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LEGUMES OF THE CERRADO

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ABSTRACT - The Cerrado is a type of savanna vegetation which covers 20% of Brazil. It is an environment with nutrient poor soils. Legumes are one source of nitrogen for agriculture in the Cerrado. There are 59 genera with 548 species of *Leguminosae* reported to occur in Cerrado vegetation. It is recommended that the search for nitrogen fixing legumes be concentrated in tribes *Caesalpinieae* and *Detarieae* and genus *Chamaecrista* of subfamily *Caesalpinioideae*, in tribe *Mimoseae* and genus *Enterolobium* of subfamily *Mimosoideae*, and in tribes *Dipteryxeae*, *Dalbergieae*, *Phaseoleae* and *Aeschynomene* and genera *Swartzia*, *Acosmium* and *Bowdichia* of subfamily *Papilinoideae*.

Index terms: N_2 fixation, nodules, *Rhizobium*.

LEGUMINOSAS DO CERRADO

RESUMO - O Cerrado é um tipo de savana que cobre quase 20% do território brasileiro, constituindo-se num ambiente de solos pobres em nutrientes. As leguminosas são uma fonte natural de nitrogênio para a agricultura no Cerrado. Há 59 gêneros e cerca de 548 espécies de leguminosas conhecidas nesta região. A pesquisa sobre leguminosas fixadoras de nitrogênio deve ser concentrada nos seguintes grupos: tribos Caesalpinieae e Detarieae, e no gênero *Chamaecrista* da subfamília Caesalpinioideae; na tribo Mimoseae e no gênero *Enterolobium* da subfamília Mimosoideae; nas tribos Dipteryxeae, Dalbergieae, Phaseoleae e Aeschynomene e nos gêneros *Swartzia*, *Acosmium* e *Bowdichia* da subfamília Papilionoideae.

Termos para indexação: Fixação de N_2, nódulos, *Rhizobium*.

INTRODUCTION

Central Brazil is dominated by a form of savanna vegetation konwn as "Cerrado", sensu lato (s.l.). Within the region other forms of vegetation, such as various types of forests and inundated grasslands, occur, but their presence is a minor element in the area. Due to the Cerrado's dominance, this region is frequently designated as a distinct vegetational province on a world-wide scale, the Cerrado Province (Eiten 1972 and Rizzini 1979).

Recently, there has been renewed interest in agricultural expansion in the Cerrado, s.l., as clearly shown by the estabilishment of the Centro de Pesquisa Agropecuária dos Cerrados near the federal capital, in 1975, and the fourth and fifth Simposia on the Cerrado (Ferri 1977, Marchetti & Machado 1982). This is a logical development following better understanding of conditions in the Cerrado, s.l., region. Adequate light and water combined with the generally excellent physical properties of the soil indicate a large potential for successful agriculture in former areas of Cerrado, s.l., vegetation. The two factors

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most limiting agricultural production in the Cerrado, s.l., are low soil fertility and irregular occurrence of rainfall (Goedert 1982). The former may be overcome by the proper application of various elements including nitrogen (Galvão & Lopes 1982), but the ever increasing costs of these additives will certainly affect agricultural expansion in Central Brazil and the Cerrado, s.l., in the future.

The objective of the present study is to survey the native legume flora of the Cerrado, s.l., vegetation in relation to the probable ability of its members to nodulate and fix nitrogen. This information will facilitate the investigation and use of native legumes in order to improve soil fertility in the Cerrado, s.l., region of Brazil.

CERRADO

Distribution

Cerrado, s.l., vegetation covers approximately 1.8 million square kilometers of Brazil, or about 20% of its land-surface. This is almost the entire state of Goiás, more than half of the states of Minas Gerais, Mato Grosso and Mato Grosso do Sul, and significant portions of the states of Bahia, Maranhão and Piauí. This combined area is approximately 10% greater than the land-surface occupied by the European Economic Community. (Fig. 1).

A portion of the Cerrado, s.l., extends from southern Mato Grosso do Sul into Paraguay, and a detached area of Cerrado, s.l., occurs in Bolivia. Aside from these two relatively insignificant areas of Cerrado, s.l., in Bolivia and Paraguay, Cerrado, s.l., vegetation occurs only in Brazil and nowhere else in the world.

Physionomy and Classification

The overall appearance of Cerrado, s.l., vegetation is highly variable, ranging from open grasslands, with only small, scattered shrubs whose height is equal to or less than that of the grass and forb layer, all the way, to tall, dense forms which are frequently considered as a type of forest. But Cerrado, s.l., is easily distinguished from all other types of savanna by the characteristic features of the woody elements in the vegetation (Warming 1973, Eiten 1972 and Eiten 1982). The trees and shrubs generally have rather large, stiff leaves or large compound leaves with tiny to large leaflets. Soft, hairy or mesomorphic leaves are infrequent. Frequently they have fewer branches and consequently more open crowns than are common in trees and shrubs of tropical mesophytic forests or of temperate forests. Branches are often rather thick right to their tips, and the bark of trunks and branches is usually very thick and furrowed. The characteristic which lends itself to instant recognition of a Cerrado, s.l., is the tortuosity of the trees and shrubs. This tortuosity results from several common aspects of growth: frequent death of the stem and branch apices; assumption of apical growth by a lateral branch; commonly a large angle between the mother axes and their branches; and that the growth of new wood and thick bark obscures the former apices and the fact that the new apices have arisen from lateral branches. (Fig. 2).

The classification and description of Cerrado, s.l., vegetation has traditionally been on a physionomic basis related to the density and height of the woody elements (Eiten 1972, Eiten 1979, Coutinho 1978). Eiten (1972) has summarized much of the confusion in the classification of the Cerrado, s.l., vegetation. The rural inhabitants of Central Brazil have, in my opinion, devised the most satisfactory classification of the Cerrado, s.l., vegetation into five categories: Cerradão, Cerrado, sensus stricto (s.s.);

Campo Cerrado; Campo Sujo; and Campo Limpo. These divisions were used by Goodland (Goodland 1971, Goodland & Ferri 1979) in his now classical phytosociological study of 110 stands of Cerrado, s.l., in western Minas Gerais. Unfortunately, he did not encounter Campo Limpo in that region, and so did not include it in his study. He clearly demonstrated that the Cerrado, s.l., vegetation forms a physionomic gradient which can be conveniently divided into the above five categories based on the characteristics derived from the arboreal element of the vegetation (Table 1). It is clearly evident from Goodland's data that the Cerrado, s.l., forms a continuous gradient often difficult to classify because of its overlapping characteristics. Campo Limpo is defined as a tree-less grassland with only a few, scattered shrubs whose height is equal to or less than that of the grass and forb layer. As a corollary of this definition, Campo Limpo vegetation should give very low or zero values for the characteristics presented in Table 1. (Fig. 3).

TABLE 1. Characteristics of Cerrado, s.l., vegetation in western Minas Gerais, adapted from Goodland (1971).

Category	Cerradão	Cerrado (s.s)	Campo Cerrado	Campo Sujo
Canopy (%)	46 (15-85)	19 (1-55)	3 (0-15)	1 (0-2)
Tree height (m)	9 (6-18)	6 (4-8)	4 (3-6)	3 (1-5)
Trees/ha	3215 (1631-4925)	2253 (836-3976)	1408 (335-2928)	849 (226-2070)
Basal area/ha ($cm^2 \times 10^3$)	312.8 (202.9-513.3)	167.6 (62.2-253.4)	76.1 (16.9-141.7)	29.8 (9.7-60.0)
Tree species/ha	55 (40-72)	43 (26-60)	36 (18-52)	31 (19-43)

Species Density

As in many other studies on the Cerrado, s.l., those of species density are few and difficult to compare. In areas of Cerrado, s.s., in the state of São Paulo and near the Federal Capital, Brasília, there were approximately 300 species of vascular plants per ha (Eiten 1982) and 320 (Heringer 1971), respectively. Eiten (1978) has found in only 0.1 ha of Cerrado, s.s., near Brasília 230 species of vascular plants! In a few tens of square km of Cerrado, s.s., the vascular flora may reach as many as 700-800 species (Warming 1973, Eiten 1971). The Cerrado, s.l., vegetation has a very high species diversity which is comparable to that of Amazon forests, consequently a very rich flora. The *Leguminosae* were the most important family in frequency and species number encountered by Goodland & Ferri (1979) in his study.

Rainfall

The annual rainfall in the Cerrado, s.l., varies from 1,000 to 1,700 mm/year (Goedert 1982). The distribution of the precipitation is strongly seasonal. There is an annual wet season of 6 to 8 months which extends from about October to April, and a dry season of 4 to 6 months which stretches from approximately May to September. The coolest period of the year coincides with the driest.

More than 90% of the total annual precipitation occurs during the wet season which generally begins between the fifteenth of September and the fifteenth of October. The rains are usually of short duration and very intense. Frequently, there occur, during the wet season, periods of 8 to 22 days or more without rain; these periods are very unpredictable, and are called the "veranico".

