FLORISTIC COMPOSITION OF THE CERRADO IN THE PÉ-DE-GIGANTE RESERVE (SANTA RITA DO PASSA QUATRO, SOUTHEASTERN BRAZIL)

Marco Antônio Batalha[1]
Waldir Mantovani[2]

Recebido em 04/02/00. Aceito em 25/07/01.

RESUMO – (Composição florística do cerrado na Reserva Pé-de-Gigante (Santa Rita do Passa Quatro, SP)). Estudamos uma área de 1225 ha, composta principalmente por cerrado, situada em Santa Rita do Passa Quatro, estado de São Paulo (21°36-38'S, 47°36-39'W). Em três fisionomias de cerrado (campo cerrado, cerrado *sensu stricto* e cerradão), coletamos, durante 18 meses, em excursões mensais, espécimes em fase fértil e os identificamos em nível específico. Encontramos 360 espécies, pertencentes a 236 gêneros e 69 famílias. As famílias mais ricas foram: Fabaceae, Asteraceae, Poaceae e Rubiaceae. As fisionomias savânicas foram mais ricas do que a florestal. A razão entre espécies arbustivo-arbóreas e herbáceo-subarbustivas foi de aproximadamente 2:1. Analisamos a flora como um todo e seus componentes herbáceo-subarbustivo e arbustivo-arbóreo separadamente, comparando-os com outras áreas disjuntas de cerrado. Dessa comparação, obtivemos valores de similaridade (índice de Sørensen) de 0,47 a 0,81, que mostraram que a diversidade 3 foi maior no componente herbáceo-subarbustivo do que no componente arbustivo-arbóreo.

Palavras-chave – cerrado, savana, fisionomia, florística.

ABSTRACT – (Floristic composition of the cerrado in the Pé-de-Gigante Reserve (Santa Rita do Passa Quatro, southeastern Brazil)). We studied a 1225 ha area, composed mainly of cerrado, in Santa Rita do Passa Quatro, São Paulo State, southeastern Brazil (21°36-38'S, 47°36-39'W). In three cerrado physiognomies (*campo cerrado* – a wooded savanna, *cerrado sensu stricto* – a woodland, and *cerradão* – a tall woodland), we collected all vascular plants in reproductive stage, and identified them to species level. We found 360 species, representing 236 genera and 69 families. The richest families were: Asteraceae, Fabaceae, Poaceae, and Rubiaceae. The savanna physiognomies were richer than the forest one. The ratio between herbaceous and woody species was approximately 2:1. We analysed the whole flora and its two components separately, woody and herbaceous, comparing them with other disjunct cerrado areas. We obtained similarity values (Sørensen index) from 0.47 to 0.81, which showed that the 3 diversity of the cerrado was higher in the herbaceous component than in the woody one.

Key words – cerrado, savanna, physiognomy, floristics, woody: herbaceous ratio

[1, 2] Depto. de Ecologia, Instituto de Biociências, Universidade de São Paulo, Caixa Postal 11.461, 05422-970, São Paulo, SP, Brasil.
[1] Pós-Graduação em Ecologia (marcobat@uol.com.br).
[2] Prof. Titular (wmantova@usp.br).

Introduction

About 23% of the Brazilian territory (2 millions km^2) were originally covered by cerrado vegetation (Ratter *et al*. 1992). Its core area covers the Brazilian Central Highlands, in the states of Minas Gerais, Mato Grosso, Mato Grosso do Sul, Goiás, Tocantins, Maranhão, and Piauí (Mantovani & Martins 1993). Outlying cerrado areas also occur in other states, as in São Paulo (Ratter *et al*. 1992).

The cerrado vegetation is characterized by its wide physiognomic variation. According to Coutinho (1978), the cerrado goes from *campo limpo*, a grassland, to *cerradão*, a woodland. The intermediate physiognomies (*campo sujo* – a shrub savanna, *campo cerrado* – a wooded savanna, and *cerrado sensu stricto* – a woodland) are considered ecotones.

Accompanying the physiognomic variation, the cerrado vegetation presents a high floristic richness. Castro *et al*. (1999) compiled many floristic and phytosociological surveys carried out in cerrado areas and estimated the number of vascular plant species in this vegetation type ranging from 3,000 to 7,000. Mendonça *et al*. (1998) listed 6,429 species for the whole domain, including, besides the cerrado itself, other associated vegetation types, such as gallery forest, deciduous and semideciduous forest, and floodplain grassland.

The cerrado vegetation has two distinct floras, a woody one and an herbaceous one, which are antagonistic, because both are sun-loving (Coutinho 1978). The importance of the herbaceous flora gradually decreases from the *campo limpo* to the *cerradão*, while the importance of the woody flora increases in this direction (Coutinho 1978). Mantovani & Martins (1993) compared some cerrado areas, and they found a species ratio of 1:2 to 1:3 between the woody and the herbaceous floras. Castro *et al*. (1999) emphasized the almost complete absence of studies that sampled the herbaceous component, in spite of its high richness.

Our aim was to carry out a floristic survey in a disjunct cerrado area, distinguishing its physiognomies. This survey intends to increase the knowledge of the cerrado flora, especially of the frequently neglected herbaceous component, and to contribute to phytogeographical studies.

Material and methods

The Pé-de-Gigante Reserve is located in Santa Rita do Passa Quatro Municipality, São Paulo State, southeastern Brazil, between 21°36-38'S and 47°36-39'W, under a Cwag' (Köppen 1948) or $B_3B'_3w$ (Thornthwaite & Mather 1955) climate type, at 590 to 740m high, on Red-Yellow Latosol (Pivello *et al*. 1998). Its name ("Pé-de-Gigante" or "Giant's foot") was given due to the presence of a foot-shaped geomorphological formation in the Paulicéia Stream drainage basin (Fig. 1). The study area covers 1225ha, in which are found mainly cerrado physiognomies: *campo sujo* (0.25% of the total area), *campo cerrado* (7.9%), *cerrado sensu stricto* (79.0%) and *cerradão* (11.1%). Other vegetation types are also present, such as floodplain grassland, gallery forest and seasonal semideciduous forest. A more detailed characterization of the study area can be found in Pivello *et al*. (1998, 1999a).

First, the reserve was mapped with remote sensing techniques, using a vegetation index that measures the green biomass, with which the occurrence of cerrado regions was assigned (Bitencourt *et al*. 1997, Pivello *et al*. 1999a). We distinguished the cerrado physiognomies following the "forest-ecotone-grassland" concept (Coutinho 1978). Then, in each cerrado physiognomy, except the *campo sujo* due to its small extension, we carried out floristic surveys in monthly field trips, each one with 23hr sampling effort, from September 1995 to February 1997, when we collected all vascular plant species in reproductive phase. We lodgeal the collected exsicata in the herbarium of São Paulo Botanical Institute (SP). Plants were classified in families according to the sys-

tem proposed by Judd *et al*. (1999). The species were classified in life forms in accordance with Raunkiaer's system, adapted by Mueller-Dombois & Ellenberg (1974). We considered the phanerophyte species as belonging to the woody component and the non-phanerophytes species as belonging to the herbaceous one. We calculated the floristic similarity among the different physiognomies at species level, grouping them in clusters, using average-linking as agglomerative algorithm (Jongman *et al*. 1995) and Sørensen index as distance measure (Magurran 1988). The results were compared in the same way with other floristic surveys, in which similar methods were used (Mantovani & Martins 1993, Batalha *et al*. 1997).

