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FLORISTICS AND PHYTOSOCIOLOGY OF THE GALLERY FOREST OF THE BACABA STREAM, NOVA XAVANTINA, MATO GROSSO, BRAZIL

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The study was carried out on the gallery forest of the Bacaba stream situated in the Municipal Ecological Reserve 'Mário Viana' (14°43′S, 52°21′W) in Nova Xavantina, Eastern Mato Grosso, Brazil. Three sections of the gallery (upper, middle and lower) running downstream and differing in slope were surveyed by stratified sampling. Forty-seven nested 10m × 10m plots were analysed in each section, giving a total sampling area of 1.41ha overall. All trees or lianas ≥ 15cm girth at breast height were recorded and a total of 129 species belonging to 105 genera and 47 families were found. Diversity was high, with the Shannon index ranging from 3.84 nats/individual in the lower section to 4.08 in the middle section. The most important families (IVI) were *Caesalpiniaceae* (upper and middle sections) and *Arecaceae* (lower section), and the most important species were *Diospyros obovata* (upper section), *Hymenaea courbaril* var. *stilbocarpa* (middle section) and *Mauritia flexuosa* (lower section). Morisita and Sørensen indices of similarity were calculated. The floristic composition was complex and included species in common with a number of Brazilian forest types and with cerrado (savanna), as well as many widespread species, but stronger links with Amazonian forests could be detected. This is to be expected since the area lies in the ecotonal zone of the cerrado and Amazonian forest biomes and the Bacaba stream itself is a tributary of the Mortes–Araguaia–Amazon river system.

Keywords. Amazon, cerrado, gallery forests, phytosociology, savanna.

Introduction

Gallery forests in the cerrado biome of Central Brazil are generally evergreen mesophytic formations occurring alongside watercourses, and are surrounded by savanna vegetation (cerrado or campo). In spite of forming a dendritic network throughout the region, gallery forests cover only 5% of the 2 million km^2 of the cerrado biome. They show high species diversity (Felfili, 1995) and have floristic links with the Amazonian and Atlantic rainforests (Oliveira-Filho & Ratter, 1995). Their flora also contains some elements of the cerrado (Oliveira-Filho *et al.*, 1994a,b) and a few endemic species. Environmental heterogeneity within the forest is high (Brinson, 1990) and mosaic patterns occur where communities related to the stages of a soil

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humidity gradient can be identified (Felfili, 1995; Felfili *et al.*, 1998; Silva-Júnior *et al.*, 1998). The presence of gaps, the edge effect caused by the sharp boundaries with cerrado and campo vegetation, and occasional fires play an important role in the maintenance of the high diversity (Felfili, 1995, 1997; Kellman & Meave, 1997).

Gallery forests are of vital importance in hydrographic basins in controlling water flow, and retaining sediments and chemical nutrients. They also provide food and habitat for much of the fauna of the cerrado biome and provide corridors for the migration of animals. Their value is recognized in Brazilian laws prohibiting their destruction; however, the present advancement of agricultural and urban frontiers, together with weak enforcement of the current legislation, is threatening their existence.

A few studies have already been conducted in the gallery forests of Eastern Mato Grosso (Ratter *et al.*, 1973, 1978; Felfili *et al.*, 1998) and have shown their high diversity. The objective of this study is to provide further data by analysing the floristic composition and structure of the Bacaba gallery forest.

Location and Methods

Study site

The study was carried out in the Bacaba gallery forest in the Municipal Ecological Reserve 'Mário Viana' (14°43′S, 52°21′W) in Nova Xavantina, Eastern Mato Grosso, Brazil (Fig. 1).

The Mário Viana Reserve covers approximately 500ha at an average altitude of 250m, and contains several vegetation types characteristic of the cerrado biome (Brazilian savanna). The main vegetation type in the Reserve is cerrado *sensu stricto* (savanna woodland) (Marimon *et al.*, 1998) but there are areas covered with campo (grasslands) and cerradão (dense savanna woodland), and a gallery forest occurs along the Bacaba stream at the west edge of the Reserve. The climate belongs to Köppen's subtype Aw, with 6–8 months of rain (annual precipitation 1300–1500mm) and a mean monthly temperature of 25°C (Camargo, 1963; Cochrane *et al.*, 1985) (Fig. 2). The present study was restricted to the gallery forest where the predominant soils are lithosols and alluvium.

Three sections of the forest running downstream and differing in slope were chosen for this study. The *upper* section is characterized by the presence of quartzite rocks and lithosols and has a 10m waterfall that flows rapidly during the rainy season. Here the forest lies in a valley with an average slope of 42%. The *middle* section is also rocky and the soils are lithosols but the topography is less steep, with an average slope of 32%. Rocks are absent in the *lower* section, where the soil is alluvium and the average slope is 5%. The distance between the upper and middle sections was 150m and between the middle and lower 200m.

The environmental heterogeneity of the forest is high due especially to variations in drainage related to the steep relief and abundance of rocky outcrops in the middle

