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FLORISTIC COMPOSITION AND COMMUNITY STRUCTURE OF A SOUTHERN CERRADO AREA IN BRAZIL

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ABSTRACT. An analysis of the cerrado (savanna) vegetation at Angatuba (São Paulo state) was carried out by means of transects. The site studied is one of the southernmost of this type of vegetation in Brazil. Species lists and analytical data are given in Tables 2–6 and comparisons are made with other cerrado areas.

RESUMO. Uma análise da vegetação de cerrado em Angatuba (SP) foi desenvolvida por meio de transetos. O local é um dos mais meridionais dêste tipo de vegetação no Brasil. São fornecidos uma lista de espécies e dados analíticos nas tabelas 2–6 e comparações são feitas com outras áreas de cerrado.

A number of communications on the floristics of cerrados (savannas) in the state of São Paulo (SP) already exist in the literature. In a pioneer study, Ferri & Coutinho (1958) published a checklist for an area of cerrado at Emas (SP), together with some comparisons with other cerrado areas at Campo Grande (Mato Grosso do Sul) and Goiânia (Goiás). Eiten (1963) provided a habitat list for Fazenda Campininha, Mogi Guaçu, another of the scattered areas of cerrado in São Paulo state, while Gibbs, Leitão Filho & Shepherd (1983) gave a detailed quantitative-floristic survey of the same locality. Another recent study by Silberbauer-Gottsberger & Eiten (1983) contributed a detailed phytosociological analysis of a hectare of cerrado at Botucatu, and this was later compared with an equal area of cerradão in the same locality (Silberbauer-Gottsberger & Gottsberger, 1984).

The present contribution is devoted to the study of a cerrado area at Angatuba (SP), one of the most southerly sites of this type of vegetation in Brazil. It is the second in a series of papers which will analyse the floristic composition of some cerrado areas in São Paulo state and then attempt to compare their flora with that of the core cerrado area in Goiás, Mato Grosso and Minas Gerais; the first of the series is Gibbs, Leitão Filho & Shepherd (1983).

SITE DESCRIPTION

The site studied near Angatuba, SP (23°27′S 48°25′W, c.175km west of São Paulo city) lies in one of the disjunct areas of cerrado vegetation occurring in São Paulo state (Fig. 1). It is a small, c.150ha, reserve in the Floresta de Angatuba of the Instituto Florestal do Estado de São Paulo (Seção de Itapetininga) consisting of gently sloping ground covered in

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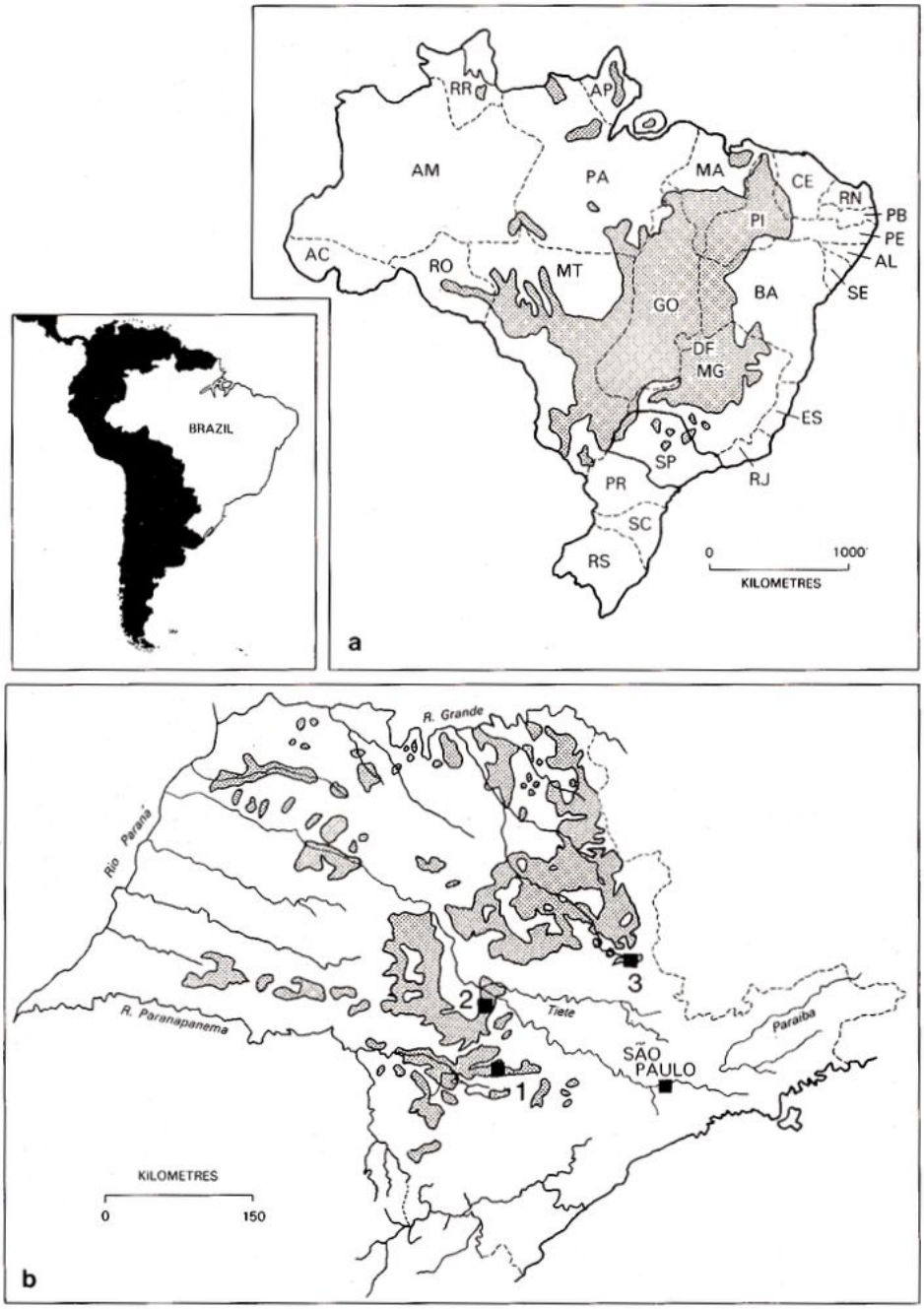

FIG 1. Distribution of cerrado vegetation in a, Brazil (letters are abbreviations of the states), and b, São Paulo State. A, Angatuba; 2, Botucatu; 3, Mogi-Guaçu. (After Borgonovi & Chiarini, 1965).

campo sujo, campo cerrado, cerrado and cerradão.* Except in the cerradão most of the trees are very low and slender with the great majority not exceeding 3m in height. Larger individuals do occur, however, particularly of *Anadenanthera peregrina* var. *falcata, Copaifera langsdorfii, Persea pyrifolia* and *Stryphnodendron adstringens*: tall specimens of the first three of which sometimes reach 12–15m in the cerradão. According to local forestry staff the area has been completely protected from fire for at least 19 and perhaps as long as 35 years.