Results and Discussion

In the cerrado physiognomies (*campo cerrado*, *cerrado sensu stricto,* and *cerradão*), 360

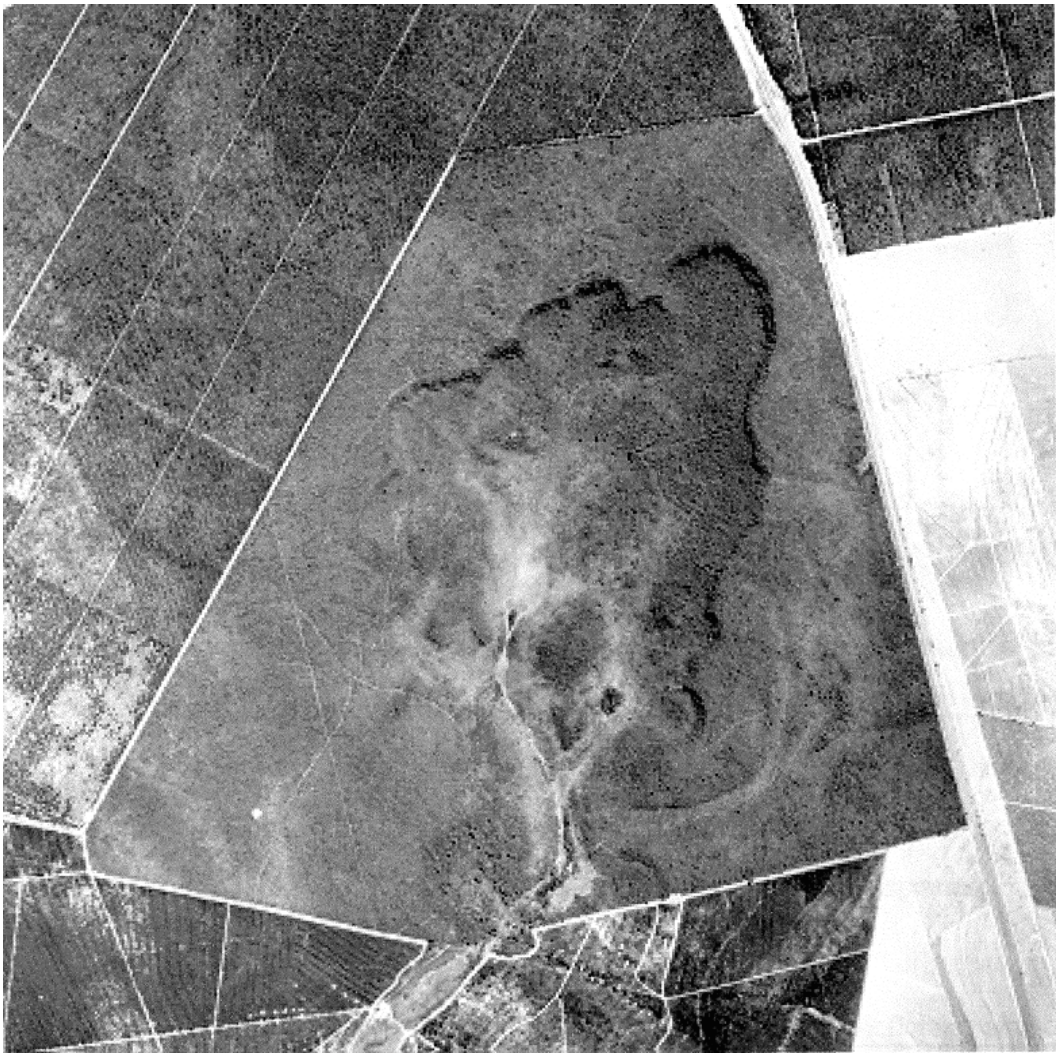

Figure 1. Aerial photograph (1:40.000) of the Pé-de-Gigante Reserve, Santa Rita do Passa Quatro, São Paulo State, Brazil (21°36-38'S, 47°36-39'W).

species were found, belonging to 236 genera and 69 families (Tab. 1 and 2). The richest families were: Fabaceae, Asteraceae, Poaceae, Rubiaceae, Bignoniaceae, Myrtaceae, Malpighiaceae, Malvaceae, and Apocynaceae, together accounting for 57.8% of collected species (Fig. 2).

These families are also the most representative ones in other cerrado areas, such as Lagoa Santa (Warming 1892), Triângulo Mineiro (Goodland 1979), Brasília (Ratter 1980), Moji Guaçu (Mantovani & Martins 1993), and Pirassununga (Batalha *et al*. 1997).

Of the total collected species, 16 (4.4%) are weeds that does not occur spontaneously in cerrado sites (Mendonça *et al*. 1998). In this vegetation type, this is mainly a consequence of the fragmentation and edge effect (Pivello *et al*. 1998, 1999b). Mendonça *et al*. (1998) listed for the whole Cerrado Domain 289 weedy species, or 4.5% of its total flora, the same proportion observed in the Pé-de-Gigante flora. Plant invasions are a major problem in cerrado fragments, occuring pratically in every one of them, dominating in patches and outcompeting native species (Pivello *et al*. 1999b). This situation occurs also in the Pé-de-Gigante Reserve, where African grasses, especially *Melinis minutiflora* P. Beauv. and *Brachiaria decumbens* Stapf, are spreading fast (Pivello *et al*. 1999c).

A total of 272 species were found in the *campo cerrado*; 308, in the *cerrado sensu stricto*; and 148, in the *cerradão* (Tab. 2). Following the "forest-ecotone-grassland" concept (Coutinho 1978), the ecotonal physiognomies are expected to be richer, because they contain species from both the herbaceous and the woody components. Indeed, the existing ecotonal physiognomies in the Pé-de-Gigante Reserve, *campo cerrado* and *cerrado sensu stricto*, were richer than one of the extremes, *cerradão*. The woody to herbaceous species ratio for all three physiognomies together (*cerrado sensu lato*) was approximately 1:2 (Tab. 2). This ratio increased from *cerradão*, in which the number of woody species was higher than those of herbaceous species, to *campo cerrado* (Tab. 2). Once again, this is expected according to the "forest-ecotone-grassland" concept (Coutinho 1978),