Soil Fertility

In general, the soils of the Cerrado, s.l., are oxisols of various types, the most frequent of which are the red latosols (Goedert 1982). The soils are deep and well drained with good structure; consequently, they have a low capacity to retain water and are, therefore, highly leached with a low natural fertility. Because of their excellent physical properties, they are well adapted to mechanical cultivation.

The most extensive study of soil characteristics in relation to the categories of Cerrado, s.l., vegetation is that of Lopes & Cox (1977). They sampled the topsoil of 520 sites scattered over approximately one third of the Cerrado, s.l., region. Their results (Table 2) show a high correlation between vegetation type and soil fertility, low stature-low fertility, high stature-high fertility. The physionomic gradient is matched by a fertility gradient.

In general, the Cerrado, s.l., soils have a very low fertility (Table 2). The cation exchange capacity is very low, and consequently the sum of exchangeable bases (K, Ca and Mg) is also low. The acidity is relatively high, and as a result the percent saturation of Al is usually above 50% and the level of P is low. The high acidity and the levels of Al and P may be strongly influenced by the low level of Ca. The results of others (Eiten 1972, Goodland & Ferri 1979, Ribeiro et al. 1981, Haridasan 1982, Miranda et al. 1982) vary considerably from those of Lopes & Cox (1977), but the general correlation of the soil fertility gradient and the physionomic gradient persists. This variation of soil fertility in the Cerrado, s.l., is a natural consequence of the immense area of Cerrado, s.l., and the consequent variation in parent materials.

TABLE 2. Mean topsoil characteristics of four vegetation types of Cerrado, s.l., from 520 sites in central Brazil, adapted from Lopes & Cox (1977).

	Campo Limpo	Campo Cerrado	Cerrado (s.s)	Cerradão
pH (H_2O)	4.87	4.94	5.00	5.14
Organic matter (%)	2.21	2.33	2.35	2.32
Exch. Ca (meq/100 ml)	0.20	0.33	0.45	0.69
Exch. Mg (meq/100 ml)	0.06	0.13	0.21	0.38
Exch. K (meq/100 ml)	0.08	0.10	0.11	0.13
Exch. Al (meq/100 ml)	0.74	0.63	0.66	0.61
Eff. CEC (meq/100 ml)	1.08	1.19	1.43	1.81
Al saturation (%)	66	58	54	44
Extr. P	0.50	0.51	0.94	2.10
Extr. Zn	0.58	0.61	0.66	0.67
Extr. Cu	0.60	0.79	0.94	1.32
Extr. Mn	5.40	10.30	15.90	22.90
Extr. Fe	35.70	33.90	33.00	27.10
Clay (%)	33	36	34	34
Silt (%)	20	16	15	16
Sand (%)	46	48	51	53

LEGUMES OF THE CERRADO

In order to determine all the legumes known from the Cerrado, s.l., data were gathered from two sources: the herbarium of the Universidade de Brasília and from the literature. The Universidade de Brasília, with approximately 90,000 specimes in its herbarium, undoubtedly has the most representative herbarium for the Cerrado, s.l., in Brazil. Since the founding of the herbarium in 1963, it has been the central focus of taxonomic research in the Cerrado, s.l. The family *Leguminosae* was examined, and if any species was represented by specimes labeled as coming from Cerrado, s.l., vegetation, then the genus and species were considered to occur in the Cerrado, s.l. Also, any mention of habit was noted.

The principal literature on the Cerrado, s.l., was also searched. There were three useful types: 1) taxonomic check lists (Ferri 1969, Goodland 1970, Eiten 1971, Rizzini 1971, Heringer et al. 1977); 2) taxonomic revisions (Irwin & Barneby 1978, 1982, Ferreira & Costa 1979); and 3) ecological studies (Heringer 1971, Ratter et al. 1973, 1977, Warming 1973, Goodland & Ferri 1979, Cesar 1980, Ratter 1980, Ribeiro et al. 1981).

The genera and species were then compared to the literature on nodulating legumes (Allen & Allen 1981, Halliday & Nakao 1982, University of Hawaii 1983) and lists of recently discovered nitrogen fixing legumes (S.M. Faria, E.M.R. da Silva, A.A. Franco & J. Döbereiner, pers. comm.) to discover which had previously been reported as nodulated. Doubtful and questionable reports were excluded.

Table 3 presents the results of these searches. Seventy two genera and five hundred and twenty seven species of legumes are known or reported from the Cerrado, s.l. 65% of the genera have one or more species reported as nodulators, and 12% of the species are reported as nodulators. Almost none of the species reported to nodulate were examined in the Cerrado, s.l., or Brazil. The majority are either wide spread species which were investigated elsewhere or species under cultivation.

Taxonomic Organization

In 1978, the first International Legume Conference was held under the auspices of the Royal Botanic Gardens, Kew. Two thirds of the results of this conference were published in Advances in Legume Systematics (Polhill & Raven 1981). In the first part, a new classification of the subfamilies, tribes, subtribes and genera of legumes is presented. This classification is a synthesis of the knowledge of 28 of the leading taxonomists now actively working on the systematics of the legumes.

The classification is very similar to and partially based on that of Bentham (1865), as modified by Hutchinson (1964). Generally, most of the changes from the classifications of Bentham and of Hutchinson are minor reorganizations of tribes, subtribes and genera, to reflect recently discovered information in such areas as chemistry and cytology and the latest systematic studies on various scattered taxa within the legumes.

Some of the final decisions did support important existing dispositions or created new fundamental realignments. One of the most basic desicions was to maintain the grouping as a single family, with three subfamilies. Much of the newer evidence over-whelmingly supports this arrangement. Between the subfamilies, the most significant change was the transfer of tribe *Swartzieae* from subfamily *Caesalpinioideae* to a basal position in subfamily *Papilionoideae.* This repositioning is supported by wood anatomy, by nodulation proclivity and by chemistry, as well as various aspects of morphology.

TABLE 3. Genera of *Leguminosae* known or reported to occur in Cerrado, s.l., vegetation with their total number of species and the number in the Cerrado, s.l., with the number of species reported as positive or negative nodulators and their habit in the Cerrado, s.l. (T = tree; S = shrub; H = herb; V = vine).

Genus	No. of Species		Nodulation Reports				
			World		Cerrado (s.l.)		
	World	Cerrado (s.l.)	Positive	Negative	Positive	Negative	Habit
Abrus Adans.	17	1	5	-	1	-	H
Acacia Mill.	1200	4	200	11	1	-	TS
Acosmium Schott in Spreng	16	6	1	-	-	-	TS
Aeschynomene L.	150	7	44	-	4	-	HS
Amburana Schwacke & Taub.	1-2	1	-	-	-	-	-
Andira	20	8	4	1	1	-	TS
Arachis L.	60	5	10	-	1	-	HS
Bauhinia L.	250	17	0	27	-	-	TS
Bowdichia Kunth	4	3	1	1	1	1	T
Caesalpinia L.	100	1	-	15	-	1	T
Calliandra Benth.	200	9	12	3	-	1	TSH
Calopogonium Desv.	8	2	3	-	-	-	S
Camptosema Hook. & Arn.	12	8	-	-	-	-	S
Cassia L.	30	1					T
Cenostigma Tul.	6	2	-	-	-	-	TS
Centrolobium Mart. ex Benth.	6	1	-	-	-	-	-
Centrosema (DC.) Benth.	45	9	8	-	3	-	V
Chaetocalyx DC.	12	2	-	2	-	-	V
Chamaecrista Moench.	250	137					SHT
Clitoria L.	70	2	8	-	1	-	SH
Collaea DC.	3	4	-	-	-	-	S
Copaifera L.	25-30	10	1	1	-	-	TS
Cratylia Mart. ex Benth.	5	2	1	-	1	-	SV
Crotalaria L.	600	18	145	-	8	-	SH
Dalbergia L.f.	100	7	15	1	1	-	T
Desmodium Desv.	300	9	76	-	7	-	SH
Dialium L.	40	1	2	2	1	-	-
Dimorphandra Schott in Sprengel	25	3	1	-	-	-	T
Dioclea Kunth.	30	6	2	-	-	-	SV
Dipteryx Schreb.	10	2	-	1	-	-	T
Diptychandra Tul.	3	2	-	-	-	-	S
Enterolobium Mart.	5	4	3	-	-	-	T
Eriosema (DC.) G.Don	130	26	29	-	3	-	SH
Erythrina L.	108	4	30	-	1	-	T
Galactia P. Br.	55	21	6	-	-	-	SV
Harpalyce Moc. & Sesse ex DC.	20	4	-	-	-	-	S
Hymenaea L.	16	4	1	1	1	1	T
Indiofera L.	700	3	193	3	1	0	SH
Inga Mill.	350	3	14	4	-	-	TS
Lonchocarpus Kunth	100	2	11	1	-	-	-
Luetzelburgia Harms	6	1	-	-	-	-	-
Lupinus L.	200	3	56	-	-	-	H
Machaerium Pers.	120	10	5	-	2	-	TS
Mimosa L.	400-450	50	25	3	6	-	S
Myrocarpus Allem.	4	1	1	-	-	-	-