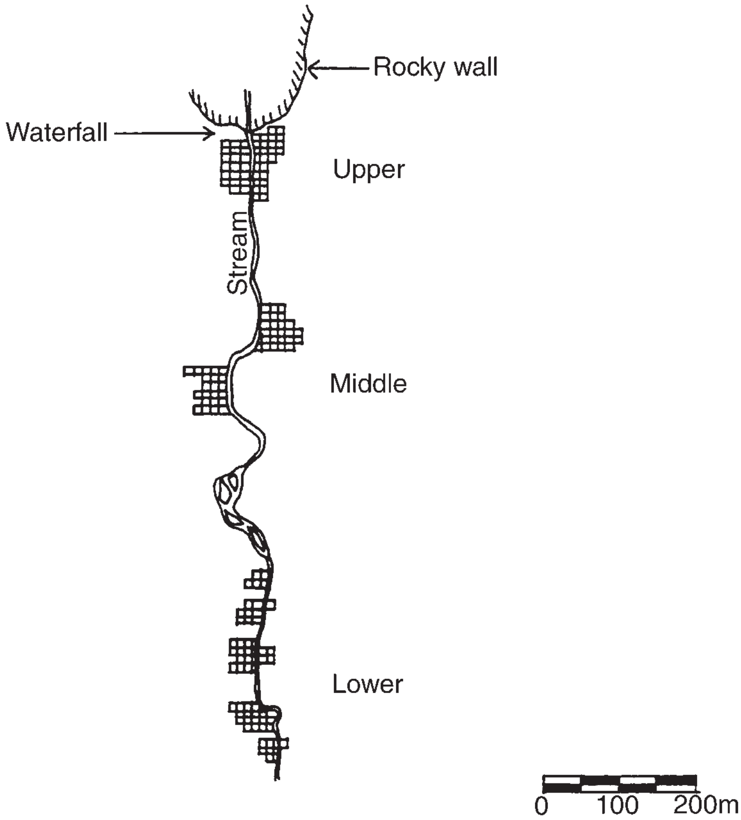

FIG. 1. Location of the plots in the three sections (upper, middle and lower) of the Bacaba gallery forest.

and upper sections and to the flat relief without rocks in the lower section. A large volume of water flows in the upper section during the rainy season and overflows the stream bed during heavy rains, but the drainage is generally rapid. In the steeper sites of the middle section the conditions are similar to the upper, but on more shallowly sloping areas water floods over the surface during the rainy season. In the lower section, the water-table lies close to the surface throughout the year and there is often flooding in the rainy season.

The vegetation surrounding the gallery forest varies from cerrado *sensu stricto* on the steeper sites with well-drained soil to campo limpo (grassland) where the terrain is flat and the soil badly drained throughout the year.

Vegetation inventory

Sampling was stratified as described by Philip (1994). In each section of the gallery forest (upper, middle and lower), 47 contiguous permanent plots $100m^2$ ($10m \times 10m$)

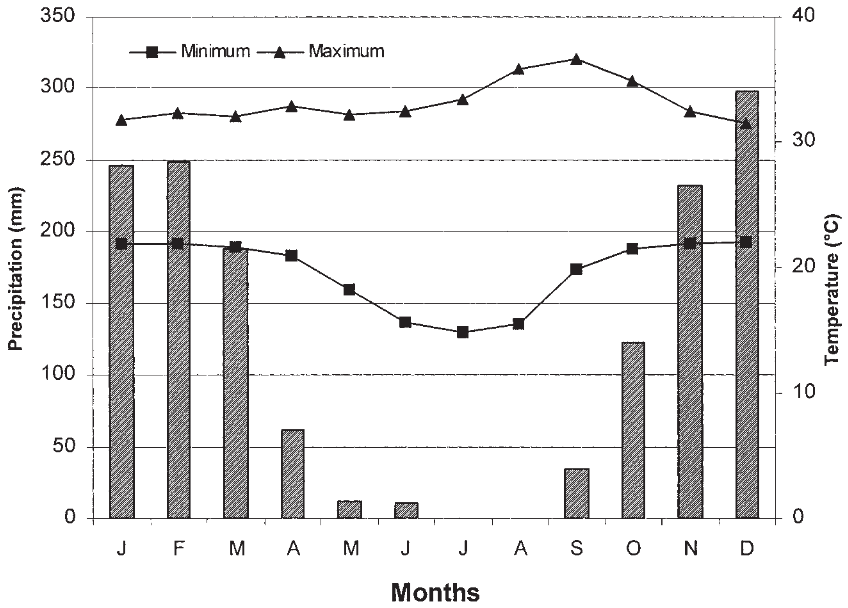

FIG. 2. Mean monthly precipitation and minimum and maximum temperature (1995–99) in the Bacaba gallery forest. Observations of the Climatological Station, Campus Universitário de Nova Xavantina, Nova Xavantina, Mato Grosso, Brazil.

were established, giving a total sampling area of 1.41ha. The plots were arranged in lines at right angles to the stream, running from the stream bank to the forest edge (Fig. 1).

All trees and lianas with girth at breast height (gbh) $\geq$ 15cm were labelled with permanent aluminium tags, identified, and measured. Girth was measured to the nearest 1mm with a tape, and a pole was used to measure height of the trees and lianas. Dead standing trees were also recorded. Voucher specimens were collected for identification and incorporated in the Herbarium NX, James Alexander Ratter Collection at the Nova Xavantina campus of the University of Mato Grosso State (UNEMAT).

Data analysis

The usual phytosociological parameters based on density, dominance and frequency (Curtis & McIntosh, 1950, 1951), Shannon's diversity index ($H' = -\Sigma(pi \ln pi)$, where $pi = ni/N$, ni is the number of individuals of species i and N is the total number of individuals) and Simpson's index ($\lambda = \Sigma ni(ni-1)/N(N-1)$), were used to evaluate species importance and diversity in each section and for the complete surveyed forest area. Pielou's evenness index ($J' = H'/\ln(S)$, where S is the number of species) was also calculated (Magurran, 1988).

Morisita's similarity index was calculated to compare each forest section. This index is based on Simpson's index and varies between 0 and 1, values higher than 0.5 suggesting high similarity between communities (Brower & Zar, 1977). The three sections were also compared using Sørensen's coefficient of similarity:

$$(2 \times \text{No. of spp. in common})/(\text{No. of spp. at locality A and No. at locality B}).$$

Results

There were 129 species belonging to 105 genera in 47 families in the total forest area surveyed. Table 1 gives the overall species list and scores the occurrence of species in each section. The richest families were *Fabaceae* (8 species), *Caesalpiniaceae* (8), *Apocynaceae* (7), *Rubiaceae* (7) and *Mimosaceae* (6). The diversity indices and evenness for the three sections and for the total sampled area are given in Table 2.