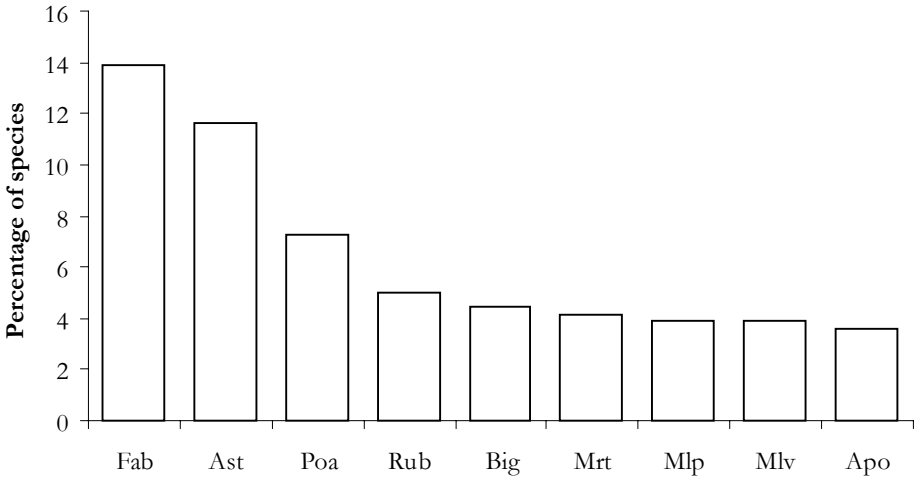

Figure 2. Percentage of species in the richest families in cerrado physiognomies in the Pé-de-Gigante Reserve, Santa Rita do Passa Quatro, São Paulo State, Brazil (21°36-38'S, 47°36-39'W). Key: Fab = Fabaceae, Ast = Asteraceae, Poa = Poaceae, Rub = Rubiaceae, Big = Bignoniaceae, Mrt = Myrtaceae, Mlp = Malpighiaceae, Mlv = Malvaceae, and Apo = Apocynaceae. Other families accounted for 42.2% of the total number of species.

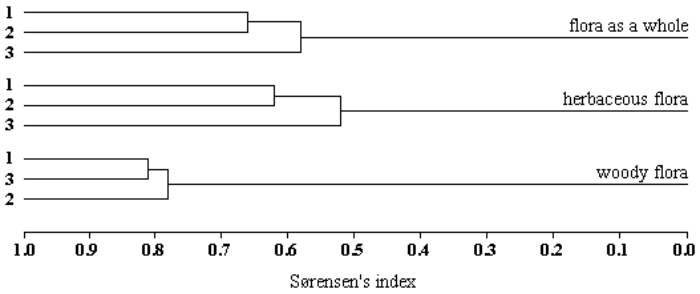

Figure 3. Cluster analysis of cerrado floras. 1 = Pé-de-Gigante Reserve, Santa Rita do Passa Quatro, São Paulo State, Brazil (21°36-38'S, 47°36-39'W); 2 = Emas, Pirassununga, São Paulo State, Brazil (22°02'S, 47°30'W); 3 = Campininha Farm, Moji Guaçu, São Paulo State, Brazil (22°15-16'S, 47°08-12'W).

which predicts a gradual decrease in the number of woody species from *cerradão* to *campo limpo*. In Brasília (Ratter 1980), this ratio was also 1:2, while in Lagoa Santa (Warming 1892) and Moji Guaçu (Mantovani & Martins 1993) it was 1:3. In Santa Rita do Passa Quatro and Brasília, there is a predominance of closed cerrado physiognomies (*cerrado sensu stricto* and *cerradão*). In Lagoa Santa and Moji Guaçu, on the other hand, open cerrado physiognomies (*campo sujo* and *campo cerrado*) prevail, explaining the higher proportion of herbaceous species in these two areas.

In the three cerrado physiognomies sampled in the Pé-de-Gigante Reserve, the highest similarity was between *campo cerrado* and *cerrado sensu stricto* (0.803). Between *cerrado sensu stricto* and *cerradão*, the similarity value was 0.592 and between *campo cerrado* and *cerradão*, this value was 0.519. The same pattern was also observed in Itirapina (Mantovani 1990), where *campo cerrado* and *cerrado sensu stricto* were the most similar physiognomies and the *campo cerrado* and *cerradão*, the most dissimilar ones.

Comparing the Pé-de-Gigante Reserve with cerrado sites in Campininha Farm and Emas, 76 families, 287 genera and 516 species occur in Campininha Farm (Mantovani & Martins 1993) and 69 families, 229 genera and 358 species in Emas (Batalha *et al*. 1997). Despite its larger area (1269 ha), the Pé-de-Gigante Reserve presented a floristic richness similar to that found in Emas (16 ha) and lower than that found in Campininha Farm (342 ha). This could be a consequence of recent human impact on the reserve, such as timber explotation and cattle-raising, and the invasion of weeds (Pivello *et al*. 1999a, 1999b), but also of the prevalence of open physiognomies in Emas and Campininha Farm. Besides, differences on sampling effort could have contributed also to these results.

Table 2. Number of families, genera and species in cerrado physionomies in the Pé-de-Gigante Reserve, Santa Rita do Passa Quatro, São Paulo State, Brazil (21°36-44'S e 47°34-41'W). Key: fam = families; gen = genera; spp = species; w = woody species; h = herbaceous species; w:h = woody to herbaceous species ratio.

physiognomy	**fam**	**gen**	**spp**	**w**	**h**	**w:h**
cerrado sensu lato	69	236	360	124	237	1:1.91
cerradão	45	113	148	82	66	1:0.80
cerrado sensu stricto	63	208	308	114	194	1:1.70
campo cerrado	60	189	272	85	187	1:2.20

The similarity index values between the Pé-de-Gigante Reserve and Campininha Farm and between the Pé-de-Gigante Reserve and Emas were 0.558 and 0.659, respectively. Between Campininha Farm and Emas, this value was 0.629 (Fig. 3).

The Campininha Farm distinguished itself from the Pé-de-Gigante Reserve and from Emas by its greater floristic richness. This variation existed mainly at species level, since the genera and families remained approximately constant, as stated previously by Mantovani & Martins (1993).

Herbaceous component - The 236 herbaceous species comprised 65.6% of the flora as a whole. The families represented only in this component accounted for 40.6% of the total number of families, a value lower than those obtained in Campininha Farm (44.7%) (Mantovani & Martins 1993) and Emas (49.7%) (Batalha *et al*. 1997). The richest families in this component were: Asteraceae, Fabaceae, Poaceae, Rubiaceae, Bignoniaceae, Malvaceae, Apocynaceae, Euphorbiaceae, and Malpighiaceae, representing 66.5% of the total number of herbaceous species. These families are also the most representative ones in this component in other cerrado sites, such as Campininha Farm (Mantovani & Martins 1993) and Emas (Batalha *et al*. 1997).

The similarity index values between the Pé-de-Gigante Reserve and the Campininha Farm and between the Pé-de-Gigante Reserve and Emas were 0.472 and 0.609, respectively. Between Campininha Farm and Emas, this value was 0.580 (Fig. 3). The much higher richness found in Campininha Farm (391) contributed to separate it from Pé-de-Gigante and Emas (236 and 250 species, respectively).