The climate of these southern peripheral areas of cerrado differs from that of the central core area in having a much less severe dry season, while early morning frosts occur on some days in most years and severe frosts are a periodic event (Anon., 1975; Silberbauer-Gottsberger, Morawetz & Gottsberger, 1977). Table 1 gives climatic data for Itapetininga, c.30km from Angatuba, and, for comparison, Formosa and Pirenopolis in the cerrado heartland.

Unfortunately no soil analyses are available, but according to Freitas & Silveira (1977) the soil in the area consists of Dystrophic Red-Yellow Latosol (Latossolo Vermelho-Amarelo Distrófico) and Dystrophic Purple Latosol (Latossolo Roxo Distrófico).

METHODS

The vegetation was studied by means of transects and by general observation and collecting.† A total of twenty-one 25 × 10m quadrats were arranged at 50m intervals along two transects at approximately right angles to each other and c.700m apart at their closest point. The total sample area, comprising all 21 quadrats, is thus 0·525ha. All quadrats were marked permanently by heavy fence posts. Within each quadrat all shrubs and trees with a basal stem diameter of $\geqslant$3cm were recorded, their heights measured or estimated, and, where possible, the species of smaller plants, including herbs, were listed.

The following were calculated from the transect data:

1. Total basal area (ba) for each species.
2. Relative density of each species = (no. of individuals of the species/total number of individuals) × 100.

*A series of forms is recognized in Brazilian savanna vegetation and these are given vernacular names. Grassland with a sparse scattering of shrubs and trees is called *campo sujo* (=dirty field). Where there are numerous trees and shrubs but still a large area of grassland, the vegetation is termed *campo cerrado* (=closed field). The next stage when the vegetation is obviously dominated by trees and shrubs but there is still a fair amount of herbaceous vegetation is known as *cerrado* (=closed, i.e. the vegetation has closed). The last stage is a dense woodland made up of trees, often of 8–12m or even taller, casting a considerable shade so that ground vegetation is much reduced—this is called *cerradão* (the augmentative of cerrado). Clearly the division between these forms is somewhat arbitrary, but workers in the field usually agree surprisingly well on the classification of the vegetation. It is unfortunate that in both common and scientific usage the term *cerrado* should have two meanings, (a) Brazilian savanna vegetation in its generic sense, and (b) one particular form of this vegetation.

†Voucher specimens are lodged in the herbaria of the State University of Campinas (UEC) and the Royal Botanic Garden, Edinburgh (E), with some duplicates at Royal Botanic Gardens, Kew (K) and the University of Brasília (UB).

3. Relative dominance of each species = (total ba of the species/total ba of all species) × 100.
4. Relative frequency of each species = (frequency of the species/sum frequency of all species) × 100.
5. Importance value of a species (IV) = (relative density + relative dominance + relative frequency).

TABLE 1

Climatic data for Itapetininga, Formosa and Pirenopolis.

	Alt. (m)	Av. ann. precip. (mm)	Av. ann. temp. (°C)	Av. temp. coldest month (°C)	Absolute max. temp. (°C)	Absolute min. temp. (°C)	Av. no. dry months per ann.
Itapetininga (SP) 23°36′S 48°03′W	650	1190	18·9	15·0	37·6	−1·4	0
Formosa (Goiás) 15°32′S 47°20′W	912	1590	20.9	—	—	—	4–5
Pirenopolis (Goiás) 15°51′S 48°57′W	750	1650	22·3	15·4	—	8·8	4–5

Itapetininga data from Nimer (1977); Formosa and Pirenopolis data from Walter & Leith (1967).

RESULTS

Table 2 lists the numbers and frequencies of the species recorded on the transects; it also serves as an overall list of larger species of the reserve. Table 3 shows the smaller species observed—no exhaustive study of these was made and the list is only of the most prominent.

The vegetation on Transect 2 varies from campo sujo and campo cerrado to cerrado but the 10 quadrats were considered sufficiently homogeneous to be analysed together. Transect 1, on the other hand, contains quadrats of both dense thicket cerradão and more open cerrado vegetation and these are so different that they have been analysed separately as two groups.

Table 4 gives analyses for Group 1, consisting of the five more open quadrats (1, 4, 5, 6 and 7) of Transect 1. The vegetation is an extremely low campo sujo or campo cerrado thickening to cerrado, with the majority of the shrubs and trees only 1–2·5m tall. Only 6·2% of the trees and shrubs (31 out of 501) are over 3m tall, while only 0·6% are over 5m. The number of individuals per quadrat varies from 41 to 166 and averages 101 (=4040 per ha); basal area extrapolates to 12 m^2/ha. The average number of species per quadrat is 25·8. Crown cover is sparse and the herbaceous ground layer is well-developed and includes much *Polypodium* sp. aff. *attenuatum*.

Group 2 (Table 5) consists of the six quadrats of cerradão on Transect 1 (2, 3, 8, 9, 10 and 11). The vegetation is a thicket of trees and shrubs which is difficult to penetrate; the number of individuals scored per quadrat ranges from 143 to 251 with an average of 187 (=7840 per ha), but there is also an abundance of young individuals too small to score.

TABLE 2

Woody species of the cerrado and cerradão at Angatuba. The figures are numbers of individuals ⩾3cm basal diameter, ⩾10cm (in brackets), and % frequency as sampled in twenty-one 10 × 25m quadrats.

*Species present in small numbers in the area but not occurring on quadrats.