Species occurrence and the phytosociological parameters of density, dominance and frequency for each section are given in Tables 3–5. *Burseraceae* was the most important family and *Caesalpiniaceae* the second in the upper section, representing 10.15% and 9.70% of total IVI respectively. The order of these two families was reversed in the middle section, with *Caesalpiniaceae* at 15.4% and *Burseraceae* at 9.60%. *Arecaceae* had the highest IVI in the lower section, representing 23.6% of the total. Most families were common to the three sections (Table 1).

Upper section

The absolute density was 1023 individuals/ha and basal area was 20.44m^2/ha. Dead individuals represented 5% of the total density and 4.09% of the basal area. The most important species (Table 3) were *Diospyros obovata* (IVI = 22.9), *Calophyllum brasiliense* (12.4), *Tetragastris altissima* (12.4), *Protium heptaphyllum* (11.7) and *Astrocaryum vulgare* (10.9), which together represented 23.5% of the total IVI. For *D. obovata*, relative density (RD = 9.8%) was the most important component of IVI composition, and for *C. brasiliense* the most important was relative dominance (RDo = 7.5%). Fifteen species were represented by single individuals. *Diospyros obovata* (with a relative frequency (RF) of 5.9%) and *T. altissima* (4.8%) were the most constant species in the sampling. Only nine species occurred in 20% or more plots, while 17 occurred only in single plots.

Amongst the most important species, *Calophyllum brasiliense*, *Apuleia leiocarpa* and *Hymenaea courbaril* var. *stilbocarpa* are emergents, with some trees reaching 25m. On the other hand, all trees of *Astrocaryum vulgare* are under 10m, while understorey species such as *Siparuna guianensis* and *Tococa formicaria* reach only 5m.

Middle section

The absolute density was 962 individuals/ha and basal area 22.28m^2/ha. Dead individuals represented 2.43% of the total density and 2.84% of the basal area. The most important species in IVI (Table 4) were *Hymenaea courbaril* var. *stilbocarpa* (15.3), *Tetragastris altissima* (12.9), *Apuleia leiocarpa* (12.3), *Pouteria torta* (11.8) and

TABLE 1. List of species occurring in the three forest sections studied in the Bacaba gallery forest, Nova Xavantina, Mato Grosso, Brazil

Species	Family	Upper	Middle	Lower
1. *Abuta grandifolia* (Mart.) Sandw.	*Menispermaceae*			x
2. *Acosmium* sp.	*Fabaceae*			x
3. *Agonandra brasiliensis* Miers	*Opiliaceae*			x
4. *Aiouea saligna* Meiss.	*Lauraceae*	x	x	x
5. *Alibertia elliptica* (Cham.) K. Schum.	*Rubiaceae*	x	x	x
6. *Amaioua guianensis* Aubl.	*Rubiaceae*	x		
7. *Anadenanthera colubrina* (Vell.) Brenan var. *cebil* (Griseb.) Altschul	*Mimosaceae*		x	
8. *Andira vermifuga* Mart. ex Benth.	*Fabaceae*	x		
9. *Apeiba tibourbou* Aubl.	*Tiliaceae*			x
10. *Apocynaceae* – indet.	*Apocynaceae*	x		
11. *Apuleia leiocarpa* (Vog.) Macbr. var. *molaris* (Spruce ex Benth.) Koeppen	*Caesalpiniaceae*	x	x	x
12. *Arrabidaea* cf. *brachypoda* (DC.) Bur.	*Bignoniaceae*		x	
13. *Aspidosperma macrocarpon* Mart.	*Apocynaceae*		x	
14. *A. subincanum* Mart.	*Apocynaceae*	x	x	x
15. *A. tomentosum* Mart.	*Apocynaceae*			x
16. *Astrocaryum vulgare* Mart.	*Arecaceae*	x	x	x
17. *Astronium fraxinifolium* Schott.	*Anacardiaceae*	x	x	x
18. *Bauhinia longifolia* (Bongard) Steud.	*Caesalpiniaceae*		x	x
19. *B. outimouta* Aubl.	*Caesalpiniaceae*	x	x	x
20. *Bauhinia* sp.	*Caesalpiniaceae*			x
21. *Bowdichia virgilioides* Kunth	*Fabaceae*		x	
22. *Byrsonima laxiflora* Griseb.	*Malpighiaceae*	x		x
23. *Callisthene fasciculata* (C.K. Spreng.) Mart.	*Vochysiaceae*	x		
24. *Calophyllum brasiliense* Cambess.	*Clusiaceae*	x	x	x
25. *Campomanesia eugenioides* Blume	*Myrtaceae*		x	
26. *Cariniana rubra* Gardner ex Miers	*Lecythidaceae*			x
27. *Casearia arborea* (L.C. Rich.) Urban	*Flacourtiaceae*		x	x
28. *C. sylvestris* Sw.	*Flacourtiaceae*		x	x
29. *Cecropia pachystachya* Tréc.	*Cecropiaceae*	x	x	x
30. *Cheiloclinium cognatum* (Miers) A.C. Smith	*Hippocrateaceae*	x	x	
31. *Combretum vernicosum* Rusby	*Combretaceae*		x	
32. *Copaifera langsdorffii* Desf.	*Caesalpiniaceae*	x	x	
33. *Cordia glabrata* (Mart.) A. DC.	*Boraginaceae*		x	
34. *C. sellowiana* Cham.	*Boraginaceae*	x		x
35. *Coussarea platyphylla* Muell. Arg.	*Rubiaceae*	x	x	x
36. *Curatella americana* L.	*Dilleniaceae*	x		x
37. *Cuspidaria* sp.	*Bignoniaceae*		x	
38. *Davilla elliptica* St. Hil.	*Dilleniaceae*			x
39. *Dendropanax cuneatum* (DC.) Decne. & Planch.	*Araliaceae*	x		x
40. *Dilodendron bipinnatum* Radlk.	*Sapindaceae*		x	

