/

1,2 2,1 3,1 4,1 5,1 6,1 7,1/2 8,1 9,1 10,2 11,2 12,1 13,1 14,1 15,U 16,U 17,2 18,2 22,3 23,1 24,2 25,U 26,1 27,2 28,1 29,2 30,2 31,1 32,1 33,4 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3/4 43,2 44,2 45,1 46,2 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#46. ***Dichanthium sericeum***/

1,2 2,2 3,1/2 4,1 5,3 6,1 7,1 8,2 9,1 10,2 11,1 12,2 13,1 14,U 15,2 17,2 18,2 22,1 23,3 24,2 25,U 26,1 27,2 28,1 29,2 30,2 31,1 32,1 33,4/5 34,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,2 46,1 47,2/3/4 48,2 49,2 50,2 51,1 52,2 53,2 54,1 55,1 56,1 57,1 58,2 59,2 60,3 61,1 63,2 64,2

#47. ***Sorghastrum elliottii***/

1,2 2,1/2 3,1 4,3 5,3 6,2 9,1 10,1 11,1 12,U 13,1 14,1/2 15,2 17,1 18,2 19,1 20,1 21,1 23,3 24,1 25,1 26,1 29,3 30,4 31,2 32,1 33,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,3 51,1 52,2 53,1 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#48. ***Sorghastrum fuscescens***/

1,2 2,1 3,1 4,3 5,3 6,1 7,1 8,1 9,1 10,1 11,1 12,1 13,1 14,1/2 15,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,2/3/4/5 26,1 27,2 28,1 29,2 30,2/4 31,2 32,1 33,1/2 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,2 51,1 52,1 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#49. ***Sorghastrum incompletum*** var. ***bipennatum***/

1,2 2,1 3,1 4,3 5,3 6,1 7,1 8,1 9,1 10,1 11,1 12,2 13,1 14,1/2 15,2 17,1 18,2 19,1 20,1 21,1 23,3 24,1 25,1 26,2 29,3 30,4 31,2 32,1 33,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,2 51,1 52,2 53,1 54,1 55,1 56,1 57,1 58,1 60,3 61,3 62,1 63,2 64,2

#50. ***Sorghastrum minarum***/

1,2 2,1/2 3,1 4,3 5,3 6,1 7,1 8,1 9,1 10,1 11,1 12,2 13,1 14,2 15,2 17,1 18,2 19,2 20,2 21,1 23,3 24,2 25,1 26,1 29,3 30,4 31,2 32,1 33,1 35,1 36,1 37,3 38,2 39,1 40,1 41,1 42,1 43,2 44,2 45,2 46,1 47,2/4 48,2 49,2 50,2 51,1 52,2 53,1 54,2 55,1 56,1 57,1 58,2 59,1 60,3 61,1 63,2 64,2

#51. ***Sorghastrum nutans***/

1,2 2,2 3,1 4,1 5,2 6,1 7,1 8,1 9,1 10,1 11,1 12,1 13,1 14,1/2 15,2 17,1 18,2 19,2 20,2 21,1 23,3 24,2 25,U 26,1 29,2 30,4 31,2 32,1 34,2 33,1 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,2/3 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,2 51,1 52,1 53,1 54,1 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,2

#52. ***Sorghastrum pogonostachyum*/**

1,2 2,1 3,1 4,1 5,3 6,1 7,2 9,1 10,1 11,1 12,U 13,1 14,U 15,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,2/3/4 26,1 27,2 28,1 29,2 30,2 31,2 32,1 33,1/2 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,2 51,1 52,2 53,1 54,1 55,1 56,2 57,2 58,1 60,2 61,1 63,2 64,2

#53. ***Sorghastrum setosum*/**

1,2 2,1 3,1 4,1 5,3 6,1 7,2 9,1 10,1 11,1 12,2 13,1 14,2 15,2 17,1 18,2 19,1 20,1 21,1 23,3 24,2 25,U 26,1 27,2 28,1 29,2 30,4 31,2 32,1 33,1 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,2 51,1/2 52,2 53,1 54,1 55,2 61,1 63,2 64,2

#54. ***Sorghum arundinaceum*/**

1,1/2 2,2 3,1 4,3 5,1 6,1 7,1/2 8,1 9,1 10,2 11,1 12,3 13,1 14,1/2 15,3 16,1 17,1 18,2 19,2 20,1 21,2 23,1 24,2 25,2/3/4 26,1 27,2 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,2 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,2 51,1 52,1 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,2 62,2 63,2 64,2

#55. ***Sorghum halepense*/**

1,2 2,2 3,1 4,1 5,2/3 6,1 7,2 9,1 10,2 11,1 12,1 13,1 14,1/2/3/4 15,2 17,1 18,2 19,2 20,1 21,2 23,1 24,2 25,1/2/3 26,U 27,2 28,1 29,2 30,2 31,2 32,1 33,4 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,2 46,1 47,1 48,2 49,1 50,2 51,1/2 52,1 53,1 54,2 55,1/2 56,2 57,2 58,1 60,3 61,1 63,2 64,1