TABLE 3. Continuation

Genus	No. of Species		Nodulation Reports				
			World		Cerrado (s.l.)		
	World	Cerrado (s.l.)	Positive	Negative	Positive	Negative	Habit
Parkia R. Br.	40	1	5	2	-	-	T
Peltogyne Vogel	23	2	-	1	-	-	T
Periandra Benth.	6	6	-	-	-	-	SV
Phaseolus L.	50	17	21	-		-	VSH
Piptadenia Benth.	15	4	1	2	-	-	T
Pithecellobium Mart.	20	2	13	1	-	-	-
Plathymenia Benth.	4	2	-	-	-	-	T
Platypodium Vogel	1-2	3	-	-	-	-	TS
Poecilanthe Benth.	7	1	-	-	-	-	-
Poiretia Vent.	6	3	-	-	-	-	S
Pterocarpus Jacq.	20	1	14	-	-	-	-
Pterodon Vogel	6	2	-	-	-	-	T
Rhynchosia Lour.	200	4	57	-	1	-	VH
Riedeliella Harms	3	1	-	-	-	-	S
Schranckia Willd.	19	1	2	-	-	-	S
Sclerolobium Vogel	35	4	2	-	1	-	T
Senna Mill.	240	28					SHT
Strynphnodendron Mart.	20	8	2	-	1	-	TS
Stylosanthes Sw.	25	16	18	-	8	-	SH
Swartzia Schreber	135	8	10	-	1	-	TS
Sweetia Sprengel	1	1	-	-	-	-	-
Tephrosia Pers.	400	4	95	-	1	-	H
Tipuana (Benth.) Benth.	1	1	1	-	1	-	-
Vatairea Aubl.	7	1	-	-	-	-	T
Vigna Savi	150	1	46	-	-	-	-
Zornia J.F. Gmel.	80	7	12	-	2	-	HS

The order of presentation of subfamilies, tribes and genera has been drastically altered to agree with the idea that the most primitive member of a taxon should appear first in a linear sequence. So, the subfamilies are presented in the following sequence: *Caesalpinioideae*, *Mimosoideae* and *Papilionoideae*.

Subfamily *Caesalpinioideae*

Within the *Caesalpinioideae*, three basic lines have been recognized without any apparent extant connections between them (Polhill et al. 1981). The basal elements of these radiations are the *Gladitsia* group of genera, subtribe *Ceratoniinae* of tribe *Cassieae* and subtribe *Cercidinae* of tribe *Cercideae*. *Gladitsia* and *Gymnocladus* exhibit a number of primitive characters: functionally unisexual flowers, scarcely differentiated tepals, stigma bilobed and fruit which dehisce like a follicle. These genera are undoubtedly in a basal position on the primary radiation of the family which gave rise to the *Mimosoideae* and *Papilionoideae*. (Fig. 4).

TABLE 4. The Cerrado, s.l., genera of subfamily *Caesalpinioideae* (*Leguminosae*) in systematic order and numbered according to Polhill & Raven (1981).

1.	tribe CAESALPINIEAE	
		1c. *Sclerolobium* group
	1.4	*Sclerolobium* Vogel
	1.5	*Diptychandra* Tul.
		1e. *Caesalpinia* group
	1.21	*Cenostigma* Tull.
	1.25	*Caesalpinia* L.
		1h. *Dimorphandra* group
	1.43	*Dimorphandra* Schott in Sprengel
2.	tribe CASSIEAE	
		2b subtribe Dialiinae IB
	2.3	*Dialium* L.
		2d. subtribe Cassiinae
	2.16	*Cassia* L. emend Gaert.
	2.17	*Senna* Mill.
	2.18	*Chamaecrista* Moench
3.	tribe CERCIDEAE	
		subtribe Bauhiniinae
	3.4	*Bauhinia* L.
4.	tribe DETARIEAE	
		4c. Hymenaea group
	4.22	*Peltyogyne* Vogel
	4.23	*Hymenaea* L.
		4e. *Detarium* group
	4.43	*Copaifera* L.

Flowers of *Ceratonia* are unisexual, lack petals and have an exposed disc which produces nectar. This genus is in a basal position to the less extensive radiation which gave rise to the assemblage of *Cassia*, s.l. (Polhill et al. 1981).

Cercideae have a calyx tube and a well developed corolla, but their bilobed leaves with palmate nervation and their seeds with the lens above the micropyle rather than below are characteristics encountered nowhere else in the legumes. Also, *Cercis* is the only genus in the family to have retained the basic chromosome number, n = 7 (Goldblatt 1981). This relatively limited radiation has led to the genus *Bauhinia* (Polhill et al. 1981).

Tribe *Caesalpinieae* comes first in the linear order because it has the most primitive genera in the family, *Gleditsia* and *Gymocladus*, as members. In the Cerrado, s.l., it is represented by five genera and twelve species (Tables 3 and 4). Two genera, *Sclerolobium* and *Dimorphandra*, are reported as nodulators; one, *Caesalpinia*, as a non-nodulator; and two, *Diptychandra* and *Cenostigma*, have not been examined. The most primitive members of the tribe are not present in the Cerrado, s.l., but scattered members of the other major groupings are represented. *Sclerolobium* and *Diptychandra* are members of the *Sclerolobium* group of genera which occupy a central position within the tribe intermediate between subfamily *Papilionoideae*, the *Caesalpinia* group and the tribe *Detarieae*. The *Caesalpinia* group is represented by *Cenostigma* and *Caesalpinia*, while the *Dimorphandra* group is represented only by the genus *Dimorphandra*. The latter group is important as the connecting link to subfamily *Mimosoideae*. The tribe is not richly represented by species in the Cerrado, s.l., but all of its various levels of advancement and more important, pivotal generic groups are each sparsely represented.

The next tribe in linear order (Table 4) is *Cassieae*. This is the radiation which has resulted in *Cassia*, s.l. Irwin & Barneby (1981) have significantly reorganized the tribe. They created five subtribes which represent the levels of advancement attained within the tribe, and the ultimate subtribe, *Cassiinae*, is *Cassia*, s.l., of Bentham (1871), divided into three genera, *Cassia* L. emend Gaertner, s.s., *Senna* Mill. and *Chamaecrista* Moench. Rizzini (1971) has reported that *Dialium guianensis* (Aubl.) Sandw. is a constituent of Cerrado, s.l., vegetation, but Bentham (1870) reported it to occur only in forests of Amazônia and of coastal Bahia. For this reason, I doubt the report of its occurrence in Cerrado, s.l., vegetation. Consequently, this radiation is represented in the Cerrado, s.l., only by *Cassiinae*. Its species comprise 31% of the legume flora of the Cerrado, s.l. Irwin and Barneby's generic reorganization (1982), based on floral characters, is significant because the non-nodulators occur in *Cassia*, s.s., and *Senna* and the nodulators in *Chamaecrista* (Corby 1981, Irwin & Barneby 1982); the systematic arrangement, based on morphological characters, corresponds with the ability or lack of it to nodulate. *Chamaecrista*, with 137 species in the Cerrado, s.l., is dominated by shrubs and herbs with few trees.

Tribe *Cercideae* is the third major radiation within the *Caesalpinoideae*. It is even more limited than the *Cassieae;* two levels of advancement have been recognized within it, subtribe *Cercidinae*, the more primitive, and subtribe *Bauhiniinae*, the more advanced (Wunderlin et al. 1981). *Bauhinia* is the only member of the tribe known in the Cerrado, s.l., but it has been reported to be a non-nodulator.

The final tribe, *Detarieae*, in a linear order with representatives in the Cerrado, s.l., is part of a secondary radiation which has concentrated on co-adaptation with animals and consequently has great variation in its floral structures (Cowan & Polhill 1981). Some the largest, finest legume trees in the Cerrado, s.l., occur in this tribe, species of *Copaifera* and *Hymenaea*. The third Cerrado, s.l., genus of this tribe, *Peltyogyne*, has been reported to be a non-nodulator. The nodulation status of *Copaifera* and *Hymenea* is unclear; *C. officinalis* (Jacq.) L and *H. courbaril* L. have been reported on different occasions to be nondulators or non-nodulators (Allen & Allen 1981).

In the *Caesalpinioideae*, the genera and species found are the more advanced ones in the tribe: The *Cassiinae* have undergone explosive radiation in the Cerrado, s.l., and dominate all the other genera with 79% of the *Caesalpinoideae* species.

Subfamily *Mimosoideae*

The subfamily *Mimosoideae*, with approximately one third as many genera as the *Caesalpinoideae*, is organizationally simpler. There are three principal groups within the *Mimosoideae*, the tribes *Mimoseae*, *Acacieae* and *Ingeae* (Table 5, Elias 1981). The *Mimoseae* is the least advanced of the three, with various phenetic links with the *Dimorphandra* group of *Caesalpinioideae*. Its members are frequent in the Cerrado, s.l., and commonly trees of low stature. It has been broken up into a series of twelve generic groups based on complexes of characters (Lewis & Elias 1981). The *Plathymenia* group consists solely of the South American genus *Plathymenia* which has characteristics in common with the *Entada* group and links to the *Dimorphandra* group. The *Piptadenia* group is also apparently linked more or less directly to the *Dimorphandra* group. The group is held together by only two characters, compound pollen and a style tip narrowed to a small porate stigma, but is otherwise very diverse in its floral structure and could

TABLE 5. The Cerrado, s.l., genera of subfamily *Mimosoideae* in systematic order and numbered according to Polhill & Raven (1981).