TABLE 1. (*Cont'd*)

Species	Family	Upper	Middle	Lower
41. *Dioclea* cf. *glabra* Benth.	*Fabaceae*	x		
42. *Dioclea* sp.	*Fabaceae*		x	
43. *Diospyros hispida* A. DC.	*Ebenaceae*			x
44. *D. obovata* Jacq.	*Ebenaceae*	x	x	
45. *D. sericea* A. DC.	*Ebenaceae*	x		x
46. *Dipteryx alata* Vog.	*Fabaceae*		x	
47. *Doliocarpus dentatus* (Aubl.) Standl.	*Dilleniaceae*	x		
48. *Duguetia marcgraviana* Mart.	*Annonaceae*	x	x	x
49. *Emmotum nitens* (Benth.) Miers	*Icacinaceae*	x	x	x
50. *Endlicheria paniculata* (Spreng.) Macbr.	*Lauraceae*		x	x
51. *Enterolobium contortisiliquum* (Vell.) Morong	*Mimosaceae*		x	
52. *Ephedranthus parviflorus* S. Moore	*Annonaceae*	x	x	
53. *Eriotheca gracilipes* (K. Schum.) A. Robyns	*Bombacaceae*		x	
54. *Erythroxylum daphnites* Mart.	*Erythroxylaceae*			x
55. *Eugenia aurata* Berg	*Myrtaceae*		x	
56. *Ficus* cf. *enormis* (Mart. ex Miq.) Miq.	*Moraceae*	x	x	x
57. *Ficus* sp. 1	*Moraceae*		x	
58. *Ficus* sp. 2	*Moraceae*			x
59. *Genipa americana* L.	*Rubiaceae*			x
60. *Guazuma ulmifolia* Lam.	*Sterculiaceae*		x	
61. *Guettarda viburnioides* Cham. & Schltdl.	*Rubiaceae*		x	
62. *Hancornia speciosa* Gomez	*Apocynaceae*			x
63. *Himatanthus bracteatus* (A. DC.) R.E. Woodson	*Apocynaceae*	x	x	x
64. *H. obovatus* (Muell. Arg.) R.E. Woodson	*Apocynaceae*	x	x	
65. *Hirtella glandulosa* Spreng.	*Chrysobalanaceae*	x	x	x
66. *H. gracilipes* (Hook.f.) Prance	*Chrysobalanaceae*	x	x	
67. *Hieronyma alchorneoides* Fr. Allem.	*Euphorbiaceae*	x		x
68. *Hymenaea courbaril* L. var. *stilbocarpa* (Hayne) Lee & Langenheim	*Caesalpiniaceae*	x	x	
69. *Ilex affinis* Gardner	*Aquifoliaceae*	x	x	
70. *Inga heterophylla* Willd.	*Mimosaceae*	x	x	x
71. *I. thibaudiana* DC.	*Mimosaceae*	x	x	x
72. *Jacaranda cuspidifolia* Mart. ex A. DC.	*Bignoniaceae*		x	
73. *Kielmeyera rubriflora* Cambess.	*Clusiaceae*		x	
74. *Licania apetala* (E. Meyer) Fritsch var. *apetala*	*Chrysobalanaceae*	x	x	x
75. *L. blackii* Prance	*Chrysobalanaceae*	x	x	x
76. *L. gardneri* (Hook.f.) Fritsch	*Chrysobalanaceae*	x		x
77. *Luehea candicans* Mart.	*Tiliaceae*	x	x	x
78. *Mabea pohliana* (Benth.) Muell. Arg.	*Euphorbiaceae*	x	x	x
79. *Machaerium acutifolium* Vog.	*Fabaceae*			x
80. *Magonia pubescens* St. Hil.	*Sapindaceae*	x	x	x

TABLE 1. (*Cont'd*)

Species	Family	Upper	Middle	Lower
81. *Matayba guianensis* Aubl.	*Sapindaceae*	x		x
82. *Mauritia flexuosa* L.	*Arecaceae*			x
83. *Mauritiella armata* (Mart.) Burret	*Arecaceae*			x
84. *Maytenus* cf. *floribunda* Reiss.	*Celastraceae*		x	
85. *Micropholis venulosa* (Mart. & Eichl.) Pierre	*Sapotaceae*	x	x	
86. *Mimosa laticifera* Rizzini & Mattos	*Mimosaceae*	x	x	x
87. *Moutabea excoriata* Mart. ex Miq.	*Polygalaceae*	x		
88. *Myrcia amazonica* DC.	*Myrtaceae*	x		
89. *M. sellowiana* Berg	*Myrtaceae*	x	x	x
90. *M. tomentosa* (Aubl.) DC.	*Myrtaceae*	x	x	
91. *Oenocarpus distichus* Mart.	*Arecaceae*	x	x	
92. *Ormosia coarctata* Jacks.	*Fabaceae*	x		
93. *Ouratea castaneaefolia* (DC.) Engl.	*Ochnaceae*	x	x	
94. *Paragonia pyramidata* (L. Rich.) Bureau	*Bignoniaceae*		x	
95. *Peltogyne confertiflora* (Hayne) Benth.	*Caesalpiniaceae*		x	
96. *Physocalymma scaberrimum* Pohl	*Lythraceae*	x	x	x
97. *Plathymenia reticulata* Benth.	*Mimosaceae*		x	
98. *Platypodium elegans* Vog.	*Fabaceae*		x	x
99. *Posoqueria* aff. *macropus* Mart.	*Rubiaceae*	x		x
100. *Pouteria* cf. *macrophylla* (Lam.) Eyma	*Sapotaceae*	x	x	x
101. *P. torta* (Mart.) Radlk.	*Sapotaceae*		x	
102. *Protium heptaphyllum* (Aubl.) March.	*Burseraceae*	x	x	x
103. *P. spruceanum* (Benth.) Engl.	*Burseraceae*	x	x	x
104. *Pseudobombax longiflorum* (Mart. & Zucc.) A. Robyns	*Bombacaceae*			x
105. *Pseudolmedia laevigata* Tréc.	*Moraceae*	x	x	x
106. *Qualea multiflora* Mart.	*Vochysiaceae*		x	x
107. *Rubiaceae* – indet.	*Rubiaceae*	x		
108. *Salacia elliptica* (Mart.) G. Don	*Hippocrateaceae*	x		
109. *Schefflera morototoni* (Aubl.) B. Maguire, Steyerm. & D.G. Frodin	*Araliaceae*	x	x	x
110. *Sclerolobium paniculatum* Vog.	*Caesalpiniaceae*	x	x	x
111. *Serjania glutinosa* Radlk.	*Sapindaceae*		x	
112. *Siparuna guianensis* Aubl.	*Monimiaceae*	x	x	x
113. *Sorocea klotzschiana* Baill.	*Moraceae*			x
114. *Sterculia excelsa* Mart.	*Sterculiaceae*	x	x	x
115. *S. striata* St. Hil. & Naud.	*Sterculiaceae*		x	
116. *Tabebuia impetiginosa* (Mart. ex DC.) Standl.	*Bignoniaceae*	x	x	x
117. *Tapirira guianensis* Aubl.	*Anacardiaceae*	x	x	x
118. *Tapura amazonica* Poepp. & Endl.	*Dichapetalaceae*			x
119. *Tetragastris altissima* (Aubl.) Swart.	*Burseraceae*	x	x	x
120. *Tetrapterys glabra* (Spreng.) Griseb.	*Malpighiaceae*	x		
121. *Tococa formicaria* Mart.	*Melastomataceae*	x		x
122. *Unonopsis lindmanii* R.E. Fries	*Annonaceae*		x	