There are few studies including the herbaceous species of the cerrado flora (Castro *et al*. 1999). The seasonality of the epigeal portion of the herbaceous species, that lasts from a few months to two years, contributes to the poor knowledge of this component. As a consequence of the short epigean cycle of many species and depending on fire frequency and intensity, the herbaceous component composition changes a lot throughout the year (Mantovani & Martins 1993).

Woody component - The 124 woody species represented 34.4% of the whole flora. Of all sampled families, 29.0% had species only in the woody component, a value between those found in Campininha Farm (34.7%) (Mantovani & Martins 1993) and Emas (24.6%) (Batalha *et al*. 1997).

The richest families in this component were: Fabaceae, Myrtaceae, Melastomaceae, Vochysiaceae, Malpighiaceae, Rubiaceae, Annonaceae, Bignoniaceae, and Erythroxylaceae, comprising 57.3% of collected species. These families are also the best represented in Campininha Farm (Mantovani & Martins 1993) and Emas (Batalha *et al*. 1997).

In this component, 108 species were sampled in Emas and 125 in Campininha Farm. The similarity index values between the Pé-de-Gigante Reserve, Campininha Farm and Emas were all between 0.77 and 0.81 (Fig. 3). The similarity index values in this component were higher than those found in the herbaceous one, showing that the heterogeneity is higher in the herbaceous than in the woody flora. This higher heterogeneity of the herbaceous component was evident only at species level, since at genus and especially at family levels there was no pronounced difference between the two components.

Castro *et al*. (1999) made an extensive compilation of many floristic and phytosociological studies carried out in cerrado vegetation and elaborated a check-list of woody species. Of the species sampled here, only *Myrcia guianensis* (Aubl.) A. DC. (Myrtaceae) was not reported by these authors.

Andira anthelmia (Vell.) J. Macbr. (Fabaceae), *Byrsonima crassa* Naud. (Malpighiaceae), *Anadenanthera peregrina* (L.) Speg. (Mimosaceae), *Eugenia langsdorffii* O. Berg (Myrta-

ceae), *Myrcia pubipetala* Miq. (Myrtaceae), *Luehea divaricata* Mart. (Tiliaceae), *Syagrus romanzoffiana* (Cham.) Glass. (Arecaceae), as well as *Myrcia guianensis*, were also not reported as ocurring in São Paulo State cerrado areas by Leitão-Filho (1992) and should be added to his list.

Acknowledgements

We are grateful to Paulo César Fernandes, for field assistance, and to FAPESP, for the financial support conceded to the first author (process 95/4290-3).

Table 1. List of species collected in cerrado physiognomies in the Pé-de-Gigante Reserve, Santa Rita do Passa Quatro, São Paulo State, Brazil (21°36-38'S, 47°36-39'W). Key: h = herbaceous component (non phanerophyte species), w = woody component (phanerophyte species); 1 = *cerradão*, 2 = *cerrado sensu stricto*, 3 = *campo cerrado*; collector # = M.A. Batalha collector number. The weedy species that does not occur spontaneously in cerrado sites, according to Mendonça *et al*. (1998), are marked by an asterisk.

Family/ *species*	**life-form**	**1**	**2**	**3**	**collector #**
Acanthaceae					
Hygrophila brasiliensis (Spr.) Lindau	h		2	3	1165
Ruellia geminiflora Kunth	h	1	2		1296
Alstroemeriaceae					
Alstroemeria pulchella L. f.	h		2	3	1255
Amaranthaceae					
Alternanthera brasiliana (L.) Kuntze	h	1	2	3	724
Froelichia procera (Seub.) Pederson	h	1	2	3	1523
Gomphrena virgata Mart.	h		2	3	762
Pfaffia jubata Mart.	h			3	1608
Anacardiaceae					
Anacardium humile A. St-Hil.	h	1	2	3	677
Tapirira guianensis Aubl.	w	1	2	3	770
Annonaceae					
Annona coriacea Mart.	w	1	2	3	671
Annona crassiflora Mart.	w	1	2	3	841
Annona dioica A. St-Hil.	h		2	3	1509
Duguetia furfuracea (A. St-Hil.) Benth. & Hook.	w	1	2	3	1518
Xylopia aromatica (Lam.) Mart.	w	1	2	3	775
Apiaceae					
Didymopanax vinosum (Cham. & Schltdl.) Seem	w	1	2	3	611
Eryngium junceum Cham. & Schltdl.	h			3	854
Apocynaceae					
Aspidosperma tomentosum Mart.	w	1	2	3	1167
Astephanus carassensis Malme	h		2		1277
Blepharodon nitidum (Vell.) J. Macbr.	h			3	1541
Ditassa acerosa Mart.	h		2	3	1638
Ditassa obcordata Fourn.	h	1	2		1445
Forsteronia glabrescens Müll. Arg.	h		2	3	1506
Hancornia speciosa Gomez	w		2		898
Himatanthus obovatus (Müll. Arg.) Woods.	w		2	3	1574
Mandevilla pohliana (Standelm.) A. Gentry	h		2		987
Odontadenia lutea (Vell.) Markgr.	h		2	3	1347
Oxypetalum appendiculatum Mart. & Zucc.	h		2		692
Rhodocalyx rotundifolius Müll. Arg.	h		2		891
Temnadenia violacea (Vell.) Miers	h	1	2	3	919

Table 1. (continued)