1.	tribe PARKIEAE	
	1.2	*Parkia* R. Br.
3.	tribe MIMOSEAE	
		3g. *Plathymenia* group
	3.14	*Plathymenia* Benth.
		3l. *Piptadenia* group
	3.19	*Stryphnodendron* Mart.
	3.21	*Piptadenia* Benth.
	3.27	*Mimosa* L.
	3.28	*Schranckia* Willd.
4.	tribe ACACIEAE	
	4.2	*Acacia* Mill.
5.	tribe INGEAE	
	5.2	*Inga* Mill.
	5.6	*Enterolobium* Mart.
	5.7	*Calliandra* Benth.
	5.8	*Pithecellobium* Mart.

be divided into two groups based on seed and fruit characters (Lewis & Elias 1981). *Stryphnodendron* and *Piptadenia* form a pair of genera with *Stryphnodendron,* most similar to the *Dimorphandra* group. *Mimosa* and *Schranckia* form a second more advanced pair, with phenetic links between *Piptadenia* and *Mimosa. Stryphnodendron* and *Schrankia* are reported as nodulators, while *Piptadenia* and *Mimosa* are reported to have both nodulating and non-nodulating species.

Acacieae and *Ingeae* are the more advanced groups, and they are closely related, separated only by free filaments in *Acacieae* and united filaments in the *Ingeae. Acacieae* consists of but tow genera: *Faidherbia* A. Chev., which is monotypic and endemic to tropical and subtropical Africa, and *Acacia (Vassal 1981). Acacia* is pantropical with about 1,200 species of which over half are found in Australia. *Acacia* is predominately a nodulator, but does have various non-nodulated species. It is represented in the Cerrado, s.l., by only four species.

Tribe *Ingeae* is a serious taxonomic problem (Nielsen 1981). Generic boundaries within this tribe have fluctuated wildy and are still uncertain for some genera. Three of the Cerrado, s.l., genera, *Inga, Calliandra* and *Pithecellobium,* are reported to have nodulating and non-nodulating species. *Enterlobium* is known so far to have only nodulating species, and is also very similar to *Albizia* Durazz. where its species could be accomodated easily (Nielsen 1981).

Elias (1981) has pointed out the anomalous character of tribe *Parkieae. Pentaclethra* and *Parkia* are joined together in the tribe by their united, imbricated sepals. *Pentaclethra* is one of the most primitive genera in the subfamily, and *Parkia* is one of the most advanced, probably an off-shoot of the *Ingeae* (Elias 1981). One species of *Parkia* occurs in the Cerrado, s.l.

The *Mimosoideae* has all of its main lines of radiation represented in the Cerrado, s.l. Although its species total is approximately 50% greater than that of the *Caesalpinioideae,* in the Cerrado, s.l., it only has 42% as many species as the *Caesalpinioides*. Its larger genera, that is *Acacia* with 1,200 species, *Mimosa* with 400-450 species and *Inga* with approximately 350 species, have not explosively radiated into the Cerrado, s.l., as *Chamaecrista* has.

Subfamily *Papilionoideae*

The subfamily *Papilionoideae*, with twice as many genera and two and a half times as many species as the *Caesalpinioideae* and *Mimosoideae* combined, has a more complex and ramified radiation. In the last few years, there has been a general grouping of tribes into five main lines: the tribe *Sophoreae*, the genistoide alliance, the galegoid complex, the advanced tropical tribes and the temperate epulvinate series (Polhill et al. 1981, Polhill 1981).

The *Sophoreae* is the diverse basal group which is linked, via tribe *Swartzieae*, to the *Sclerolobium* group of tribe *Caesalpinieae* (Polhill et al. 1981, Polhill 1981). The *Swartzieae*, in their flower structure, are equal to the *Caesalpinioideae*, but their wood anatomy, nodulation and chemistry link them intimately to the *Papilionoideae* (Cowan 1981, Polhill 1981, Polhill et al. 1981). The *Swartzieae* and the *Sophoreae* are the grouping of genera with free stamens. In the *Sophoreae*, there is a general trend from the *Caesalpinioideae androecium* and corolla to that typical of the *Papilionoideae*, with all of the various intermediate grades present.

The *Swartzeae* are represented only by the genus *Swartzia* in the Cerrado, s.l. (Table 6). The *Sophoreae* are reported to be represented by six genera. The *Sophoreae* can be divided into three general levels of increasing flower specialization (Polhill 1981 a): 1) flowers regular, *Cadia* group with *Acosmium* and *Myrocarpus* in the Cerrado, s.l.; 2) flowers with the vexillum differentiated and the other four petals more or less equal, *Myroxylon* group with *Sweetia*, *Luetzelburgia* and *Amburiana*; and 3) flowers with progressive differentiation of the wings and keel-petals, *Dussia* group with *Bowdichia*.

The huge galegoid complex dominates the center of the subfamily. It is separated from the *Sophoreae* by union of the stamens, presence of canavanine and general stabilization of the base chromosome number at x = 11 or 10 in the tropical woody members (Polhill et al. 1981). The Cerrado, s.l., members of the complex are from the tribes *Dipteryxeae*, *Dalbergieae* and *Abreae*. *Dipteryxeae* with *Dipteryx* and *Pterodon* in the Cerrado, s.l., and *Dalbergieae* with nine genera are typical members of the complex. Their genera are important constituents of the arboreal flora and produce some of the finest quality woods for cabinet making. The *Abreae* with but a single genus, *Abrus*, are considered to be an outlier of the complex (Polhill 1981 b). The only member of the genus known rarely from the Cerrado, s.l., is *A. precatorius* L. whose origin is uncertain and often considered as an Asian species introduced into the New World (Bentham 1859-62).

The temperate epulvinate series is easily distinguished by absence of the basal foliar pulvinus, closure of the vascular system and leaves tending to be distichous and with phloem transfer cells (Polhill et al. 1981). As its name indicates, practically all of its members are temperate and also mainly herbaceous. The series is absent from the Cerrado, s.l., and so will not be treated further.

The remainder of the pulvinate series (the advanced tropical tribes) can be subdivided into a core, the *Tephrosieae*, and a series of advanced, mainly tropical tribes which cluster about it. The group as a whole shows increased specialization and variation in floral structure and reduced variation in root nodules, leaves, inflorescences, fruits, seeds and seedlings (Polhill et al. 1981). The *Tephrosieae*, as traditionally

TABLE 6. The Cerrado, s.l., genera of subfamily *Papilionoideae* (*Leguminosae*) in systematic order and numbered according to Polhill & Raven (1981).

1.	tribe SWARTZIEAE	
	1.2	*Swartzia* Schreber
2.	tribe SOPHOREAE	
		2a. *Cadia* group
	2.2	*Acosmium* Schott in Sprengel
	2.3	*Myrocarpus* Allem
		2b. *Myroxylon* group
	2.10	*Sweetia* Sprengel
	2.11	*Luetzelburgia* Harms
	2.13	*Amburana* Schwacke & Taub.
		2g. *Dussia* group
	2.34	*Bowdichia* Kunth
3.	tribe DIPTERYXEAE	
	3.1	*Dipteryx* Schreb.
	3.3	*Pterodon* Vogel
4.	tribe DALBERGIEAE	
	4.1	*Andira* A.L. Juss.
	4.3	*Vatairea* Aubl.
	4.5	*Machaerium* Pers.
	4.6	*Dalbergia* Linn. f.
	4.8	*Centrolobium* Mart. ex Benth.
	4.10	*Pterocarpus* Jacq.
	4.11	*Tipuana* (Benth.) Benth.
	4.12	*Platypodium* Vogel
	4.17	*Riedeliella* Harms
5.	tribe ABREAE	
	5.1	*Abrus* Adans.
6.	tribe TEPHROSIEAE	
		Lonchocarpus Kunth.
		Poecilanthe Benth.
		Tephrosia Pers.
8.	tribe INDIGOFEREAE	
	8.2	*Indigofera* L.
9.	tribe DESMODIEAE	
		subtribe Desmodiinae
	9.9	*Desmodium* Desv.
10.	tribe PHASEOLEAE	
		10a. subtribe Erythrininae
	10.1	*Erythrina* L.
		10b. subtribe Diocleinae
	10.10	*Dioclea* Kunth
	10.17	*Camptosema* Hook. & Arn.
	10.18	*Cratylia* Mart. ex Benth.
	10.19	*Collaea* DC.
	10.20	*Galactia* P. Browne
	10.21	*Calopogonium* Desv.