TABLE 1. (*Cont'd*)

Species	Family	Upper	Middle	Lower
123. *Virola urbaniana* Warb.	*Myristicaceae*	x	x	x
124. *Vismia* sp.	*Clusiaceae*			x
125. *Vitex polygama* Cham.	*Verbenaceae*	x	x	x
126. *Vochysia haenkeana* Mart.	*Vochysiaceae*		x	
127. *Xylopia aromatica* (Lam.) Mart.	*Annonaceae*	x	x	x
128. *X. emarginata* Mart.	*Annonaceae*	x	x	
129. *Zanthoxylum riedelianum* Engl.	*Rutaceae*		x	x

Total	Upper	Middle	Lower
No. of species	74	86	77
No. of genera	62	73	67
No. of families	37	38	41

TABLE 2. Simpson's and Shannon's diversity indices and evenness in upper, middle and lower sections of the Bacaba gallery forest, and total area sampled

	Shannon's index (H′)	Simpson's index (1/Ds)	Pielou's evenness index ($J' = H'/\ln(S)$)
Upper	3.84	34.57	0.89
Middle	4.08	49.09	0.91
Lower	3.57	24.03	0.82
Total area	4.21	48.32	0.87

Ephedranthus parviflorus (11.5), which together represented 21.3% of the total IVI. *Hymenaea courbaril* var. *stilbocarpa*, with only nine large individuals, occupied the first IVI position. Relative dominance (RDo = 11.3%) was the most important component of the IVI of this species, while density was the most important for *T. altissima*, the second species in IVI, with RD of 4.9%. Eighteen species were represented by single individuals. *Tetragastris altissima* and *Aspidosperma subincanum* were the most constant species in the sampling, each with RF of 4.0%. Only eight species occurred in 20% or more of the plots, while 21 occurred only in single plots.

The average heights of the most important species were above 15m, and some emergent individuals of *H. courbaril* var. *stilbocarpa*, *A. leiocarpa* and *P. torta* reached 25m. All individuals of *E. parviflorus* were under 10m high. *Alibertia elliptica* and *Luehea candicans* were restricted to the understorey, with the tallest individuals under 5m.

Lower section

The absolute density was 1351 individuals/ha and basal area 23.46m^2/ha. Dead individuals represented 6.93% of the total density and 3.51% of the basal area. The

TABLE 3. Phytosociological indices for species in the upper section plots of the Bacaba gallery forest. The 27 spp. listed constitute 75% of total IVI (226 units). A further 48 spp. account for the other 25% of IVI. AD, absolute density (individuals/ha); RD, relative density (%); ADo, absolute dominance (basal area/ha); RDo, relative dominance (%); AF, absolute frequency (% of plots at which a species occurs); RF, relative frequency – (frequency of a species/sum frequency of all species) $\times$ 100. Total density: 1023 individuals/ha; total basal area: 20.44m^2/ha; total sampling area: 4700m^2