Family/ *species*	**life-form**	**1**	**2**	**3**	**collector #**
Arecaceae					
Attalea geraensis Barb. Rodr.	h		2	3	772
Butia paraguayensis (Barb. Rodr.) Bailey	w		2	3	818
Syagrus flexuosa (Mart.) Becc.	w		2	3	848
Syagrus loefgrenii (Mart.) Becc.	h	1	2	3	1237
Syagrus romanzoffiana (Cham.) Glass.	w	1	2		1732
Aristolochiaceae					
Aristolochia giberti Hook.	h			3	1081
Asteraceae					
Acanthospermum australe (Loefl.) Kuntze	h			3	1540
Achyrocline satureoides (Lam.) A. DC.	h			3	828
Aspilia reflexa Baker	h		2		991
Baccharis dracunculifolia A. DC.	h		2	3	1433
Baccharis humilis Sch. Bip.	h		2	3	969
Baccharis rufescens Spr.	h		2	3	1703
Bidens gardneri Baker	h	1	2	3	1038
Campuloclinium chlorolepis Baker	h		2	3	1275
Chaptalia integerrima (Vell.) Burk	h		2	3	1281
Chromolaena maximiliani (Schrad.) King & H. Rob.	h	1	2	3	902
Chromolaena squalida (A. DC.) King & H. Rob.	h		2	3	618
Conyza canadensis (L.) Cronquist	h		2	3	963
Dasyphyllum sprengelianum (Gardner) Cabrera	h	1	2		659
Elephantopus biflorus Less.	h			3	1263
Elephantopus mollis L.	h	1	2	3	1606
Emilia coccinea (Sims) Sweet *	h		2	3	1032
Eremanthus erythropappus Sch. Bip.	w		2	3	1341
Eremanthus sphaerocephalus Baker	h		2	3	1443
Gochnatia barrosae Cabrera	h		2	3	1456
Gochnatia pulchra Cabrera	h	1	2	3	1636
Kanimia oblongifolia Baker	h		2	3	750
Mikania cordifolia (L.) Willd.	h		2	3	1599
Orthopappus angustifolius (Sw.) Gleason *	h		2	3	1536
Piptocarpha rotundifolia (Less.) Baker	w		2	3	1025
Porophyllum angustissimum Gardner	h		2	3	1362
Porophyllum ruderale (Jacq.) Cass. *	h			3	1631
Pterocaulon rugosum (Vahl) Malme	h			3	1130
Stenocephalum apiculatum (A. DC.) Sch. Bip.	h		2		1293
Tilesia baccata (A. DC.) Pruski	h		2	3	1607
Trichogonia salviifolia G. M. Barroso	h			3	1045
Vernonia bardanoides Less.	h	1	2	3	666
Vernonia cephalotes A. DC.	h		2		1446
Vernonia ferruginea Less.	h		2		1412
Vernonia herbacea (Vell.) Rusby	h			3	1291
Vernonia holosericea Mart.	h		2	3	1352
Vernonia lappoides Baker	h		2	3	1173
Vernonia obtusata Less.	h		2	3	1375
Vernonia onopordioides Baker	h		2	3	1641
Vernonia polyanthes (Spr.) Less.	h		2	3	833
Vernonia rubriramea Mart.	h		2	3	1282
Vernonia scabra Pers.	h		2		1426

`Table 1. (continued)

Family/ *species*	life-form	1	2	3	collector #
Viguiera discolor A. DC.	h		2	3	1607
Bignoniaceae					
Anemopaegma arvense (Vell.) Stellfeld	h		2		796
Anemopaegma chamberlaynii (Sims) Bur. & K. Schum.	h			3	1451
Arrabidaea brachypoda (A. DC.) Bur.	h		2	3	1005
Arrabidaea craterophora (A. DC.) Bur.	h	1	2	3	658
Arrabidaea florida A. DC.	h		2	3	1615
Arrabidaea pulchra (Cham.) Bur.	h		2	3	1338
Cybistax antisyphillitica (Mart.) Mart.	w		2		1175
Distictella mansoana (A. DC.) Urban	h	1	2	3	964
Jacaranda caroba (Vell.) A. DC.	h	1	2	3	1431
Jacaranda decurrens Cham.	h		2	3	751
Jacaranda rufa Silva Manso	h		2		970
Memora peregrine (Miers.) Sandwith	h	1	2	3	975
Pyrostegia venusta (Ker Gawl.) Bur.	h	1	2	3	1434
Tabebuia aurea (Silva Manso) S. Moore.	w		2	3	1177
Tabebuia ochracea (Cham.) Standl.	w	1	2	3	933
Zeyheria montana Mart.	w			3	
Boraginaceae					
Cordia corymbosa (L.) G. Don.	h			3	1595
Bromeliaceae					
Aechmea bromeliifolia (Rudge) Baker	h	1	2		878
Ananas ananassoides (Baker) L.B. Sm.	h	1	2	3	737
Bromelia balansae Mez	h	1	2	3	683
Dickia tuberosa (Vell.) Beer	h		2	3	788
Tillandsia geminiflora Brogn.	h	1	2		684
Burseraceae					
Protium heptaphyllum (Aubl.) March	w	1	2	3	1413
Cactaceae					
Epyphyllum phyllanthus (L.) Haw.	h	1			829
Caryocaraceae					
Caryocar brasiliense Cambess.	w	1	2	3	771
Caryophyllaceae					
Polycarpea corymbosa (L.) Lam.	h		2	3	1511
Celastraceae					
Peritassa campestris (Cambess.) A.C. Sm.	w		2		1444
Plenckia populnea Reissek	w		2	3	949
Tontelea micrantha (Mart.) A.C. Sm.	w		2		1097
Chrysobalanaceae					
Couepia grandiflora (Mart. & Zucc.) Hook. f.	w	1	2	3	689
Licania humilis Cham. & Schltdl.	w	1	2	3	1358
Parinari excelsa Sabine	h	1	2	3	757
Clusiaceae					
Kielmeyera coriacea Mart.	w		2	3	1736
Kielmeyera rubriflora Cambess.	w	1	2		1270
Kielmeyera variabilis Mart.	w	1	2	3	1017
Cochlospermaceae					
Cochlospermum regium (Mart.) Pilg.	h		2	3	645
Commelinaceae					
Commelina erecta L.	h	1	2	3	1476

Table 1. (continued)

Family/ *species*	**life-form**	**1**	**2**	**3**	**collector #**
Connaraceae					
Connarus suberosus Planch.	w	1	2	3	931
Rourea induta Planch.	w	1	2	3	974
Convolvulaceae					
Ipomoea procurrens C.F.W. Meissn.	h		2	3	1189
Jacquemontia tamnifolia (L.) Griseb.	h		2	3	1076
Cucurbitaceae					
Cayaponia espelina (Cogn.) Silva Manso	h		2	3	1484
Cyperaceae					
Bulbostylis hirtella (Schrad.) Urban	h		2	3	1416
B.sphaerocephala (Boeck.) C.B. Clarke	h		2	3	876
Cyperus cayennensis (Lam.) Britton	h		2	3	822
Cyperus diffusus Vahl	h	1	2	3	1474
Rhynchospora exaltata Kunth	h	1	2	3	721
Scleria comosa (Nees) Steud.	h	1	2	3	811
Dilleniaceae					
Davilla elliptica A. St-Hil.	w		2	3	760
Davilla rugosa A. St-Hil.	h		2		993
Ebenaceae					
Diospyros hispida A. DC.	w	1	2	3	1479
Erythroxylaceae					
Erythroxylum campestre A. St-Hil.	w	1	2	3	951
Erythroxylum pelleterianum A. St-Hil.	w	1	2		1190
Erythroxylum suberosum A. St-Hil.	w		2	3	1514
Erythroxylum tortuosum Mart.	w	1	2		901
Euphorbiaceae					
Croton eriocladus Müll. Arg.	h		2	3	935
Croton pohlianus Müll. Arg.	h			3	917
Croton sclerocalyx Müll. Arg.	h		2	3	1060
Manihot caerulescens Pohl	h		2		1694
Manihot tripartita Müll. Arg.	h		2	3	918
Phyllanthus orbiculatus Müll. Arg.	h		2	3	1359
Sapium glandulatum (Vell.) Pax	h			3	1061
Sebastiania bidentata (Mart.) Pax	h			3	1034
Sebastiania serrulata Müll. Arg.	h		2	3	989
Fabaceae					
Acosmium dasycarpum (Vogel) Yakovlev	w	1			1297
Acosmium subelegans (Mohl) Yakovlev	w		2		915
Aeschynomene marginata Benth.	h		2	3	1327
Anadenanthera falcata (Benth.) Speg.	w	1	2	3	1589
Anadenanthera peregrina (L.) Speg.	w		2		1082
Andira anthelmia (Vell.) J. Macbr.	w		2		1033
Andira laurifolia Benth.	h		2	3	699
Bauhinia rufa (Bong.) Steud.	w	1	2	3	1000
Bowdichia virgilioides Kunth.	w	1	2		1071
Centrosema venosum Mart. ex Benth.	h			3	1199
Chamaechrista campestris Irwin & Barneby	h		2	3	948
Chamaechrista cathartica (Mart.) Irwin & Barneby	h			3	1543
Chamaechrista debilis (Vogel) Irwin & Barneby	h			3	954
Chamaecrista desvauxii (Collad.) Killip	h		2	3	992