TABLE 6. Continuation

		10f. subtribe Clitoriinae
	10.45	*Centrosema* (DC.) Benth.
	10.46	*Periandra* Benth.
	10.47	*Clitoria* L.
		10g. subtribe Phaseolinae
	10.65	*Vigna* Savi
	10.71	*Phaseolus* L.
		10h. subtribe Cajaninae
	10.81	*Rhynchosia* Lour.
	10.82	*Eriosema* (DC.) G. Don
14.	tribe AESCHYNOMENEAE	
		14a. subtribe Ormocarpinae
	14.6	*Chaetocalyx* DC.
		14b. subtribe Aeschynomeninae
	14.8	*Aeschynomene* L.
		14d. subtribe Poiretiinae
	14.19	*Poiretia* Vent.
	14.20	*Zornia* J.F. Gmel.
		14e. subtribe Stylosanthinae
	14.24	*Stylosanthes* Swartz
	14.25	*Arachis* L.
24.	tribe BRONGNIARTIEAE	
	24.2	*Harpalyce* Moc. & Sesse ex DC.
29.	tribe CROTALARIEAE	
	29.6	*Crotalaria* L.
32.	tribe GENISTEAE	
		32a. subtribe Lupininae
	32.1	*Lupinus* L.

organized into genera, have a number a inseparable genera (Geesink 1981), and their reorganization is continuing. Around the *Tephrosieae* are various advanced tribes of which five are found in the Cerrado, s.l.: *Indigofereae, Desmodieae, Phaseoleae, Aeschynomeneae* and *Brongniartieae.* These are principally New World tribes except for *Phaseoleae* that is pantropical. Of the five tribes, it has the most representatives in the Cerrado, s.l., with fourteen genera which are either vines, shrubs or herbs except *Erythrina* which is reported to have four arboreal species. Next in importance in the Cerrado, s.l., is the *Aeschynomeneae* with six genera. There is special emphasis on members of this tribe in the Brazilian agricultural research because some genera, especially *Stylosanthes,* offer promise in pasture improvement and because the center of diversity of *Arachis* is in the drier areas of Brazil. The *Indigofereae* and *Desmodieae* are represented in the Cerrado, s.l., by only their type genera, both of which are large, diverse and pantropical. Polhill (1981) has suggested that the *Brongniartieae* have tribal status only because they have a straight radicle combined with a relatively advanced flower, and inferred that the tribe could easily be accomodated within the *Tephrosieae.* It is represented in the Cerrado, s.l., by four species of *Harpalyce,* all shrubs.

The genistoid alliance is a lateral group which has evolved in areas of Mediterranean climate all over the world, with two main lines: one in the southern hemisphere and another in the northern hemisphere (Polhill et al. 1981, Polhill 1981). Many of the specializations of other groups are brought together here, but the trends do not seem to resemble those of the other groups. *Crotalaria* of the *Crotalarieae* and *Lupinus* of the *Lupinineae* are encountered in the Cerrado, s.l. These are two of the most advanced genera in the alliance which suggest that the Cerrado, s.l., is not a major center of development for the alliance and that only its most advanced members have come into the Cerrado, s.l., after they had undergone evolution and dispersal.

The *Papilionoideae* is represented in the Cerrado, s.l., by all of the major tropical radiations which are present in the New World. The genistoid alliance is represented by its most advanced members which were probably the results of later introductions. The temperate epulvinate series is not represented at all. Like the *Mimosoideae*, no one genus in the *Papilionoideae* has adapted and radiated explosively as has *Chamaecrista*. Consequently, the *Papilionoideae* has just 252 species in the Cerrado, s.l., which is only 19% more than the *Caesalpinioideae*, altough there are six times as many species in *Papilionoideae* than in *Caesalpinioideae*.

RECOMMENDATIONS

In the subfamily *Caesalpinioideae*, special effort to determine nodulation capacity should be concentrated on members of the tribe *Caesalpinieae*, the genus *Chamaecrista* and the tribe *Detarieae*. *Caesalpinieae* has some fine arboreal species, such as those of *Sclerolobium* and *Dimorphandra*, which are very frequent in the Cerrado, s.l. *Chamaecrista*, with 137 species reported from the Cerrado, s.l., has the greatest variation of any legume genus, and with the recent excellent revision of Irwin & Barneby (1978, 1982) will be easy to work with. *Detarieae* has some of the finest Cerrado, s.l., trees in the genera *Hymenea* and *Copaifera*, but so far the nodulation reports for these genera are conflicting and need clarification.

In subfamily *Mimosoideae*, special study should be concentrated on tribe *Mimoseae* and the genus *Enterolobium*. Within *Mimoseae* occur several genera of high frequency, such as *Stryphnodendron* and the genus *Mimosa*, which with 50 species or more is the second largest legume genus in the Cerrado, s.l., and is also very variable. *Enterolobium* is a frequent arboreal element in the Cerrado, s.l.

In subfamily *Papilionoideae*, effort should be concentrated on tribes *Dipteryxeae*, *Dalbergieae*, *Phaseoleae* and *Aeschynomene*, and on the genera *Swartzia*, *Acosmium* and *Bowdichia*. *Dipteryxeae* and *Dalbergieae* have the majority of the arboreal species in the subfamily and produce some of the finest cabinet woods found in the Cerrado, s.l. *Phaseoleae* and *Aeschynomeneae* are now the focci of intense research into pasture management and improvement. The genera *Swartzia*, *Acosmium* and *Bowdichia* contain arboreal species of significant stature and high frequency in the Cerrado, s.l.

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APPENDIX

Check list of the species of *Leguminosae* known or reported from the Cerrado, s.l.

Abrus Adans.
precatorius L.[a]

Acacia Mill.
adhaerens Benth.[a], *farnesiana* (L.) Willd.[a], *paniculata* Willd.[a], *plumosa* Lowe[a,p]

Acosmium Schott in Sprengel
brachystachyum (Benth.) Yakovl.[a,p], *dasycarpum* (Vog.) Yakovl.[a,p], *elegans* (Vog.) Yakovl.[p], *glabrifolium* (Tul.) Yakovl.[p], *nitens* (Vog.) Yakovl.[a], *pseudoelegans* Yakovl.[e]

Aeschynomene L.
brasiliana (Poir.) DC.[a], *falcata* (Poir.) DC.[a,q], *histrix* Poir.[a], *marginata* Benth.[a], *oroboides* Benth.[a], *paniculata* Willd.[a,p], *paucifolia* Vog.[a,g]

Amburana Schwacke & Taub.
cearense (Allem.) A.C. Smith[g]

Andira A.L. Juss.
cuyabensis Benth.[a,p], *humilis* Mart. ex Benth.[a,p], *inermis* H.B.X.[p], *laurifolia* Benth.[p], *paniculata* Benth.[a,l], *pisonis* Mart.[a], *stipulacea* Benth.[m], *vermifuga* Mart.[a,p]

Arachis L.
glabrata Benth.[r], *marginata* Gardn.[r], *lutescens* Krap. & Rigoni[r], *prostrata* Benth.[a], *tuberosa* Benth.[r]

Bauhinia L.
bongardi Steud.[a,p], *burchellii* Benth.[a,f], *caloneura* Malme[p], *cheilantha* (Bong.) Benth.[a,i], *cunamensis* H.B.K.[a,p], *cupulata* Benth.[a,n], *curvula* Benth.[a], *depauperata* Glaz.[a], *dumosa* Benth.[a,b], *goyazensis* Harms[a,m], *holophylla* Steud.[p], *leiopetala* Glaz.[a], *nitida* Benth.[a,e], *pulchella* Mart.[p], *rubiginosa* Bong.[a], *rufa* (Bong.) Steud.[a,p], *tenella* Benth.[a,f,h]

Bowdichia Kunth
major (Mart.) Benth.[p], *virgilioides* H.B.K.[a,p]

Caesalpinia L.
pulcherrima (L.) Sw.[a]

Calliandra Benth.
axillaris Benth.[a], *dysantha* Benth.[a,l], *longipes* Benth.[a], *macrocephala* Benth.[a], *microphylla* Benth.[a,m], *parviflora* Benth.[a,p], *pauciflora* Griseb.[a], *virgata* Benth.[a]

Calopogonium Desv.
caerulescens Hemsl.[q], *sericeum* Benth.[a]

Camptosema Hook. & Arn.
coccineum Benth.[a], *coriaceum* (Nees. & Mart.) Benth.[a,p], *goiasana* Cowan[a], *isopetala* (Lam.) Benth.[c], *nobile* Lindm.[p], *pedicellatum* Benth.[a], *scarlatinum* (Mart. ex Benth.) Burk.[a], *tomentosum* Benth.[a,p]

Cassia L. emend Gaert.
ferruginea (Schrader) DC. var. *ferruginea*[a,k]

Cenostigma Tul.
gardnerianum Tul.[a,p], *macrophyllum* Tul.[a]

Centrolobium Mart. ex Benth.
tomentosum Benth.[p]

Centrosema (DC.) Benth.
angustifolium (H.B.X.) Benth.[a,q], *bifidum* Benth.[a], *bracteosum* Benth.[a,c], *brasilianum* Benth.[a,q], *coriaceum* Benth.[a], *dasyanthum* Benth.[q], *hastatum* Benth.[q], *pascuorum* Mart.[a], *venosum* Mart.[a]