		Density		Dominance		Frequency		
Species		AD	RD	ADo	RDo	AF	RF	IVI
1.	*Diospyros obovata*	100.0	9.77	1.484	7.26	44.68	5.90	22.93
2.	Dead individuals	51.1	4.99	0.836	4.09	34.04	4.49	13.57
3.	*Calophyllum brasiliense*	27.7	2.70	1.531	7.49	17.02	2.25	12.44
4.	*Tetragastris altissima*	44.7	4.37	0.670	3.28	36.17	4.78	12.42
5.	*Protium heptaphyllum*	40.4	3.95	0.724	3.54	31.91	4.21	11.71
6.	*Astrocaryum vulgare*	51.1	4.99	0.405	1.98	29.79	3.93	10.90
7.	*Apuleia leiocarpa*	23.4	2.29	1.271	6.22	17.02	2.25	10.75
8.	*Mabea pohliana*	42.6	4.16	0.456	2.23	27.66	3.65	10.04
9.	*Physocalymma scaberrimum*	23.4	2.29	0.809	3.96	23.40	3.09	9.34
10.	*Licania blackii*	31.9	3.12	0.585	2.86	23.40	3.09	9.06
11.	*Hymenaea courbaril* var. *stilbocarpa*	10.6	1.04	1.288	6.30	10.64	1.40	8.74
12.	*Oenocarpus distichus*	27.7	2.70	0.566	2.77	21.28	2.81	8.28
13.	*Tapirira guianensis*	14.9	1.46	0.977	4.78	14.89	1.97	8.20
14.	*Himatanthus bracteatus*	27.7	2.70	0.421	2.06	17.02	2.25	7.01
15.	*Aspidosperma subincanum*	27.7	2.70	0.354	1.73	19.15	2.53	6.97
16.	*Protium spruceanum*	10.6	1.04	0.850	4.16	8.51	1.12	6.32
17.	*Licania apetala*	23.4	2.29	0.337	1.65	17.02	2.25	6.18
18.	*Ephedranthus parviflorus*	27.7	2.70	0.247	1.21	14.89	1.97	5.88
19.	*Bauhinia outimouta*	21.3	2.08	0.260	1.27	19.15	2.53	5.87
20.	*Myrcia sellowiana*	19.1	1.87	0.298	1.46	17.02	2.25	5.57
21.	*Ormosia coarctata*	23.4	2.29	0.237	1.16	14.89	1.97	5.42
22.	*Vitex polygama*	10.6	1.04	0.544	2.66	10.64	1.40	5.10
23.	*Pseudolmedia laevigata*	19.1	1.87	0.239	1.17	14.89	1.97	5.00
24.	*Inga thibaudiana*	19.1	1.87	0.245	1.20	12.77	1.69	4.76
25.	*Licania gardneri*	14.9	1.46	0.268	1.31	14.89	1.97	4.74
26.	*Luehea candicans*	14.9	1.46	0.219	1.07	14.89	1.97	4.49
27.	*Andira vermifuga*	6.4	0.62	0.554	2.71	6.38	0.84	4.18
28–75.	48 other spp.	267.6	26.18	3.765	18.42	223.39	29.47	74.13
Total		1023	100	20.44	100	757.4	100	300

Estimate of the confidence interval (CI):
Density: CI = P[$869 \leq \mu \leq 1177$] = 0.95; basal area: CI = P[$17.24 \leq \mu \leq 23.62$] = 0.95.

highest importance values (IVI) (Table 5) were recorded for *Mauritia flexuosa* (50.5), *Cecropia pachystachya* (24.1), *Astrocaryum vulgare* (18.2), *Tapirira guianensis* (16.5) and *Xylopia aromatica* (13.7), which together represented 41% of the total IVI.

TABLE 4. Phytosociological indices for species in the middle section plots of the Bacaba gallery forest. The 34 spp. listed constitute 75.7% of total IVI (227 units). A further 53 spp. account for the other 24.3% of IVI. AD, absolute density (individuals/ha); RD, relative density (%); ADo, absolute dominance (basal area/ha); RDo, relative dominance (%); AF, absolute frequency (% of plots at which a species occurs); RF, relative frequency – (frequency of a species/sum frequency of all species) × 100. Total density: 962 individuals/ha; total basal area: 22.28m^2/ha; total sampling area: 4700m^2

		Density		Dominance		Frequency		
Species		AD	RD	ADo	RDo	AF	RF	IVI
1.	*Hymenaea courbaril* var. *stilbocarpa*	19.1	1.99	2.520	11.31	14.89	2.01	15.31
2.	*Tetragastris altissima*	46.8	4.87	0.898	4.03	29.79	4.02	12.92
3.	*Apuleia leiocarpa*	21.3	2.21	1.615	7.25	21.28	2.87	12.34
4.	*Pouteria torta*	12.8	1.33	1.956	8.78	12.77	1.72	11.83
5.	*Ephedranthus parviflorus*	53.2	5.53	0.504	2.26	27.66	3.74	11.52
6.	*Aspidosperma subincanum*	42.6	4.42	0.682	3.06	29.79	4.02	11.51
7.	*Vitex polygama*	8.5	0.88	1.658	7.44	8.51	1.15	9.48
8.	*Luehea candicans*	36.2	3.76	0.301	1.35	27.66	3.74	8.85
9.	*Protium heptaphyllum*	42.6	4.42	0.276	1.24	23.40	3.16	8.82
10.	Dead individuals	23.4	2.43	0.633	2.84	23.40	3.16	8.44
11.	*Pouteria* cf. *macrophylla*	29.8	3.10	0.441	1.98	21.28	2.87	7.95
12.	*Sclerolobium paniculatum*	27.7	2.88	0.602	2.70	17.02	2.30	7.88
13.	*Protium spruceanum*	25.5	2.65	0.479	2.15	14.89	2.01	6.82
14.	*Unonopsis lindmanii*	27.7	2.88	0.214	0.96	12.77	1.72	5.56
15.	*Alibertia elliptica*	21.3	2.21	0.156	0.70	19.15	2.59	5.50
16.	*Calophyllum brasiliense*	6.4	0.66	0.858	3.85	6.38	0.86	5.37
17.	*Diospyros obovata*	14.9	1.55	0.457	2.05	10.64	1.44	5.03
18.	*Tabebuia impetiginosa*	6.4	0.66	0.769	3.45	6.38	0.86	4.98
19.	*Mabea pohliana*	21.3	2.21	0.102	0.46	17.02	2.30	4.97
20.	*Copaifera langsdorffii*	4.3	0.44	0.878	3.94	4.26	0.57	4.96
21.	*Cecropia pachystachya*	17.0	1.77	0.345	1.55	10.64	1.44	4.75
22.	*Platypodium elegans*	17.0	1.77	0.174	0.78	14.89	2.01	4.56
23.	*Anadenanthera colubrina* var. *cebil*	10.6	1.11	0.428	1.92	10.64	1.44	4.47
24.	*Sterculia striata*	6.4	0.66	0.648	2.91	6.38	0.86	4.44
25.	*Aiouea saligna*	17.0	1.77	0.140	0.63	14.89	2.01	4.41
26.	*Siparuna guianensis*	23.4	2.43	0.067	0.30	10.64	1.44	4.17
27.	*Astronium fraxinifolium*	12.8	1.33	0.241	1.08	12.77	1.72	4.13
28.	*Coussarea platyphylla*	19.1	1.99	0.145	0.65	10.64	1.44	4.07
29.	*Physocalymma scaberrimum*	12.8	1.33	0.189	0.85	12.77	1.72	3.90
30.	*Pseudolmedia laevigata*	17.0	1.77	0.152	0.68	10.64	1.44	3.89
31.	*Combretum vernicosum*	12.8	1.33	0.123	0.55	12.77	1.72	3.60
32.	*Oenocarpus distichus*	10.6	1.11	0.301	1.35	8.51	1.15	3.60
33.	*Inga thibaudiana*	12.8	1.33	0.247	1.11	8.51	1.15	3.59
34.	*Xylopia aromatica*	14.9	1.55	0.082	0.37	10.64	1.44	3.36
35–87.	53 other spp.	266.0	27.67	2.999	13.47	236.13	31.91	73.02
Total		962	100	22.28	100	740.4	100	300