Acosmium subelegans (Mohl) Yakovlev	107(4), 100
Aegiphila lhotskyana Cham.	6, 23·8
Alchornea triplinervia Müll. Arg.	1(1), 4·8
Alibertia sessilis (Cham.) Schumann?	1, 4·8
Amaioua guianensis Aublet	7(2), 9·5
Anadenanthera peregrina (L.) Speg. var. falcata (Benth.) Altschul	145(57), 76·2
Andira sp.?	1, 4·8
Annona coriacea Mart.	9, 23·8
A. crassiflora Mart.	17(3), 47·6
Aspidosperma tomentosum Mart.	44(1), 28·6
Austroplenckia populnea (Reiss.) Lund	31(2), 33·3
Baccharis dracunculifolia DC.	15, 38·1
B. sp.	1, 4·8
Bauhinia rufa (Bong.) Steudel	13, 19·0
Brosimum gaudichaudii Trécul	3, 9·5
Butia paraguayensis (Barb. Rodr.) L. Bailey	3(3), 14·3
Byrsonima coccolobifolia Kunth	20(2), 38·1
B. intermedia Adr. Juss.	4, 14·3
B. verbascifolia [Rich. ex] Adr. Juss	6, 28·6
Campomanesia pubescens (DC.) O. Berg	8, 28·6
Casearia sylvestris Sw.	3, 9·5
Copaifera langsdorfii Desf.	9(2), 14·3
Couepia grandiflora (Mart. & Zucc.) Benth.	9(5), 23·8
Cybistax antisiphylitica Mart.	1, 4·8
Dalbergia violacea (Vogel) Malme	36(6), 71·4
Daphnopsis fasciculata (Meissner) Nerl.	36, 23·8
Didymopanax vinosum (Cham. & Schlecht.) March.	78(4), 52·4
Dimorphandra mollis Benth.	22(3), 61·9
Diospyros hispida DC.	103(1), 57·1
Enterolobium ellipticum Benth.*	
Eriotheca gracilipes (Schumann) Robyns	9, 23·8
Erythroxylum cuneifolium (Mart.) O. Schulz	10, 38·1
E. suberosum St. Hil.	40, 76.2
E. tortuosum Mart.	12, 42·9
Eugenia aurata O. Berg	10(1), 23·8
E. sp. aff. bimarginata DC.	7(2), 23·8
E. sp. R4863	1, 4·8
E. sp. plot 10	1, 4·8
Gochnatia barrosii Cabrera	20, 38·1
G. polymorpha DC.	1(1), 4·8
G. pulchra Cabrera	28, 61·9
Guapira noxia (Netto) Lundell	30(6), 57·1
Jacaranda caroba (Vell.) DC.	2, 9·5
Kielmeyera coriacea Mart.	40, 57.1
Lacistema floribundum Miq.	3, 9·5
Lafoensia pacari St. Hil.	1, 4·8
L. sp.*	
Leandra lacunosa Cogn.	2, 9·5
Lippia corymbosa Cham.	51, 76·2
Machaerium acutifolium Vogel	8(3), 28·6
Manihot tripartita (Spreng.) Müll. Arg.	3, 14·3
Miconia albicans (Sw.) Triana	18(1), 23·8
M. ligustroides Naudin	7, 19·0
Myrcia albotomentosa DC.	118(3), 85·7
M. lasiantha DC.	273(15), 85·7
M. rostrata DC.	1, 4·8
M. rufipes DC.	7, 4·8
M. tomentosa (Aublet) DC.	2, 9·5
M. sp. R4829	1, 4·8
Ocotea pulchella Mart.	64(3), 33·3
O. sp.	1, 4·8
Ouratea spectabilis (Mart.) Endl.	169(21), 85·7
Palicourea rigida Kunth	3, 14·3
Pera glabrata (Schott.) Baill.	1, 4·8
Persea pyrifolia [Nees & Mart. ex] Nees	23(5), 33·3
Piptocarpha rotundifolia (Less.) Baker	29(1), 47·6
Pouteria ramiflora (Mart.) Radlk.	12(1), 47·6
Psidium australe Cambess.	17(1), 9·5
Psidium sp. R4849	5, 14·3
P. so. 2	9, 14.3
Psychotria sessilis Vell.	1, 4·8
Qualea dichotoma (Mart.) Warm.	28(5), 23·8
Q. grandiflora Mart.	10(3), 19·0
Q. multiflora Mart.	21(4), 9·5
Rapanea guiaensis Aublet	58(2), 76·2
R. lancifolia Mez	40(2), 38·1
R. umbellata Mez	54(7), 19·0
Rhamnus sphaerosperma Sw. var. pubescens (Reiss.) M. C. Johnston	4, 14·3

TABLE 2 (cont.)

Roupala montana Aublet	41(1), 42·8
Solanum megalochiton Mart.*	
Stryphnodendron adstrigens (Mart.) Cov.	30(19), 42·8
Styrax camporum Pohl	13, 28·6
S. ferrugineus Nees & Mart.	36(4), 61·9
Symphyopappus cuneatus [Schultz Bip. ex] Baker	1, 4·8
Tabebuia caraiba (Mart.) Bureau	17(12), 38·1
T. ochracea (Cham.) Standley	34(4), 52·4
Tapirira guianensis Aublet	7(4), 9·5
Terminalia brasiliensis Eichler	1, 4·8
Tibouchina stenocarpa (Schbr. & Mart. ex DC.) Cogn.	11, 14·3
Tocoyena formosa (Cham. & Schlecht.) Schumann	4, 14·3
Vitex polygama Cham.*	
Vochysia tucanorum Mart.	2(2), 9·5
Xylopia brasiliensis Spreng.	2, 4·8
Zehyeria montana Mart.*	
Compositae sp.	1, 4·8
Lauraceae sp. (8/21)	7(1), 19·0
Myrtaceae sp. R4855	6, 4·8
Myrtaceae sp. 3	2, 9·5
Myrtaceae sp. 4	1, 4·8
Myrtaceae sp. 5	3, 4·8
Myrtaceae sp. 6	7, 4·8
Myrtaceae sp. 7	1, 4·8
Myrtaceae sp. 18	1, 4·8
Indet. sp. 43	2, 4·8

TABLE 3

Species of herbs and smaller shrubs of the cerrado reserve: (l) = liana or herbaceous climber; (et) = epiphyte on trunk of cerradão tree. A number of species in this table also occur in Table 2 since they sometimes attain greater size.

Allagoptera campestris (Mart.) Kuntze
Anacardium humile St. Hil.?
Ananas ananassoides (Baker) Lyman B. Smith
Andira humilis Mart.
Arrabidaea brachypoda Bureau & Schumann
Aristida riparia Trin.
Aspilia montevidensis (Spreng.) Kuntze
Attalea geraensis Barb. Rodr.
Banisteriopsis campestris (Adr. Juss.) Little
B. pubipetala (Adr. Juss.) Cuatrecasas
Blepharodon bicuspidatum Fourn.
B. linearis Fourn.
Borreria sp.
Bromelia balansae Mez
Butia paraguayensis (Barb. Rodr.) L. Bailey
Campomanesia pubescens (DC.) O. Berg
Caryocar brasiliense Cambess.
Casearia sylvestris Sw.
Cassia rugosa G. Don
Cayaponia espelina Cogn.
Chrysophyllum soboliferum Rizz.
Coccocypselum hasslerianum Chodat
Cordia sessilifolia Cham.
Davilla rugosa Poiret
Districtella mansoana (DC) Urban (l)
Dyckea leptostachya Baker
Epiphyllum phyllanthus Haw.
Eremanthus sphaerocephalus (DC.) Baker
Eriosema heterophyllum Benth.
Erythroxylum campestre St. Hil.
E. cuneifolium (Mart.) O. Schulz
E. tortuosum Mart.
Evolvulus aurigenius Mart.
E. linoides Moric.
Eugenia sulcata [Spreng, ex] Mart.
Eupatorium campestre DC.
Froelichia lanata Moq.
Gomphrena officinalis Mart.
Jacaranda caroba (Vell.) DC.
J. decurrens Cham.
J. rufa Manso
Julocroton humilis Didr.
Kielmeyera variabilis Mart.
Leandra lacunosa Cogn.
Leptocoryphium lanatum (Kunth) Nees
Lippia lupulina Cham.
Mandevilla illustris (Vell.) Woodson
M. velutina (Mart). Woodson
Manihot tripartita (Spreng.) Müll. Arg.
Melinis minutiflora P. Beauv.
Merremia digitata (Spreng.) Hallier
Miconia albicans (Sw.) Triana
M. ligustroides Naudin
Microgramma squamulosa (Kaulf.) de la Sota (et)
Mikania officinalis Mart.
Mimosa meticulosa Mart.
Myrcia intermedia Kiaerskov
Palicourea rigida Kunth
Panicum olyroides Kunth
Parinari obtusifolia Hook. f.
Peritassa campestris (Cambess.) A. C. Smith
Polypodium sp. aff. attenuatum [H. & B. ex] Willd.
P. bombycinum Maxon (et)
P. loriceum L. (et)