Chaetocalyx DC.

brasiliens (Vog.) Benth.[a], *hebecarpa* Benth.[a]

Chamecrista Moench

acosmifolia (Benth.) IB[a, j, k], *adenophora* (Harms) IB[a, j, k], *adenophylla* (Taub.) IB[a], *amambaya* (IB) IB[j, k], *apoucouita* (Aubl.) IB[a], *astrochiton* (IB) IB[a, j, k], *auris-zerdae* (IB) IB[j, k], *aurivilla* (Benth.) IB[a, j, k], *azulana* (IB) IB[j, k], *basifolia* (Vog.) IB[a, j, k], *benthami* (Ghesquiere) IB[j, k], *benthamiana* (Harms) IB[a, j, k], *bifoliola* (Harms) IB[a, j, k], *brachyblepharis* (Harms) IB[j, k], *brachyrachis* (Harms) IB[a, j, k], *bracteolata* (Vog.) IB[a], *brevicalyx* (Benth.) IB[a, j, k], *burchellii* (Benth.) IB[j, k], *caespitosa* (Benth.) IB[a, j, k], *caiapo* (IB) IB[j, k], *calycioides* (Coll.) Greene[a, j, k], *campestris* IB[j, k], *campicola* (Harms) IB[a, j, k], *cardiostegia* IB[a, k], *cathartica* (Mart.) IB[a, j, k], *catiarae* (IB) IB[j, k], *cavalcantina* (IB) IB[a, j, k], *celiae* (IB) IB[a, j, k], *centiflora* (IB) IB[j, k], *chaetostegia* (IB) IB[a, j, k], *choriophylla* (Vog.) IB[a, j, k], *ciliolata* (Benth.) IB[a, j, k], *cipoana* (IB) IB[a, j, k], *clausseni* (Benth.) IB[a, j, k], *continifolia* (G. Don) IB[a, j, k], *crenulata* (Benth.) IB[a], *cristalinae* (IB) IB[a, j, k], *crommyotricha* (Harms) IB[a, j, k], *cytisoides* (Coll.)IB[a, j, k], *dalbergiifolia* (Benth.) IB[a], *dawsonii* (Cowan) IB[a, j, k], *debilis* (Vog.) IB[a], *decrescens* (Benth.) IB[a], *decumbens* (Benth.) IB[a, j, k], *densifolia* (Benth.) IB[a, j, k], *dentata* (Vog.) IB[a, j, k], *desertorum* (Benth.) IB[a, j, k], *desvauxii* (Coll.) Killip[a, j, k], *diphylla* (L.) Greene[a, j, k], *distichoclada* (Benth.) IB[a, j, k], *dumalis* (Hoehne) IB[a, j, k], *elachistophylla* (Harms) IB[j, k], *exsudans* (Benth.) IB[j, k], *fagonioides* (Vog.) IB[a, j, k], *fasciculata* (Mich.) Greene[a, j, k], *feliciana* (IB) IB[a, j, k], *filicifolia* (Benth.) IB[a, j, k], *flexuosa* (L.) Greene[a, j, k], *foederalis* (IB) IB[a, j, k], *fragilis* (IB) IB[a, j, k], *geminata* (Benth.) IB[a, j, k], *gilliesii* (Harms) IB[j, k], *gonoclada* (Benth.) IB[j, k], *gymonothyrsa* (IB) IB[a, j, k], *hedysaroides* (Vog.) IB[a, j, k], *huntii* (IB) IB[a, j, k], *imbricans* (IB) IB[a, j, k], *incana* (Vog.) IB[a, j, k], *incurvata* (Benth.) IB[a], *isidorea* (Benth.) IB[a, j, k], *itambana* (Benth.) IB[j, k], *ixodes* (IB) IB[j, k], *juruenensis* (Hoehne) IB[a, j, k], *kunthiana* (Schlect. & Cham.) IB[a, j, k], *labouriaeae* (IB) IB[j, k], *lamprosperma* (Benth.) IB[j, k], *lavradiiflora* (Harms) IB[a, j, k], *lavradioides* (Benth.) IB[a, j, k], *lentiscifolia* (Benth.) IB[j, k], *leucopilis* (Harms) IB[a], *lomatopoda* (Benth.) IB[a], *lundii* (Benth.) IB[a, j, k], *macedoi* (IB) IB[j, k], machaeriifolia (Benth.) IB[a, j, k], *mollicaulis* (Harms) IB[a, j, k], *multinervia* (Benth.) IB[j, k], *multiseta* (Benth.) IB[a, j, k], *neesiana* (Benth.) IB[a, j, k], *nictitans* (L.) Moench[a, j, k], *nummulariifolia* (Benth.) IB[a, j, k], *obtecta* (Benth.) IB[a, j, k], *ochnoacea* (Vog.) IB[a, j, k], *ochrosperma* (IB) IB[j, k], *oligosperma* (Benth.) IB[a, j, k], *orbiculata* (Benth.) IB[a, j, k], *pachyclada* (Harms) IB[a, j, k], *paniculata* (Benth.) IB[a, j, k], *paraunana* (IB) IB[a, j, k], *parvistipula* (Benth.) IB[a, j, k], *pascuorum* (Benth.) IB[a, j, k], *philippi* (IB) IB[j, k], *pilosa* (L.) Greene[a, j, k], *planaltoana* (Harms) IB[a, j, k], *pohliana* (Benth.) IB[a, j, k], *polita* (IB) IB[a, j, k], *ramosa* (Vog.) IB[a, j, k], *repens* (Vog.) IB[a, j, k], *rigidifolia* (Benth.) IB[a, j, k], *roncadorensis* (IB) IB[a, j, k], *roraimae* (Benth.) Gleason[a, j, k], *rugosula* (Benth.) IB[j, k], *rotundata* (Vog.) IB[a, j, k], *rotundifolia* (Pers.) Greene[a, j, k], *scabra* (Benth.) IB[a], *secunda* (Benth.) IB[j, k], *serpens* (L.) Greene[a, j, k], *seticrenata* (IB) IB[j, k], *setosa* (Vog.) IB[a, j, k], *sophoroides* (Benth.) IB[a, j, k], *souzana* (IB) IB[j, k], *spinulosa* (IB) IB[a], *stillifera* (IB) IB[a], strictula (IB) IB[a, j, k], *subdecrescens* (IB) IB[a, j, k], *supplex* (Benth.) Britton & Rose ex Britton & Killip[a, j, k], *tephrosiifolia* (Benth.) IB[j, k], *tragacanthoides* (Benth.) IB[a, j, k], *trichopoda* (Benth.) Britton & Rose ex Britton & Killip[a, j, k], *urophyllidia* (IB) IB[a, j, k], *ursina* (Benth.) IB[a, j, k], *venatoria* (Benth.) IB[a, j, k], *venulosa* (Benth.) IB[j, k], *viscosa* (H.B.K.) IB[a, j, k], *xanthadena* (Benth.) IB[j, k], *zygophylloides* (Taub.) IB[a, j, k]

Clitoria L.

densiflora (Benth.) Benth.[q], *guianensis* Benth.[a, g]

Collaea DC.

decumbens Benth.[q], *glaucescens* (H.B.K.) Benth.[q], *macrophylla* Benth.[q], *neesii* (DC.) Benth.[a]