Table 1. (continued)

Family/ *species*	**life-form**	**1**	**2**	**3**	**collector #**
Chamaecrista flexuosa (L.) Greene	h		2	3	639
Chamaecrista rotundifolia (Pers.) Greene	h			3	1332
Clitoria falcata Lam.	h			3	1612
Clitoria laurifolia Poir.	h			3	1480
Copaifera langsdorffii Desf.	w	1	2	3	642
Crotalaria vitellina Ker Gawl.	h		2	3	1009
Dalbergia miscolobium Benth.	w	1	2	3	1344
Deguelia nitidula (Benth.) Az.-Tozzi	h		2		1743
Dimorphandra mollis Benth.	w	1	2	3	1706
Dyptichandra aurantiaca Tul.	w	1	2	3	1181
Enterolobium gummiferum (Mart.) Macbr.	w		2		1470
Eriosema crinitum (Kunth) Gardner	h		2	3	1298
Galactia decumbens (Benth.) Hassl.	h			3	960
Galactia grewiifolia (Benth.) Taub.	h	1	2	3	1065
Hymenaea stigonocarpa Mart.	w	1	2	3	1027
Indigofera suffruticosa Mill.	h		2		1414
Machaerium acutifolium Vogel	w	1	2	3	1060
Macroptilium gracile (Poepp. ex Benth.) Urban	h		2		1357
Mimosa debilis Humb. & Bonpl. ex Willd.	h			3	1616
Mimosa gracilis Benth.	h		2	3	1016
Mimosa pigra L. *	h		2		1010
Mimosa xanthocentra Mart.	h		2	3	1584
Periandra mediterranea (Vell.) Taub.	h	1	2	3	1268
Plathymenia reticulata Benth.	w	1	2		1521
Platypodium elegans Vogel	w	1			1388
Pterodon pubescens Benth.	w	1	2	3	661
Rhynchosia melanocarpa Grear	h		2	3	1635
Sclerolobium paniculatum Vogel	w	1	2		1252
Senna rugosa (G. Don.) Irwin & Barneby	w		2	3	693
Senna silvestris (Vell.) Irwin & Barneby	w	1	2	0	1184
Stryphnodendron adstringens (Mart.) Coville	w		2	3	1711
Stryphnodendron obovatum Mart.	w	1	2		1048
Stylosanthes gracilis Kunth	h		2	3	1308
Stylosanthes guianensis (Aubl.) Sw.	h		2		1497
Vatairea macrocarpa (Benth.) Ducke	w	1	2	3	1200
Zornia latifolia Sm.	h		2	3	1491
Flacourtiaceae					
Casearia grandiflora Cambess.	w	1	2	0	1023
Casearia sylvestris Sw.	w	1	2	3	672
Iridaceae					
Trimezia juncifolia (Kl.) Kunth	h	1	2	3	862
Lamiaceae					
Hyptidodendron canum (Pohl ex Benth.) Harley	w	1	2	3	657
Hyptis brevipes Poit. *	h	1	2	3	1335
Hyptis eriophylla Pohl	h		2	3	1640
Hyptis mutabilis (A. Rich.) Briq.	h		2		1316
Hyptis reticulata Mart.	h		2	3	747
Hyptis rugosa Benth.	h		2	3	1356
Peltodon tomentosus Pohl	h		2	3	1534
Lauraceae					

Table 1. (continued)

Family/ *species*	**life-form**	**1**	**2**	**3**	**collector #**
Cassytha americana Nees	h		2		1462
Ocotea corymbosa (Meiss.) Mez	w	1	2	3	600
Ocotea pulchella Mart.	w		2	3	1038
Loganiaceae					
Strychnos bicolor Progel	h	1	2		1585
Strychnos pseudoquina A. St-Hil.	w	1			743
Loranthaceae					
Psittacanthus robustus Mart.	h		2		710
Lythraceae					
Cuphea carthaginensis (Jacq.) Macbr.	h		2	3	1561
Lafoensia pacari A. St-Hil.	w		2	3	1264
Malpighiaceae					
Banisteriopsis argyrophylla (A. Juss.) B. Gates	h	1			1287
Banisteriopsis campestris (A. Juss.) Little	h		2	3	1210
Banisteriopsis laevifolia (A. Juss.) B. Gates	h		2	3	1560
Banisteriopsis pubipetala (A. Juss.) Cuatrec.	h	1	2	3	628
Banisteriopsis stellaris (Griseb.) B. Gates	h	1	2	3	1024
Banisteriopsis variabilis B. Gates	h	1	2	3	784
Byrsonima coccolobifolia A. Juss.	w	1	2	3	1036
Byrsonima crassa Nied.	w		2		1019
Byrsonima intermedia A. Juss.	w		2	3	606
Byrsonima verbascifolia (L.) Rich ex A. Juss.	w		2	3	1354
Heteropteris byrsonimifolia A. Juss.	w		2	3	1621
Heteropteris umbellata A. Juss.	h		2	3	853
Mascagnia cordifolia (A. Juss.) Griseb.	h	1	2	3	1494
Peixotoa tomentosa A. Juss.	h		2	3	1610
Malvaceae					
Byttneria sagittifolia A. St-Hil.	h	1	2	3	1493
Eriotheca gracilipes (K. Schum.) A. Robyns	w	1	2	3	1427
Helicteres sacarolha A. St-Hil.	h			3	1235
Luehea divaricata Mart.	w	1	2	3	582
Pavonia communis A. St-Hil.	h			3	1038
Pavonia hexaphylla (S. Moore) Krapov.	h		2	3	1024
Peltaea edouardii (Hochr.) Krapov. & Cristóbal	h			3	1056
Pseudobombax longiflorum (Mart. & Zucc.) A. Robyns	w	1			1288
Sida glaziovii K. Schum. *	h			3	634
Sida linifolia A. Juss. *	h		2	3	1624
Sida rhombifolia L. *	h			3	1051
Sida urens L. *	h			3	1644
Waltheria americana L.	h		2	3	835
Waltheria communis L.	h		2	3	984
Melastomataceae					
Leandra lacunosa Cogn.	w		2	3	620
Miconia albicans Triana	w	1	2	3	1629
Miconia fallax A. DC.	h	1	2	3	1575
Miconia ligustroides Naudin	w	1	2	3	1639
Miconia rubiginosa (Bonpl.) A. DC.	w	1	2	3	1522
Miconia stenostachya A. DC.	w	1	2	3	732
Tibouchina stenocarpa (A. DC.) Cogn.	w	1	2	3	662
Menispermaceae					