TABLE 3 (cont.)

Psidium incanescens [Mart. ex] DC.
P. australe Cambess.
Pteridium aquilinum (L.) Kuhn
Rhynchospora exaltata Kunth
Sapium marginatum var. intermedium (Müll. Arg.) Pax
Scleria scabra Willd.
Sebastiana serrulata (Mart.) Müll. Arg.
Serjania erecta Radlk.
Sida ulmifolia Cav.
Sinningia allagophylla (Mart.) Wiehler
Smilax brasiliensis Spreng.
Syagrus loefgrenii Glassman
Symphyopappus cuneatus [Schultz Bip. ex] Baker
Talisia pygmaea Radlk.
Temnadenia violacea (Vell.) Miers
Tibouchina stenocarpa Cogn.
Tillandsia usneoides L.
Trimezia juncifolia Benth. & Hook.
Tristachya sp.
Vernonia brevifolia Less.
V. grandiflora Less.
Zehyeria montana Mart.

TABLE 4

Transect 1, Group 1—cerrado group of five 25 × 10m quadrats (no. 1, 4, 5, 6 & 7)
Plants with basal diameter ⩾3cm. Species in order of Importance Value (IV)
n = no. of individuals; ba = basal area (cm^2)
Total = 501 individuals. Total ba 14,997cm^2 (= 12 m^2/ha)
Av. no. of individuals per quadrat = 101 (= 4040 per ha)

		n	ba	Rel. dens.	Rel. dom.	Rel freq.	IV
1	Ouratea spectabilis	80	3033·0	16·0	20·2	3·9	40·1
2	Myrcia lasiantha	55	2271·4	11·0	15·1	3·9	30·0
3	Acosmium subelegans	37	864·3	7·4	5·8	3·9	17·1
4	Diospyros hispida	35	740·9	7·0	5·0	2·3	14·3
5	Dalbergia violacea	20	830·3	4·0	5·5	3·9	13·4
6	Rapanea guianensis	28	557·4	5·6	3·7	3·9	13·2
7	Myrcia albotomentosa	27	434·4	5·4	2·9	3·9	12·2
8	Roupala montana	22	556·6	4·4	3·7	3·9	12·0
9	Erythroxylum suberosum	22	378·9	4·4	2·5	3·9	10·8
10	Kielmeyera coriacea	24	397·9	4·8	2·7	3·1	10·6
11	Tabebuia ochracea	13	368·9	2·6	2·5	3·1	8·2
12	Styrax ferrugineus	10	473·3	2·0	3·2	2·3	7·5
13	Guapira noxia	9	330·8	1·8	2·2	3·1	7·1
14	Anadenathera peregrina var. falcata	5	555·4	1·0	3·7	1·6	6·3
15	Byrsonima coccolobifolia	8	199·2	1·6	1·3	3·1	6·0
16	Dimorphandra mollis	4	401·3	0·8	2·7	2·3	5·8
17	Piptocarpha rotundifolia	6	251·3	1·2	1·7	2·3	5·2
18	Lippia corymbosa	6	108·5	1·2	0·7	2·3	4·2
19	Psidium sp. 2	7	144·1	1·4	1·0	1·6	4·0
20 =	Gochnatia barrosii	6	167·3	1·2	1·1	1·6	3·9
20 =	Machaerium acutifolium	3	256·0	0·6	1·7	1·6	3·9
22	Rapanea lancifolia	5	41·0	1·0	0·3	2·3	3·6
23	Gochnatia pulchra	7	80·5	1·4	0·5	1·6	3·5
24	Annona crassiflora	5	137·0	1·0	0·9	1·6	3·5
25 =	Aegiphila lhotskyana	4	48·2	0·8	0·3	2·3	3·4
25 =	Tocoyena formosa	4	43·4	0·8	0·3	2·3	3·4
27	Stryphnodendron adstringens	1	346·4	0·2	2·3	0·8	3·3
28 =	Palicourea rigida	3	23·8	0·6	0·2	2·3	3·1
28 =	Psidium sp. R4849	4	103·9	0·8	0·7	1·6	3·1
30	Erythroxylum tortuosum	4	79·8	0·8	0·5	1·6	2·9
31 =	Byrsonima verbascifolia	2	120·3	0·4	0·8	1·6	2·8
31 =	Aspidosperma tomentosum	4	57·6	0·8	0·4	1.6	2·8
33	Baccharis dracunculifolia	3	40·5	0·6	0·3	1·6	2·5
34 =	Byrsonima intermedia	3	29·3	0·6	0·2	1·6	2·4

TABLE 4 (cont.)

	n	ba	Rel. dens.	Rel. dom.	Rel. freq.	IV
34 = Miconia ligustroides	2	57·4	0·4	0·4	1·6	2·4
36 = Myrtaceae sp. 3	2	35·4	0·4	0·2	1·6	2·2
36 = Leandra lacunosa	2	22·2	0·4	0·2	1·6	2·2
38 Didymopanax vinosum	2	98·1	0·4	0·7	0·8	1·9
39 = Tibouchina stenocarpa	3	21·3	0·6	0·1	0·8	1·5
39 = Gochnatia polymorpha	1	78·5	0·2	0·5	0·8	1·5
41 = Casearia sylvestris	2	35·4	0·4	0·2	0·8	1·4
41 = Lafoensia pacari	1	63·6	0·2	0·4	0·8	1·4
43 Daphnopsis fasciculata	2	12·0	0·4	0·1	0·8	1·3
44 Manihot tripartita	1	23·8	0·2	0·2	0·8	1·2
45 = Annona coriacea	1	12·6	0·2	0·1	0·8	1·1
45 = Baccharis sp.	1	12·6	0·2	0·1	0·8	1·1
45 = Compositae sp.	1	12·6	0·2	0·1	0·8	1·1
45 = Ocotea pulchella	1	12·6	0·2	0·1	0·8	1·1
45 = Qualea grandiflora	1	12·6	0·2	0·1	0·8	1·1
45 = Erythroxylum cuneifolium	1	7·1	0·2	0·1	0·8	1·1
45 = Jacaranda caroba	1	7·1	0·2	0·1	0·8	1·1