Estimate of the confidence interval (CI):
Density: CI = P[837 ≤ μ ≤ 1085] = 0.95; basal area: CI = P[20.35 ≤ μ ≤ 23.77] = 0.95.

TABLE 5. Phytosociological indices for species in the lower section plots of the Bacaba gallery forest. The 20 spp. listed constitute 75% of total IVI (225 units). A further 58 spp. account for the other 25% of IVI. AD, absolute density (individuals/ha); RD, relative density (%); ADo, absolute dominance (basal area/ha); RDo, relative dominance (%); AF, absolute frequency (% of plots at which a species occurs); RF, relative frequency – (frequency of a species/sum frequency of all species) × 100. Total density: 1351 individuals/ha; total basal area: 23.46m^2/ha; total sampling area: 4700m^2

		Density		Dominance		Frequency		
Species		AD	RD	ADo	RDo	AF	RF	IVI
1.	*Mauritia flexuosa*	87.2	6.46	9.188	39.16	40.43	4.88	50.50
2.	*Cecropia pachystachya*	125.5	9.29	1.659	7.07	63.83	7.71	24.07
3.	*Astrocaryum vulgare*	110.6	8.19	1.201	5.12	40.43	4.88	18.20
4.	Dead individuals	93.6	6.93	0.824	3.51	53.19	6.43	16.86
5.	*Tapirira guianensis*	72.3	5.35	1.356	5.78	44.68	5.40	16.53
6.	*Xylopia aromatica*	76.6	5.67	0.751	3.20	40.43	4.88	13.75
7.	*Physocalymma scaberrimum*	55.3	4.09	0.786	3.35	40.43	4.88	12.33
8.	*Virola urbaniana*	83.0	6.14	0.493	2.10	31.91	3.86	12.10
9.	*Mabea pohliana*	44.7	3.31	0.263	1.12	31.91	3.86	8.28
10.	*Cordia sellowiana*	36.2	2.68	0.488	2.08	23.40	2.83	7.58
11.	*Himatanthus bracteatus*	42.6	3.15	0.364	1.55	23.40	2.83	7.53
12.	*Inga thibaudiana*	34.0	2.52	0.591	2.52	19.15	2.31	7.36
13.	*Aspidosperma subincanum*	38.3	2.83	0.352	1.50	19.15	2.31	6.65
14.	*Endlicheria paniculata*	31.9	2.36	0.277	1.18	23.40	2.83	6.37
15.	*Acosmium* sp.	27.7	2.05	0.523	2.23	17.02	2.06	6.34
16.	*Bauhinia longifolia*	19.1	1.42	0.143	0.61	17.02	2.06	4.08
17.	*Tetragastris altissima*	17.0	1.26	0.397	1.69	8.51	1.03	3.98
18.	*Coussarea platyphylla*	19.1	1.42	0.223	0.95	12.77	1.54	3.91
19.	*Vismia* sp.	17.0	1.26	0.127	0.54	14.89	1.80	3.60
20.	*Sterculia excelsa*	10.6	0.79	0.303	1.29	10.64	1.29	3.36
21–78.	58 other spp.	308.7	22.83	3.151	13.45	251.11	30.33	66.62
Total		1351	100	23.46	100	827.7	100	300

Estimate of the confidence interval (CI):
Density: CI = P[$1213 \leq \mu \leq 1467$] = 0.95; basal area: CI = P[$19.84 \leq \mu \leq 27$] = 0.95.

For *M. flexuosa*, relative dominance (RDo = 39%) was the most important component of the IVI composition. Twenty species were represented by only one individual. *Cecropia pachystachya* (RF = 7.71%) and *T. guianensis* (RF = 5.4%) were the most constant species in the area. Twelve species occurred in 20% or more of the plots, while 24 occurred only in single plots.

Only *M. flexuosa* stood out as an emergent, reaching 25m, while some individuals of *Physocalymma scaberrimum* and *T. guianensis* reached 20m. All individuals of *C. pachystachya* and *Astrocaryum vulgare* were under 10m and the *Acosmium* sp. was restricted to the understorey, with heights under 5m.

Similarity

The Venn diagram (Zar, 1999) in Fig. 3 shows the floristic relationships of the sections. Sørensen's coefficients of similarity gave the same relatively high figure of 0.65 for both the comparisons of the middle section with the upper and the upper with the lower, but a rather smaller value of 0.56 for comparison of the middle with the lower. The Morisita index, which takes species importance into account in addition to occurrence, agreed with Sørensen's in its high value ($C\lambda = 0.66$) for comparison of upper with middle sections, but this fell to $C\lambda = 0.41$ for upper with lower and to $C\lambda = 0.36$ for middle with lower.