Copaifera L.
cordifolia Hayne[a], *coriacea* Mart.[p], *elliptica* Mart.[a], *langsdorffii* Desf.[a, p], *luetzelburghii* Harms[a], *malmei* Harms[a, p], *martii* Hayne[a, p], *nana* Rizz.[a], *oblongifolia* Mart.[a, p], *trapezifolia* Hayne[a]
Cratylia Mart. ex Benth.
argentea Desv.[a], *floribunda* Benth.[a]
Crotalaria L.
anagyroides H.B.K.[a, p], *breviflora* DC.[q], *depauperata* Mart.[c], *flavicoma* Benth.[a, q], *incana* L.[a], *juncea* L.[a], *leptophylla* Benth.[c], *maypurensis* H.B.K.[c], *nitens* H.B.K.[a], *paulina* Schrank.[a], *pohliana* Benth.[q], *pterocaulon* Desv.[a, q], *retusa* L.[f], *stipularis* Desv.[a, q], *unifoliata* Benth.[a, h], *velutina* Benth.[a, q], *vespertilio* Benth.[a]
Dalbergia Linn. f.
ferrugineo-tomentosa Hoehne[p], *glandulosa* Benth.[a], *gracilis* Benth.[a], *hiemalis* Malme[p], *miscolobium* Benth.[a], *spruceana* Benth.[p], *violacea* (Vog.) Malme[a, p]
Desmodium Desv.
asperum (Desv.) Poir.[a], *barbatum* (L.) Benth.[a], *canum* (Gmel.) Schinz. & Thell.[c], *discolor* Vog.[a], *leiocarpum* D. Don[a], *pachyrhizum* Vog.[q], *platycarpum* Benth.[a, q], *procumbens* (Mill.) Hitch[a], *sclerophyllum* Benth.[a]
Dialium L.
guianense (Aubl.) Sandw.[p]
Dimorphandra Schott in Sprengel
biretusa Tul.[a], *gardneriana* Tul.[a, p], *mollis* Benth.[a, p]
Dioclea Kunth
bicolor Benth.[a], *coriacea* Benth.[a], *erecta* Hoehne[p], *latifolia* Benth.[a], *paraguayensis* Benth.[a], *virgata* (Rich.) Amsh.[a]
Dipteryx Schreb.
alata Vog.[a, p], *odorata* (Aubl.) Willd.[a]
Diptychandra Tul.
aurantica Tul.[a, p], *glabra* Benth.[a, p]
Enterolobium Mart.
contortisiliquum (Vell.) Morong[p], *ellipticum* Benth.[a, p], *incuriale* (Vell.) Kuhlm.[p], *gummiferum* (Mart.) MacBr.[i]
Eriosema (DC.) G. Don
benthamianum Mart. ex Benth.[a, q], *brachyrhachis* Harms[a], brevipes Grear[a], *campestris* Benth.[h], *congestum* Benth.[a, l], *crinitum* (H.B.K) Don[a, c], *cupreum* Harms[a], *defoliolatum* Benth.[h], *floribundum* Benth.[a], *glabrum* Mart. ex Benth.[a], *glaziovii* Harms[a], *heterophyllum* Benth.[a, c], *irwinii* Grear[a], *lagoense* Micheli[q], *longiflorum* Benth.[a], *longifolium* Benth.[q], *prorepens* Benth.[a], *pycnanthum* Benth.[a, q], *rigidum* Benth.[a, l], *rufum* (H.B.K.) G. Don[a, q], *simplicifolium* (H.B.K.) G. Don[a, q], *stipulare* Benth.[a], *strictum* Benth.[q]

Erythrina L.
dominguezzi Hasseler[a], *falcata* Benth.[p], *mulungu* Mart.[p], *velutina* Willd.[p]
Galactia P. Browne
benthamiana Micheli[q], *boavista* (Vell.) Burk.[a], *crassifolia* (Benth.) Taub.[a, l], *decumbens* (Benth.) Hoehne[a, c], *dimorpha* Burk.[a], *eriosematoides* Harms[a], *glaucesens* H.B.K.[a, p], *greweiaefolia* (Benth.) Taub.[a, h], *heringerii* Burk.[a], *hoehnei* Burk.[a], *irwinii* Cowan[a], *martii* Benth.[a], *nana* Burk.[a], *neesii* DC.[a], *peduncularis* (Benth.) Burk.[a, l], *previaefolia* (Benth.) Taub.[b], *rhynchosoides* Benth.[a], *speciosa* (DC.) Brit.[a], *stereophylla* Harms[a, b]

Harpalyce Moc. & Sesse ex DC.
brasiliana Benth.[a, p], *lepidota* Taub.[a], *parvifolia* Irwin & Arroyo[a], *robusta* Irwin & Arroyo[a]
Hymenaea L.
courbaril L.[a, p], *martiana* Hayne[a, p], *stigonocarpa* Mart.[a, p], *stilbocarpa* Hayne[g]
Indiogofera L.
gracilis Bong.[a, g], *lespedezioides* H.B.K.[a, q], *suffruticosa* Mill.[a, c]
Inga Mill.
affinis DC.[a, p], *fagifolia* Willd.[a, p], *umbellifera* (Vahl) Steud.[a]
Lonchocarpus Kunth
campestris Mart.[p], *spruceanus* Benth.[p]
Luetzelburgia Harms
praecox (Harms) Malme[h, p]
Lupinus L.
crotalarioides Mart. ex Benth.[q], *vaginans* Benth.[a], *velutinus* Benth.[b]
Machaerium Pers.
aculeatum Raddi[a, p], *acutifolium* Vog.[a, p], *amplum* Benth.[a, p], *angustifolium* Vog.[i], *eriocarpum* Benth.[p], *lanatum* Tul.[p], *mucronulatum* Mart.[a], *oblongifolia* Vog.[a], *opacum* Vog.[a, p], *villosum* Vog.[p]
Mimosa L.
adenocarpa Benth.[a], *albida* H. & B.[c], *angusta* Benth.[a], *arachnoides* Taub.[c], *asperata* L.[a], *barbigera* Benth.[a], *brachycarpa* Benth.[a], *brachycaulis* Harms[l], *calycina* Benth.[q], *capillipes* Benth.[c, h], *claussenii* Benth.[a, b], *conferta* Benth.[a, i], *debilis* Mart.[a], *densa* Benth.[a, h], *distans* Benth.[q], *dumetorum* St.-Hil.[a], *gardneri* Benth.[a], *goyazensis* Benth.[a], *gracilis* Benth.[a, b], *hapaloclada* Malme[p], *imbricata* Benth.[a, h], *invisa* Mart.[a, q], *lanata* Benth.[a, h], *lanuginosa* Glaz. ex Burk.[a, b], *lasiocarpa* Benth.[q], *laticifera* Rizz. & Mattos[a, p], *microcarpa* Benth.[a], *nervosa* Bong.[q], *neurolema* Benth.[c], *obovata* Benth.[a], *paludosa* Benth.[a], *paucifolia* Benth.[h], *pigra* L.[a], *pithecolobioides* Benth.[a], *platyphylla* Benth.[p], *polycarpa* Benth.[l], *pteridifolia* Benth.[a], *radula* Benth.[a, l], *rixosa* Mart.[a, c], *sensitiva* L.[q], *setosa* Benth.[a, h], *somnians* H. & B.[a], *stipularis* Bong.[a], *subsericea* Benth.[c], *viscosa*[a], *xanthocentra* Mart.[q]
Myrocarpus Allem
fastigiatus Allem.[p]
Parkia R. Br.
platycephala Benth.[a, p]
Peltogyne Vog.
confertiflora (Hayne) Benth.[a, i], *maranhensis* Ducke[a]
Periandra Benth.
acutifolia Benth.[a], *densiflora* Benth.[a], *dulcis* Mart.[b, g], *heterophylla* Benth.[a, q], *mediterranea* (Vell.) Taub.[a, b, g]
Phaseolus L.
brachycalyx Hasseler[a], *bracteolatus* Nees & Mart.[a], *candidus* Vell.[h], *clitorioides* Mart.[a], *erythoroloma* Mart. ex Benth.[q], *firmulus* Mart.[a, q], *linearis* H.B.K.[b], *longifolius* Benth.[a], *longipedunculatus* Mart. ex Benth.[a], *monophyllus* Benth.[q], *obliquifolius* Mart. ex Benth.[q], *peduncularis* H.B.K.[a], *pius* Mart. ex Benth.[q], *prostratus* Benth.[c], *semierectus* L.[a], *truxillensis* H.B.K.[q]
Piptadenia Benth.
falcata Benth.[p], *macrocarpa* Benth.[p], *peregrina* (L.) Benth.[i], *rigida* Benth.[a]
Pithecolobium Mart.
campestre Spruce[p], *multiflorum* (H.B.K.) Benth.[p]