TABLE 5

Transect 1, Group 2—group of six 25 × 10m quadrats of cerradão/thicket (no. 2, 3, 8, 9, 10 & 11)
Plants with basal diameter ⩾3cm. Species in order of Importance Value (IV)
n = no. of individuals; ba = basal area (cm^2)
Total = 1118 individuals. Total ba 49,449cm^2 (= 33 m^2/ha)
Av. no. of individuals per quadrat = 187 (= 7840 per ha)

	n	ba	Rel. dens.	Rel. dom.	Rel. freq.	IV
1 Myrcia lasiantha	189	4183·8	17·0	8·5	2·9	28·4
2 Anadenanthera peregrina var. falcata	84	8686·6	7·5	17·6	2·9	28·0
3 Persea pyrifolia	20	4655·7	1·8	9·4	2·4	13·6
4 Didymopanax vinosum	72	1676·8	6·4	3·4	2·9	12·7
5 Rapanea umbellata	54	2444·0	4·8	4·9	1·9	11·6
6 = Myrcia albotomentosa	57	1454·7	5·1	2·9	2·9	10·9
6 = Ocotea pulchella	61	1498·5	5·5	3·0	2·4	10·9
8 Ouratea spectabilis	44	1638·7	3·9	3·3	2·9	10·1
9 = Qualea dichotoma	28	1396·1	2·5	2·8	2·4	7·7
9 = Stryphnodendron adstringens	20	1745·4	1·8	3·5	2·4	7·7
11 Aspidosperma tomentosum	40	687·4	3·6	1·4	1·9	6·9
12 Acosmium subelegans	27	660·7	2·4	1·3	2·9	6·6
13 = Daphnopsis fasciculata	34	562·7	3·0	1·1	1·9	6·0
13 = Austroplenckia populnea	26	870·2	2·3	1·8	1·9	6·0
13 = Rapanea lancifolia	32	813·5	2·9	1·7	1·4	6·0
16 Copaifera langsdorfii	9	1767·7	0·8	3·6	1·4	5·8
17 Qualea multiflora	21	1392·4	1·9	2·8	1·0	5·7
18 Couepia grandiflora	9	1094·5	0·8	2·2	2·4	5·4
19 Guapira noxia	16	690·9	1·4	1·4	2·4	5·2
20 Dalbergia violacea	10	871·4	0·9	1·8	2·4	5·1
21 Dimorphandra mollis	12	531·7	1·1	1·1	2·4	4·6
22 Qualea grandiflora	8	944·1	0·7	1·9	1·0	3·6
23 Psidium australe	17	512·9	1·5	1·0	1·0	3·5
24 = Tabebuia ochracea	8	595·2	0·7	1·2	1·4	3·3
24 = Rapanea guianensis	12	179·7	1·1	0·3	1·9	3·3

TABLE 5 (cont.)

	n	ba	Rel. dens.	Rel. dom.	Rel. freq.	IV
26 = Roupala montana	12	325·7	1·1	0·7	1·4	3·2
26 = Tapirira guianensis	7	780·0	0·6	1·6	1·0	3·2
28 Eugenia aurata	8	439·7	0·7	0·9	1·4	3·0
29 Lippia corymbosa	12	145·2	1·1	0·3	1·4	2·8
30 = Gochnatia barrosii	10	176·0	0·9	0·4	1·4	2·7
30 = Byrsonima coccolobifolia	9	450·8	0·8	0·9	1·0	2·7
32 = Lauraceae 8/21	6	323·6	0·5	0·7	1·4	2·6
32 = Erythroxylum cuneifolium	6	77·2	0·5	0·2	1·9	2·6
32 = Diospyros hispida	11	289·2	1·0	0·6	1·0	2·6
35 = Bauhinia rufa	9	128·7	0·8	0·3	1·4	2·5
35 = Styrax camporum	5	70·2	0·5	0·1	1·9	2·5
37 Eugenia bimarginata	4	315·9	0·4	0·6	1·4	2·4
38 = Eriotheca gracilipes	6	185·2	0·5	0·4	1·4	2·3
38 = Machaerium acutifolium	4	251·7	0·4	0·5	1·4	2·3
38 = Amaioua guianensis	7	339·9	0·6	0·7	1·0	2·3
41 = Gochnatia pulchra	5	91·0	0·5	0·2	1·4	2·1
41 = Vochysia tucanorum	2	431·2	0·2	0·9	1·0	2·1
43 Piptocarpha rotundifolia	6	206·1	0·5	0·4	1·0	1·9
44 = Styrax ferrugineus	3	70·7	0·3	0·1	1·4	1·8
44 = Erythroxylum suberosum	3	48·1	0·3	0·1	1·4	1·8
44 = Miconia albicans	5	184·0	0·5	0·3	1·0	1·8
47 Eugenia sp. R4863	4	176·0	0·4	0·2	1·0	1·6
48 = Pouteria ramiflora	6	236·6	0·5	0·5	0·5	1·5
48 = Myrcia rufipes	7	191·9	0·6	0·4	0·5	1·5
48 = Alchornea triplinervia	1	452·4	0·1	0·9	0·5	1·5
48 = Kielmeyera coriacea	3	112·2	0·3	0·2	1·0	1·5
52 = Annona coriacea	3	57·2	0·3	0·1	1·0	1·4
52 = Butia paraguayensis	1	380·1	0·1	0·8	0·5	1·4
52 = Byrsonima verbascifolia	2	83·2	0·2	0·2	1·0	1·4
52 = Lacistema floribunda	3	37·1	0·3	0·1	1·0	1·4
56 = Erythroxylum tortuosum	2	52·8	0·2	0·1	1·0	1·3
56 = Myrcia tomentosa	2	20·6	0·2	0·1	1·0	1·3
58 Myrtaceae sp. R4855	6	48·1	0·5	0·1	0·5	1·1
59 = Manihot tripartita	1	153·9	0·1	0·3	0·5	0·9
59 = Unknown 43	3	51·3	0·3	0·1	0·5	0·9
59 = Myrtaceae sp. 5	3	33·8	0·3	0·1	0·5	0·9
62 = Annona crassiflora	1	95·0	0·1	0·2	0·5	0·8
62 = Myrtaceae sp. 18	1	78·5	0·1	0·2	0·5	0·8
62 = Rhamnus sphaerosperma	2	27·6	0·2	0·1	0·5	0·8
62 = Baccharis dracunculifolia	2	19·7	0·2	0·1	0·5	0·8
66 = Myrcia rostrata	1	63·6	0·1	0·1	0·5	0·7
66 = Xylopia brasiliensis	2	16·7	0·2	0·1	0·5	0·8
66 = Myrtaceae sp. 4	1	56·7	0·1	0·1	0·5	0·7
66 = Pera glabrata	1	38·5	0·1	0·1	0·5	0·7
66 = Ocotea sp.	1	33·2	0·1	0·1	0·5	0·7
66 = Terminalia brasiliensis	1	28·3	0·1	0·1	0·5	0·7
72 = Alibertia sessilis	1	19·5	0·1	0·04	0·5	0·64
72 = Brosimum gaudichaudii	1	21·2	0·1	0·04	0·5	0·64
74 = Psidium sp. R4849	1	12·6	0·1	0·03	0·5	0·63
74 = Psychotria sessilis	1	12·6	0·1	0·03	0·5	0·63
74 = Myrtaceae sp. 3	1	12·6	0·1	0·03	0·5	0·63
77 = Andira sp.?	1	8.0	0·1	0·02	0·5	0·62
77 = Casearia sylvestris	1	7·5	0·1	0·02	0·5	0·62
77 = Tibouchina stenocarpa	1	7·1	0·1	0·01	0·5	0·62