Table 1. (continued)

Family/ *species*	life-form	1	2	3	collector #
Cissampelos ovalifolia Ruiz & Pav.	h		2	3	1556
Monimiaceae					
Siparuna guianensis Aubl.	w		2		1495
Moraceae					
Brosimum gaudichaudii Trècul	w		2		820
Ficus citrifolia Mill.	w		2		1011
Myristicaceae					
Virola sebifera Aubl.	w	1	2		1576
Myrtaceae					
Campomanesia pubescens (A. DC.) O. Berg	w		2	3	1050
Eugenia aurata O. Berg	w		2	3	1634
Eugenia bimarginata A. DC.	w	1	2	3	1455
Eugenia hiemalis Cambess.	w		2		1314
Eugenia langsdorffii O. Berg	w	1	2	3	1475
Eugenia livida O. Berg	w	1	2	3	1389
Eugenia punicifolia (Kunth) A. DC.	w	1	2	3	1222
Myrcia bella Cambess.	w	1	2	3	965
Myrcia guianensis (Aubl.) A. DC.	w		2		1220
Myrcia lasiantha A. DC.	w	1	2	3	754
Myrcia pubipetala Miq.	w	1			1215
Myrcia tomentosa (Aubl.) A. DC.	w	1	2		940
Myrcia uberavensis O. Berg	w	1	2	3	921
Psidium australe Cambess.	h		2	3	947
Psidium cinereum Mart.	h		2	3	877
Nyctaginaceae					
Guapira noxia (Netto) Lund	w	1	2		794
Neea theifera Oerst.	w		2	3	1054
Ochnaceae					
Ouratea castaneaefolia (A. DC.) Engl.	w	1			1007
Ouratea spectabilis (Mart.) Engl.	w	1	2	3	909
Orchidaceae					
Galeandra montana Barb. Rodr.	h		2		1096
Ionopsis paniculata Lindl.	h	1			1460
Oxalidaceae					
Oxalis physocallyx Zucc.	h		2	3	1517
Poaceae					
Andropogon leucostachys Kunth	h		2	3	980
Aristida jubata (Arechav.) Herter	h		2	3	612
Axonopus barbigerus (Kunth) Hitchc.	h		2	3	1577
Axonopus marginatus (Trin.) Chase	h		2	3	968
Brachiaria decumbens Stapf *	h		2	3	851
Chloris barbata (L.) Sw.	h		2		1563
Digitaria insularis (L.) Fedde	h	1	2	3	857
Echinolaena inflexa (Poir.) Chase	h	1	2	3	1698
Eragrostis airoides Ness	h		2	3	1058
Eragrostis articulata (Schrank) Nees	h		2		1579
Eragrostis maypurensis (Kunth) Steud.	h		2	3	1379
Gymnopogon foliosus (Willd.) Nees	h		2	3	1325
Ichnanthus sericeus Hack.	h	1	2	3	846
Loudetiopsis chrysothrix (Nees) Conert	h	1	2	3	1067

Table 1. (continued)

Family/ *species*	**life-form**	**1**	**2**	**3**	**collector #**
Melinis minutiflora P. Beauv. *	h	1	2	3	622
Panicum cayennensis Lam.	h		2	3	1331
Panicum maximum Jacq. *	h	1	2		1266
Panicum olyroides Kunth	h		2	3	832
Panicum parvifolium Lam.	h		2	3	1244
Panicum procurrens Nees	h		2		1722
Panicum repens L. *	h		2		1477
Rhynchelitrum repens (Nees) C.E. Hubb. *	h		2	3	844
Schyzachirium condensatum (Kunth) Nees	h		2	3	1442
Setaria geniculata (L.) P. Beauv. *	h		2		1350
Sporolobus indicus (L.) R. Br.	h			3	1246
Tristachya leiostachya Nees	h		2	3	1098
Polygalaceae					
Bredemeyera floribunda Willd.	w	1	2	3	1226
Securidaca tomentosa A. St-Hil.	h		2		1001
Polypodiaceae					
Adiantum fructuosum Spr.	h	1	2	3	660
Polypodium latipes Langsd. & Fisch.	h	1	2	3	1013
Portulacaceae					
Portulaca hirsutissima Cambess.	h		2	3	836
Portulaca mucronata Link	h		2	3	1014
Tallinum paniculatum (Jacq.) Gaertn.	h	1	2		999
Proteaceae					
Roupala montana Aubl.	w	1	2	3	663
Rhamnaceae					
Crumenaria polygaloides Reissek	h		2		679
Rosaceae					
Prunus sellowii Sm.	w		2		986
Rubiaceae					
Alibertia macrophylla K. Schum.	w	1	2		1087
Alibertia sessilis (Vell.) K. Schum.	h	1	2	3	1360
Amaioua guianensis Aubl.	w	1			985
Borreria verticilata (L.) Mey.	h	1	2	3	1569
Borreria warmingii K. Schum.	h		2	3	941
Coccocypselum lanceolatum (Ruiz & Pav.) Pers.	h	1	2		1261
Declieuxia fruticosa (Roem. & Schult) Kuntze	h	1	2	3	1087
Diodia schumanii Standl. ex Bacigalupo	h	1	2	3	1090
Diodia teres Walt.	h		2		1366
Palicourea coriacea (Cham.) K. Schum.	h	1	2	3	1526
Palicourea rigida Kunth	w	1	2	3	983
Psychotria barbiflora A. DC.	h	1			1306
Psychotria capitata Ruiz & Pav.	h	1			1468
Psychotria deflexa A. DC.	h		2		971
Psychotria tricholoba Müll. Arg.	h	1	2		972
Rudgea viburnoides (Cham.) Benth.	w	1			1093
Sabicea brasiliensis Wernham	h			3	967
Tocoyena formosa (Cham. & Schltdl.) K. Schum.	w		2	3	1515
Sapindaceae					
Magonia pubescens A. St-Hil.	w		2		1250
Matayba elaeagnoides Radlk.	w		2	3	1679

Table 1. (continued)