Plathymenia Benth.
foliolosa Benth.[a], *reticulata* Benth.[a, p]
Platypodium Vog.
elegans Vog.[a, p], *grandiflorum* Benth.[a, n], *viride* Vog.[a]
Poecilanthe Benth.
subcordata Benth.[p]
Poiretia Vent.
angustifolia Vog.[a, h], *latifolia* Vog.[a, q], *psoralioides* DC.[q]
Pterocarpus Jacq.
rohrii (H.B.K.) Vahl[p]
Pterodon Vog.
polygaliflorus Benth.[a, p], *pubescens* Benth.[a, p]
Rhynchosia Lour.
clausseni Benth.[a, q], *edulis* Griseb.[a], *melanocarpa* Grear[a], *phaseoloides* (SW.) DC.[a]
Riedeliella Harms
graciliflora Harms[a, p]
Schrankia Willd.
Unidentified specimen in the herbarium of the Universidade de Brasília.
Sclerolobium Vog.
aureum (Tul.) Benth.[a, p], *beaurepairei* Harms[a], *paniculatum* Vog.[a, p], *rugosum* Mart.[p]
Senna Mill.
alata (L.) Roxb.[a], *bicapsularis* (L.) Roxb.[a], *cana* (Nees. & Mart.) IB[a, k], *cernua* (Balbis) IB[k], *chrysocarpa* (Desv.) IB[a], *corifolia* (Benth.) IB[a, k], *hirsuta* (L.) IB[k], *kuhlmannii* Hoehne[k], *macranthera* (Coll.) IB[a, k], *mucronifera* (Benth.) IB[a, k], *obtusifolia* (L.) IB[a], *occidentalis* (L.) Link.[k], *pendula* (Willd.) IB[a, k], *pentagonia* (P. Miller) IB[k], *pilifera* (Vog.) IB[a, k], *reniformis* (G. Don) IB[k], *rizzinii* IB[k], *rostrata* (Mart.) IB[k], *rugosa* (G. Don) IB[a, k], *septemtrionalis* (Viviani) IB[k], *silvestris* (Vell.) IB[a, k], *spectabilis* (DC.) IB[a, k], *splendida* (Vog.) IB[k], *tapajozensis* (Ducke) IB[k], *trachypus* (Benth.) IB[i], *uniflora* (P. Miller) IB[k], *velutina* (Vog.) IB[a, k]
Stryphnodendron Mart.
adstringens (Mart.) *Coville*[a, c], *confertum* Rizz. & Her.[a], *coriaceum* Mart.[a, p], *cristalinae* Her.[a], *obovatum* Benth.[a, p], *platyspicum* Rizz. & Her.[a], *polyphyllum* Benth.[p], *rotundifolium* Mart.[a, p]
Stylosanthes Sw.
acuminata Ferr. & Costa[d], *bracteata* Vog.[d, q], *capitata* Vog.[d, h], *debilis* Ferr. & Costa[d], *gracilis* H.B.K.[a, d], *grandifolia* Ferr. & Costa[d], *guyanensis* (Aubl.) Sw.[a, d], *hippocampoides* Mohlenbr.[d], *humilis* H.B.K.[d], *leiocarpa* Vog.[d, q], *linearifolia* Ferr. & Costa[d], *macrocephala* Ferr. & Costa[d], *montevidensis* Vog.[a, d, g], *scabra* Vog.[a, c, d], *viscosa* Sw.[c, d]
Swartzia Schreber
auriculata Poepp.[a], *flaemingii* Raddi[a], *grazielana* Rizz.[a, p], *leptopetala* Benth.[a], *macrostachya* Benth.[a, p], *multijuga* Vog.[a, p], *pilulifera* Benth.[p]
Sweetia Sprengel
fruticosa Sprengel[p]
Tephrosia Pers.
adunca Benth.[a, q], *leptostachya* DC.[a, q], *nitens* Benth.[a], *rufescens* St.-Hil.[c]

Tipuana (Benth.) Benth.
cinerascens (Benth.) Malme[p]
Vatairea Aubl.
macrocarpa (Benth.) Ducke[p]

Vigna Savi

paraguensis Benth.[c]

Zornia J.F. Gmel.

brasiliensis Vog.[q], *diphylla* Pers.[g], *latifolia* Sm[a, c], *reticulata* Sm.[a, c], *ulei* Harms[a], *vestita* Mohlenbr.[a], *virgata* Moric.[a, q]

[a] Represented by a specimen in the herbarium of the Universidade de Brasília.

Reported to be found in the Cerrado, s.l., from the following literature: b) Cesar 1980; c) Eiten 1971; d) Ferreira & Costa 1979; e) Ferri 1969; f) Goodland 1970; g) Goodland & Ferri 1979; h) Heringer 1971; i) Heringer et al. 1977; j) Irwin & Barneby 1978; k) Irwin & Barneby 1982; l) Ratter 1980; m) Ratter et al. 1973; n) Ratter et al. 1977; o) Ribeiro et al. 1981; p) Rizzini 1971; q) Warming 1973.

[r] José Valls, personal communication.

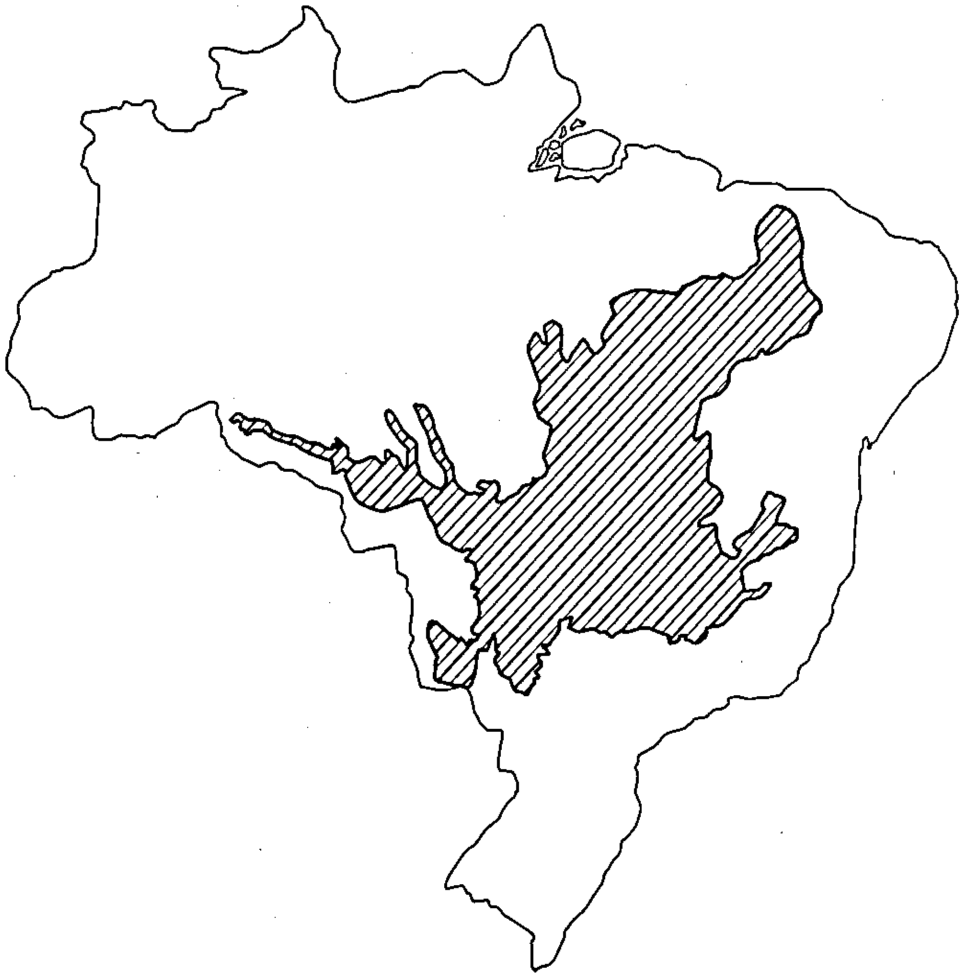

FIG. 1. The area of Cerrado, s.l., vegetation in Brazil, adapted from Azevedo and Caser (1982).

FIG. 2. Cerrado, s.s., on the Chapada da Contagem near Brasília showing the tortuosity of the trees and shrubs; courtesy of George Eiten.

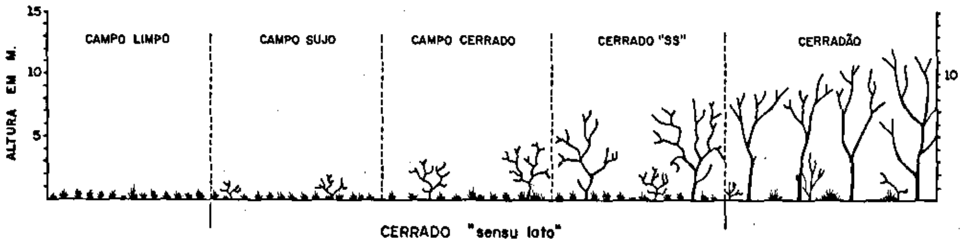

FIG. 3. Stylized profiles of the five categories of Cerrado, s.l., vegetation, adapted from Coutinho (1978).

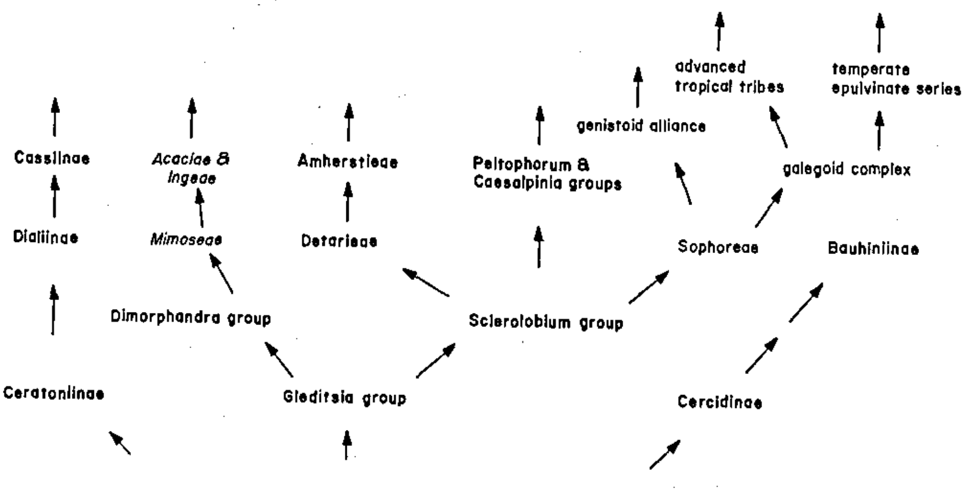

FIG. 4. The main evolutionary radiations in the *Leguminosae*, from Polhill et al. (1981).