Averaged over the group of quadrats, basal area extrapolates to 33m²/ha, 37.6% of the trees are over 3m tall and 8·1% over 5m. However, on the plot with the tallest vegetation (No. 11), 59·3% of trees and shrubs are over 3m and 16.28% over 5m. Occasional trees reach 12–15m. The average number of species per quadrat is 34·8. In the densest quadrats crown cover is complete and the herbaceous ground vegetation is suppressed, the floor having a cover of tree saplings and dead leaves.

Group 3 (Transect 2, Table 6) is similar in physiognomy to Group 1 and consists of campo sujo and campo cerrado thickening in places to cerrado. Tree and shrub cover, however, is generally sparser and the individuals larger: the number of individuals per plot varies from 26 to 105 (average 59 = 2360 per ha), average basal area is 7·54 m²/ha, while 11·41% of trees are over 3m tall and 1·84% over 5m. The average number of species per plot is 20.5. Crown cover is very sparse and there is an abundant herbaceous ground layer.

DISCUSSION

It is interesting to compare the density of the vegetation in the present study with that observed by Gibbs, Leitão Filho & Shepherd (1983) who used the same plant size qualification and quadrat size for the cerrado at Mogi Guaçu (SP). The figures recorded by these authors extrapolate to an average of 6400 individuals per ha in cerrado at the SE of their reserve, 8040 in their cerrado 'Transition II' and 3920 in campo cerrado in the NW, in comparison to 7840 in our thicket cerradão (Group 2), 4040 in Group 1 and 2360 in Group 3. Their figures indicate that the average height of trees at Mogi Guaçu was greater than at Angatuba. Many other figures are available for density in cerrado vegetation but exact comparison is difficult since somewhat larger size qualifications than ours are generally used. Nevertheless they all demonstrate that the Angatuba thicket cerradão (extrapolating to an average of 7840 individuals per ha, and 10040 per ha for the densest quadrat) and the SE and 'Transition II' vegetation of Mogi Guaçu are extremely dense: for example, Silberbauer-Gottsberger & Eiten (1983) found 4197 individuals on a hectare at Botucatu (SP) (using ⩾10cm circumference at 30cm), Oliveira Filho (1984) 1943 per ha at the Chapada dos Guimarães (Mato Grosso) (using ⩾3cm basal diameter—i.e. the same as in the present study) and Ratter (1985a, b) 1958 per ha (⩾12cm circumference at breast height) in very dense dystrophic facies cerradão on the Ilha do Bananal (Goiás) and 1112 per ha (⩾3cm dbh) in dystrophic facies cerradão in the Federal District. Total basal area of the Angatuba thicket cerradão is also very high: 33 m²/ha as compared, for example, to 13 m²/ha in dystrophic facies cerradão in the Federal District (Ratter, 1985b).

The floristic relationship of the three groups is demonstrated by comparison of Tables 4–6. Groups 1 and 3 have five of the first 10 species in terms of importance value (IV) in common, as have Groups 2 and 3, but Groups 1 and 2 only have three species in common—and these three are the common element of the IV top 10 in all three groups. These three abundant species are *Myrcia albotomentosa, M. lasiantha* and *Ouratea spectabilis*, all of which are usually small, low shrubs. The larger trees

TABLE 6

Transect 2 (Group 3)—cerrado, ten 25 × 10m quadrats at 50m intervals (no. 12–21)
Plants with basal diameter ⩾3cm. Species in order of Importance Value (IV)
n = no. of individuals; ba = basal area (cm^2)
Total = 596 individuals. Total ba 18,849cm^2 (= 7·54 m^2/ha)
Av. no. of individuals per quadrat = 59 (= 2360 per ha)