Family/ *species*	**life-form**	**1**	**2**	**3**	**collector #**
Paullinia elegans Cambess.	h	1	2	3	864
Serjania erecta Radlk.	h	1	2	3	1554
Serjania lethalis A. St-Hil.	h	1	2	3	664
Serjania reticulata Cambess.	h	1	2	3	1329
Talisia angustifolia Raddi	h	1	2	3	914
Toulicia tomentosa Radlk.	w		2	3	693
Sapotaceae					
Pouteria ramiflora (Mart.) Radlk.	w	1	2	3	1524
Pouteria subcaerulea Pierre ex Dubard	h	1	2	3	655
Pouteria torta (Mart.) Radlk.	w	1	2	3	1428
Pradosia brevipes (Pierre) Penn.	h	1	2	3	887
Schizaeaceae					
Anemia ferruginea Kunth	h		2	3	1260
Scrophulariaceae					
Buchnera lavandulacea Cham. & Schltdl.	h			3	1292
Smilacaceae					
Smilax cissoides Mart. ex Griseb	h	1	2	3	1499
Solanaceae					
Solanum erianthum D. Don *	w		2	3	868
Solanum lycocarpum A. St-Hil.	h		2	3	929
Solanum palinacanthum Dunal	h		2	3	656
Styracaceae					
Styrax ferrugineus Nees & Mart.	w	1	2	3	1324
Turneraceae					
Piriqueta rosea (Cambess.) Urban	h			3	1055
Verbenaceae					
Aegiphila lhotzkiana Cham.	w		2		906
Lantana camara L.	h	1	2	3	1597
Lantana hypoleuca Briq.	h	1	2	3	939
Lippia lasiocalycina Cham.	h		2		821
Lippia lupulina Cham.	h		2		870
Lippia salviifolia Cham.	h	1	2	3	911
Stachytarpheta maximilliani Schauer	h			3	1548
Vitaceae					
Cissus erosa Rich.	h		2	3	953
Cissus inundata (Baker) Planch.	h		2	3	826
Vochysiaceae					
Qualea dichotoma Warm.	w	1	2	3	729
Qualea grandiflora Mart.	w	1	2	3	650
Qualea multiflora Mart.	w	1	2		981
Qualea parviflora Mart.	w	1	2	3	676
Vochysia cinamommea Pohl	w	1	2	3	892
Vochysia tucanorum Mart.	w	1	2	3	819

References

Batalha, M.A., Aragaki, S. & Mantovani, W. 1997. Florística do cerrado em Emas (Pirassununga, SP). **Boletim de Botânica da Universidade de São Paulo** 16:49-64.

Bitencourt, M.D.; Mesquita Jr., H. N. de; Mantovani, W.; Batalha, M.A. & Pivello, V.R. 1997. Identificação de fisionomias de cerrado com imagem índice de vegetação pp. 316-320. In L.L. Leite & C.H. Saito (eds.). **Contribuição ao conhecimento ecológico do cerrado**. Universidade de Brasília, Brasília.

Castro, A.A.J.F.; Martins, F.R.; Tamashiro, J.Y. & Shepherd, G.J. 1999. How rich is the flora of Brazilian cerrados? **Annals of Missouri Botanical Garden** 86:192-224.

Coutinho, L.M. 1978. O conceito do cerrado. **Revista Brasileira de Botânica** 1:17-23.

Goodland, R. 1979. Análise ecológica da vegetação de cerrado pp. 61-186. In R. Goodland & M.G. Ferri (eds.). **Ecologia do cerrado**. Itatiaia, Belo Horizonte.

Jongman, R.H.G.; Ter Braak, C.J.F. & van Tongeren, O.F.R. 1995. **Data analysis in community and landscape ecology**. Cambridge University, Cambridge.

Judd, W.S.; Campbell, C.S.; Kellog, E.A. & Stevens, P.F. 1999. **Plant systematics: a phylogenetic approach**. Sinauer, Sunderland.

Köppen, W. 1948. **Climatologia**. Fondo de Cultura Económica, México.

Leitão Filho, H. de F. 1992. A flora arbórea dos cerrados do estado de São Paulo. **Hoehnea** 19:121-163.

Magurran, A.E. 1988. **Ecological diversity and its measurement**. Princeton University, Princeton.

Mantovani, W. 1990. Variação da flora arbustivo-arbórea de diversas fisionomias de cerrado, em Itirapina, estado de São Paulo pp. 125-135. In **Anais do XLI Congresso Nacional de Botânica**, Curitiba 1990. Sociedade Botânica do Brasil, Curitiba.

Mantovani, W. & Martins, F.R. 1993. Florística do cerrado na reserva biológica de Moji Guaçu, SP. **Acta Botanica Brasilica** 7:33-60.

Mendonça, R.C. de; Felfili, J.M.; Walter, B.M.T.; Silva Júnior, M.C. da; Rezende, A.V.; Filgueiras, T.S. & Nogueira, P.E. 1998. A flora vascular do cerrado pp. 279-556. In S.M. Sano & S.P. de Almeida (eds.). **Cerrado – ambiente e flora**. EMBRAPA, Planaltina.

Mueller-Dombois, D. & Ellenberg, H. 1974. **Aims and methods of vegetation ecology**. John Wiley & Sons, New York.

Pivello, V.R.; Bitencourt, M.D.; Mantovani, W.; Mesquita Jr., H.N. de; Batalha, M.A. & Shida, C. 1998. Proposta de zoneamento ecológico para a reserva de cerrado Pé-de-Gigante (Santa Rita do Passa Quatro, SP). **Brazilian Journal of Ecology** 2:108-118.

Pivello, V.R.; Bitencourt, M.D.; Mesquita Jr., H.N. de & Batalha, M.A. 1999a. Banco de dados em SIG para ecologia aplicada: exemplo do cerrado Pé-de-Gigante, S.P. **Caderno de Informações Georreferenciadas** 1:http://www.cpa.unicamp.br/revista/cigv1n3a4.html.

Pivello, V.R.; Carvalho, V.M.C.; Lopes, P.F.; Peccinini, A.A. & Rosso, S. 1999b. Abundance and distribution of native and alien grasses in a "cerrado" (Brazilian savanna) Biological Reserve. **Biotropica** 31:71-82.

Pivello, V.R.; Shida, C.N. & Meirelles, S.T. 1999c. Alien grasses in Brazilian savannas: a threat to the biodiversity. **Biodiversity and Conservation** 8:1281-1294.

Ratter, J.A. 1980. **Notes on the vegetation of Fazenda Água Limpa (Brasília - DF, Brasil)**. Royal Botanical Garden, Edinburgh.

Ratter, J.A., Ribeiro, J.F. & Bridgewater, S. 1992. The Brazilian cerrado vegetation and threats to its biodiversity. **Annals of Botany** 80:223-230.

Thornthwaite, C.W. & Mather, J.R. 1955. **The water balance**. Centerton, New Jersey.

Warming, E. 1892. Lagoa Santa, contribuição para a geografia fitobiológica pp. 1-284. In E. Warming & M.G. Ferri (eds.). 1973. **Lagoa Santa e a vegetação dos cerrados brasileiros**. Itatiaia, Belo Horizonte.