#56. ***Sorghum macrospermum*/**

1,1 2,2 3,1 5,1 6,1 7,2 9,1 10,2 11,1 12,4 13,1 14,4 15,3 16,1 17,1 18,2 19,1/2 20,1 21,2 23,1 24,2 25,4/5 26,1 27,2 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,1 43,2 44,2 45,2 46,2 48,2 49,2 50,2 51,1 52,1 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,1/2

#57. ***Sorghum nitidum*/**

1,2 2,2 3,1 4,3 5,1 6,1 7,1 8,1 9,1 10,2 11,1 12,2 13,1 14,3 15,3 16,2 17,1 18,2 19,1 20,1 21,2 23,3 24,2 25,2/3 26,U 27,2 28,1 29,2 30,2 31,2 32,1 33,4/5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,2 51,1/2 52,1 53,1 54,2 55,1/2 56,1 57,2 58,1 60,3 61,1 63,2 64,1

#58. ***Sorghum versicolor*/**

1,1 2,2 3,1 5,3 6,1 7,1 8,2 9,1 10,2 11,1 12,U 13,1 14,3 15,2 17,1 18,2 19,1 20,1 21,2 23,3 24,2 25,2/3/4 26,1 27,2 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,3 39,2 40,1 41,1 42,3 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,2 51,1 52,1 53,1 54,2 55,1 56,1 57,1 58,1 60,3 61,1 63,2 64,1

#59. ***Sorghum plumosum*/**

1,2 2,1 3,1 4,3 5,3 6,1 7,1 8,1 9,1 10,2 11,1 12,2 13,1 14,1/2/3 15,3 16,1 17,1 18,2 19,1 20,2 21,2 23,3 24,2 25,1/2/3/4 26,1 27,2 28,1 29,2 30,2 31,2 32,1 33,5 34,2 35,1 36,1 37,3 38,2 39,1 40,1 41,1 42,3 43,2 44,2 45,2 46,1 47,1 48,2 49,1 50,2 51,1 52,1 53,1 54,2 55,1 56,1 57,1 58,2 59,1 60,3 61,3 62,2 63,2 64,1

#60. ***Sorghum stipoideum/***

1,1 2,2 3,1 5,1 6,1 7,1/2 8,1/2 9,1 10,2 11,1 12,U 13,1 14,3 15,2 17,1 18,2 19,1 20,1 21,2 23,3 24,2 25,1/2 26,1 27,2 28,1 29,2 30,2 31,2 32,1 33,4 34,2 35,1 36,1 37,3 38,2 39,1 40,1 41,1 42,3 43,2 44,2 45,2 46,1 47,1 48,2 49,2 50,2 51,1 52,1 53,1 54,2 55,1 56,1 57,1 58,2 59,1 60,3 61,1 63,2 64,1

Appendix 11.4

Table 11.1: A table showing character coding for cladistic analysis.

Characters	Character states
1. Longevity	0. prennial
	1. annual
2. Perennating organs	0. absent
	1.present
3. Culm internode	0. terete
	1. channelled on one side
4. Leaf sheath	0. auriculate
	1. non auriculate
5. Leaf blade width	0. broad
	1. narrow
6. Ligule	0. unfringed membrane
	1. fringed membrane
7. Inflorescence type	0. paniculate
	1. racemose
	2. spatheate
8. Paniculate inflorescence	0. with simple branches
	1. with divided branches
9. Racemose inflorescence	0. subdigitate racemes
	1. digitate racemes
	2. a single raceme
10. Racemes (disarticulation)	0. breaking at the joints
	1. falling entire
11. Rachis internodes	0. without a translucent groove
	1. with a translucent groove
12. Spikelets	0. consistently in triplets
	1. sometimes in triplets and pairs

	2. consistently paired
	3. solitary
13. Spikelet type	0. in a triplet of 1 seesile and 2 pedicellate
	1. in a pedicellate/sessile pair
	2. sessile and accompanied by barren pedicels
	3. sessile only
14. Pedicellate spikelet	0. present
	1. absent
15. Lowest sessile spikelet	0. heterogamous
	1. homogamous
16. Pedicel development	0. well developed
	1. rudimentary
	2. absent
17. Callus point shape	0. blunt
	1. pungent
18. Lower glume (of sessile spikelet)	0. two keeled
	1. not two keeled
19. Lower glume awn	0. absent
	1. present
20. Lower glume wings	0. absent
	1. present
21. Lower glume pitting	0. without a pit
	1. with a pit
22. Upper glume	0. awnless
	1. awned
23. Palea	0. present
	1. absent
24. Lodicules	0. present
	1. absent
25. Lodicule margins and apex	0. ciliate
	1. glabrous
26. Upper lemma	0. awnless
	1. awned