		n	ba	Rel. dens.	Rel. dom.	Rel. freq.	IV
1	Anadenanthera peregrina var. falcata	56	4764·4	9·4	25·3	3·9	38·6
2	Ouratea spectabilis	44	1838·1	7·4	9·8	3·4	20·6
3	Acosmium subelegans	43	1279·2	7·2	6·8	4·9	18·9
4	Diospyros hispida	57	825·5	9·6	4·4	3·4	17·4
5	Tabebuia caraiba	17	1754·2	2·9	9·3	3·9	16·1
6	Myrcia albotomentosa	34	1024·7	5·7	5·4	3·4	14·5
7	Lippia corymbosa	32	436·1	5·4	2·3	4·9	12·6
8	Myrcia lasiantha	29	390·6	4·9	2·1	3·4	10·4
9	Styrax ferrugineus	23	421·5	3·9	2·2	3·4	9·5
10	Stryphnodendron adstringens	9	1024·9	1·5	5·4	1·5	8·4
11	Rapanea guianensis	18	341·4	3·0	1·8	3·4	8·2
12	Gochnatia pulchra	16	277·1	2·7	1·5	3·9	8·1
13	Annona crassiflora	11	440·2	1·9	2·3	3·4	7·6
14	Erythroxylum suberosum	14	263·6	2·4	1·4	3·5	7·3
15	Piptocarpha rotundifolia	17	313·6	2·9	1·7	2·5	7·1
16	Tabebuia ochracea	12	400·8	2·0	2·1	2·0	6·1
17	Kielmeyera coriacea	13	145·3	2·2	0·8	2·9	5·9
18	Baccharis dracunculifolia	10	130·5	1·7	0·7	2·5	4·9
19	Miconia albicans	13	188·4	2·2	1·0	1·5	4·7
20 =	Campomanesia pubescens	8	56·8	1·3	0·3	2·9	4·5
20 =	Erythroxylum tortuosum	7	78·4	1·2	0·4	2·9	4·5
22	Dalbergia violacea	6	149·1	1·0	0·8	2·5	4·3
23	Dimorphandra mollis	6	131·3	1·0	0·7	2·5	4·2
24	Butia paraguayensis	2	428·1	0·3	2·3	1·0	3·6
25	Guapira noxia	6	130·3	1·0	0·7	1·5	3·2
26 =	Styrax camporum	8	129·7	1·3	0·7	1·0	3·0
26 =	Didymopanax vinosum	4	52·2	0·7	0·3	2·0	3·0
28	Persea pyrifolia	3	250·7	0·5	1·3	1·0	2·8
29	Pouteria ramiflora	6	135·6	1·0	0·7	1·0	2·7
30	Austroplenckia populnea	5	60·8	0·8	0·3	1·5	2·6
31	Gochnatia barrosii	4	53·4	0·7	0·3	1·5	2·5
32	Roupala montana	7	125·1	1·1	0·7	0·5	2·3
33	Annona coriacea	5	75·9	0·8	0·4	1·0	2·2
34 =	Erythroxylum cuneifolium	3	26·8	0·5	0·1	1·5	2·1
34 =	Miconia ligustroides	5	53·5	0·8	0·3	1·0	2·1
36	Eugenia aurata	3	103·9	0·5	0·5	1·0	2·0
37 =	Rapanea lancifolia	3	55·2	0·5	0·3	1·0	1·8
37 =	Eugenia bimarginata	3	49·5	0·5	0·3	1·0	1·8
39 =	Eriotheca gracilipes	3	44·8	0·5	0·2	1·0	1·7
39 =	Byrsonima coccolobifolia	3	39·3	0·5	0·2	1·0	1·7
41	Tibouchina stenocarpa	5	53·5	0·8	0·3	0·5	1·6
42 =	Byrsonima verbascifolia	2	45·8	0·3	0·2	1·0	1·5
42 =	Bauhinia rufa	4	62·3	0·7	0·3	0·5	1·5
44 =	Aegiphila lhotskyana	2	26·7	0·3	0·1	1·0	1·4
44 =	Rhamnus sphaerosperma	2	19·7	0·3	0·1	1·0	1·4
46 =	Brosmum gaudichaudii	2	22·2	0·3	0·1	0·5	0·9
46 =	Ocotea pulchella	2	16·7	0·3	0·1	0·5	0·9
46 =	Psidium sp. 2	2	14·2	0·3	0·1	0·5	0·9
46 =	Qualea grandiflora	1	28·3	0·2	0·2	0·5	0·9
50 =	Cybistax antisyphilitica	1	19·6	0·2	0·1	0·5	0·8
50 =	Manihot tripartita	1	19·6	0·2	0·1	0·5	0·8
50 =	Machaerium acutifolium	1	12·6	0·2	0·1	0·5	0·8
53 =	Byrsonima intermedia	1	7·1	0·2	0·04	0·5	0·74
53 =	Jacaranda caroba	1	7·1	0·2	0·04	0·5	0·74

which are responsible for producing much of the appearance of the cerradão are *Anadenanthera peregrina* var. *falcata, Persea pyrifolia, Stryphnodendron adstringens* and others which are not in the top 10 species in order of IV, such as *Copaifera langsdorfii, Tapirira guianensis* and *Vochysia tucanorum. Anadenanthera peregrina* var. *falcata* is also by far the most important species on Transect 2.

Some floristic comparisons between our area and others in São Paulo for which detailed information is available, Botucatu (Silberbauer-Gottsberger & Eiten, 1983) and Mogi Guaçu (Gibbs *et al.*, 1983), can now be made. The number of species with individuals reaching qualifying size in 0·525ha at Angatuba is 99, whilst at Botucatu 54 were recorded in 1ha and at Mogi Guaçu 96 in 1·5ha. Of the 54 species recorded at Botucatu 37 (68%) are found at Angatuba as are 56 of the 96 species (58%) from Mogi Guaçu. Of the 20 species produced by adding together the first 10 species in IV order from Groups 1, 2 and 3, 15 (75%) are present at Mogi Guaçu and 12 (60%) at Botucatu—they include species such as *Erythroxylum suberosum, Ouratea spectabilis* and *Styrax ferrugineus* which are extremely important at both Botucatu and Mogi Guaçu.

We are reserving more extensive floristic comparisons of cerrado for a future publication, but it is interesting at this stage to compare the 104* species with individuals reaching qualifying size from Angatuba on the southern periphery of the cerrado area with the 122 species recorded at the Hylaean margin on the Ilha do Bananal (Goiás) and the 108 species recorded from the core area in the Federal District (Ratter 1985a, b; 1987). The number of species in common between Angatuba and the Ilha do Bananal is 26 (representing 29.9% of the species from Angatuba and 21·3% of those from the Ilha do Bananal) and between Angatuba and the Federal District 36 (representing 41·4% of the species from the former and 33·3% from the latter).

Comparing Angatuba with all localities considered above using Sørensen's (1948) Index of Similarity

$$\left(\frac{\text{No. of spp. in common}}{\frac{1}{2}(\text{No. of spp. at locality A} + \text{No. at B})} \times 100\right)$$

the figure with Mogi Guaçu is 61·2, with Botucatu 52·5, with the Federal District 36·9, and with the Ilha do Bananal 24·9. The IS for Angatuba/Botucatu is probably depressed by the nature of the sample areas: a single 1ha block at Botucatu, while those at Angatuba, Mogi Guaçu, the Federal District and the Ilha do Bananal are all made up of quadrats spread over a much more extensive area and therefore likely to give a wider range of species.

There seems little doubt that the peculiar character of the thicket cerradão has been produced by prolonged protection from fire (for at least 19 and perhaps as much as 35 years). The closing of this vegetation

*The total number recorded is 104 (including five species occurring in the area but not present on the quadrats) but this is reduced to the 87 with reliable determinations for the purposes of the percentages and indices which follow, since the undetermined species clearly cannot be compared.

has been brought about by the establishment of vast numbers of saplings which would normally have been eliminated, or at least greatly checked in their development, by fire. Many of the species present do not have fire-resistant barks and are probably not true cerradão species, e.g. *Daphnopsis fasciculata, Rapanea umbellata* and *R. lancifolia,* while others are, in our experience, generally more typical of forest although sometimes occurring in cerradão, e.g. *Amaioua guianensis* and *Tapirira guianensis.*

The prolonged protection of the reserve from fire also affords an opportunity for making other observations. *Caryocar brasiliense* is frequent but occurs only as a hemixyle, i.e. as a perennial subshrub which renews its aerial shoots each year rather than producing the more normal tree form. Clearly in this case the hemixyle growth-form is not the result of destruction of vulnerable young shoots by fire, and perhaps it can be related to the observation of Labouriau, Marques Vâlio & Heringer (1964) who demonstrated that under experimental conditions *C. brasiliense* only produced perennial shoots if the young plants were supplied with sufficient water during the dry season. However, this would be something of a paradox, since climatic data show that the dry season is much less severe in São Paulo state than in the cerrado core area where the tree form is abundant (Table 1). The works of Gibbs *et al.* (1983) and Silberbauer-Gottsberger & Eiten (1983) seem to indicate that *C. brasiliense* produces a perennial trunk at the nearest sites for which other observations are available: Mogi Guaçu and Botucatu. The form at Angatuba is probably *C. brasiliense* subsp. *intermedium* (Wittmack) Prance & Freitas da Silva which has a southern distribution and is often a low subshrub (Prance & Freitas da Silva, 1973).

Three points which impressed one of us (JAR), whose experience of cerrado is derived from the central core area, are, (a) the paucity of termites, which must indicate a profound difference in the pattern of nutrient cycling, (b) the sparse occurrence of *Qualea grandiflora* and the complete absence of *Q. parviflora* Mart., two extremely important species in the core area, and (c) the abundance of the 'straggling stick' growth-form, as exemplified by *Lippia corymbosa, Gochnatia barrosii, G. pulchra* and *Jacaranda caroba,* in which the aerial part of the plant consists of slender, short-lived, often arching, woody shoots to c.2·5m—a growth-form much less frequent in the central cerrados.

The cerrado reserve at Angatuba has been protected from most of the factors, such as fire, timber extraction, charcoal burning, etc, which threaten so many cerrado areas; however, two invading species pose a threat of irreversible damage. *Melinis minutiflora,* the Capim gordura, is present over a considerable area, and in places near the margin of the reserve, where there is disturbance from grazing cattle, forms a smothering mat c.80cm thick; Ferri (1973) described a similar invasion of protected cerrado at Emas (SP) while Coutinho (1982) has drawn attention to the same threat in cerrado-murundu vegetation. Invasion by bracken, *Pteridium aquilinum,* is an even more serious problem: it is entering the reserve from the west in a compact advancing mass usually about 2m tall, smothering the lower cerrado vegetation and sometimes even producing giant 4m fronds which cover the trees. In addition to

these two threats, the prolonged protection from fire is in itself changing the vegetation, allowing the development of thicket cerradão which will probably eventually be transformed into forest by the establishment of forest species.

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References

Anon. (1975). As geadas severíssimas em 02, 18 e 75. *Correio Agropecuária. Novembro.* São Paulo.

Borgonovi, M. & Chiarini, J. V. (1965). Cobertura vegetal do estado de São Paulo 1—Levantamento por fotointerpretação das áreas com cerrado, cerradão e campo em 1962. *Bragantia* 24:159–172.

Coutinho, L. M. (1982). Aspectos ecológicos da saúva no cerrado—os murundus de terra, as caraterísticas psamofíticas das espécies de sua vegetação e a sua invasão pelo capim gordura. *Rev. Brasil Biol.* 42:147–153.

Eiten, G. (1963). Habitat Flora of Fazenda Campininha, São Paulo, Brazil. *Simpôsio sobre o Cerrado* 155–202. Universidade de São Paulo.

Ferri, M. G. (1973). Sobre a origem, a manutenção e a transformação dos cerrados, tipos de savana do Brasil. *Revista de Biologia* 9:1–13.

—— & Coutinho, L. M. (1958). Contribuição ao conhecimento da ecologia do cerrado. Estudo comparativo da economia d'água de sua vegetação, em Emas (Est. de São Paulo), Campo Grande (Est. de Mato Grosso) e Goiânia (Est. de Goiás). *Bol. Fac. Filos. Univ. São Paulo* 224, Bot. 15:103–150.

Freitas, F. G. de & Silveira, C. O. da (1977). Principais solos sob vegetação de cerrado e sua aptidão agrícola. *IV Simpôsio sobre o Cerrado*: 155–194. Ed. USP.

GIBBS, P. E., LEITÃO FILHO, H. DE F. & SHEPHERD, G. (1983). Floristic composition and community structure in an area of cerrado in SE Brazil. *Flora* 173:433–449.

LABOURIAU, L. G., MARQUES VÂLIO, I. F. & HERINGER, E. P. (1964). Sobre o sistema reproductivo de plantas dos Cerrados. *An. Acad. Bras. Ciênc.* 36:449–464.

NIMER, E. (1977). Clima in *Geografia do Brasil 3: Região Sudeste*: 51–89. SERGRAF-IBGE, Rio de Janeiro.

OLIVEIRA FILHO, A. T. DE (1984). Estudo florístico e fitossociológico em um cerrado na Chapada dos Guimarães-Mato-Grosso—uma análise de gradientes. Master's thesis, Univ. of Campinas, SP.

PRANCE, G. T. & FREITAS DA SILVA, M. (1973). Caryocaraceae. *Flora Neotropica Monograph* No. 12. New York.

RATTER, J. A. (1985a). *Notes on the vegetation close to the sede of the Parque Nacional do Araguaia*, Royal Botanic Garden, Edinburgh.

—— (1985b). *Notas sobre a vegetação da Fazenda Água Limpa (Brasília, DF)*. Royal Botanic Garden, Edinburgh.

—— (1987). Notes on the vegetation of the Parque Nacional do Araguaia (Brazil). *Notes RBG Edinb.* 44:311–342.

SILBERBAUER-GOTTSBERGER, I. & EITEN, G. (1983). Fitossociologia de um hectare de cerrado. *Brasil Florestal* No. 54:55–70.

——, MORAWETZ, W. & GOTTSBERGER, G. (1977). Frost damage of cerrado plants in Botucatu, Brazil, as related to the geographical distribution of the species. *Biotropica* 9:253–261.

—— & GOTTSBERGER, G. (1984). Cerrado-Cerradão. A comparison with respect to number of species and growth forms. *Phytocoenologia* 12:293–303.

SØRENSEN, T. A. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analyses of the vegetation on Danish commons. *K. dan Vidensk Selsk Biol. Skr.* 5:1–34.

WALTER, H. & LIETH, H. (1967). *Klimadiagramm-Weltatlas*. Jena.