Discussion

The flora of the Bacaba forest is probably characteristic of galleries in Eastern Mato Grosso, judging by the few other detailed surveys which have been conducted (Ratter *et al.*, 1973; Felfili *et al.*, 1998). The vast majority of the species are widespread in Central Brazil, and amongst the most common are *Hymenaea courbaril* var. *stilbocarpa*, *Copaifera langsdorffii*, *Apuleia leiocarpa*, *Siparuna guianensis*, *Calophyllum brasiliense*, *Cariniana rubra*, *Protium heptaphyllum*, *Tapirira guianensis*, *Matayba guianensis* and the weedy colonizers *Sclerolobium paniculatum* and *Cecropia pachystachya*. Ten of the 13 species quoted by Oliveira-Filho & Ratter (1995) as being the most frequent in 13 gallery forests were found in the Bacaba.

A number of elements differing in habitat preference are found amongst the species listed in Table 1. Species of wetter and swampy habitats are represented by, for instance, *Calophyllum brasiliense*, *Dendropanax cuneatum*, *Hieronyma alchorneoides*, *Mauritia flexuosa*, *Mauritiella armata*, *Oenocarpus distichus*, *Pseudolmedia laevigata* and *Xylopia emarginata*. Those typical of the mesophilous forests of mesotrophic

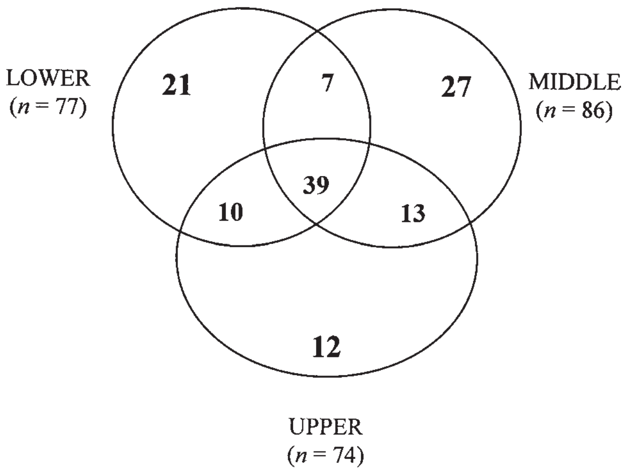

FIG. 3. Venn diagram showing floristic relationships of the sections (species shared and exclusive).

soils are represented by *Anadenanthera colubrina* var. *cebil*, *Aspidosperma subincanum*, *Cordia glabrata*, *Copaifera langsdorffii*, *Enterolobium contortisiliquum*, *Platypodium elegans*, *Sterculia striata*, *Tabebuia impetiginosa*, *Vitex polygama* and *Zanthoxylum riedelianum*. The cerrado element is represented by many species such as *Aspidosperma macrocarpon*, *A. tomentosum*, *Bowdichia virgilioides*, *Curatella americana*, *Davilla elliptica*, *Himatanthus obovatus*, *Kielmeyera rubriflora*, *Qualea multiflora*, etc., while *Emmotum nitens* and *Hirtella glandulosa* are typical of the dystrophic element of cerradão and *Callisthene fasciculata*, *Dipteryx alata*, *Luehea candicans* and *Magonia pubescens* of the mesotrophic (Ratter, 1971; Ratter *et al.*, 1973, 1977). Colonizing species, often particularly associated with human disturbance, are also common, for example *Apeiba tibourbou*, *Astrocaryum vulgare*, *Cecropia pachystachya*, *Genipa americana*, *Sclerolobium paniculatum* and *Xylopia aromatica*. The species list reflects the variety of microhabitats and other environmental factors of the Bacaba gallery and the ecotones occurring there.

Ratter *et al.* (1973) suggested that the gallery forests of the Eastern Mato Grosso contain many elements of the Amazonian forest flora since the rivers on which they occur are part of the Amazon drainage. Oliveira-Filho & Ratter (1995), studying the phytogeography of South American forests, also found strong floristic links between these gallery forests and the Amazonian flora. By contrast, the gallery and valley forests of the Chapada dos Guimarães in central-southern Mato Grosso have stronger links with the Atlantic forests, probably because of the climatic conditions dictated by the high altitude and their location in the Paraná-Paraguai River basin (Pinto & Oliveira-Filho, 1999). In the present study *Oenocarpus distichus* and *Astrocaryum vulgare* are examples of typical Amazonian palms (the vernacular name of the former is 'Bacaba' and it gives its name to the stream). *Tapura amazonica*, *Protium spruceanum*, *Hirtella glandulosa* and *Vochysia haenkeana* are examples of widespread species that extend their distribution to the Amazon basin (Oliveira-Filho & Ratter, 1995), as do many others, for example *Abuta grandifolia*, *Moutabea excoriata*, *Schefflera morototoni*, *Sterculia excelsa* and those species originally described from Guyana, *Amaioua guianensis*, *Matayba guianensis*, *Siparuna guianensis* and *Tapirira guianensis*.

Shannon's diversity index was high for all sections, ranging from 3.84 nats/individual in the lower section to 4.08 in the middle. This index is sensitive to species richness and to evenness, normally ranging from 1.5 to 3.5 (Magurran, 1988). Evenness was higher in the upper section than in the lower, even though the latter was richer in species. Values of Shannon's index found in other studies in gallery forests in Mato Grosso (Oliveira-Filho, 1989; Pinto & Oliveira-Filho, 1999) were in the same range as those found in this study, even though different methodologies were used. Simpson's index (1/Ds), which gives more weight to the common species (Magurran, 1988), and evenness were lower in the lower portion as a result of the dominance of *Mauritia flexuosa*.

Density was slightly higher in the lower wetter portion (Table 5), agreeing with other descriptions of seasonally flooded sites in gallery forests (Walter, 1995). The dominance of palms such as *Mauritia flexuosa* is typical of such flooded sites. *Astrocaryum vulgare*, another palm, occurred in the lower section but also in well-drained upper section sites which are occasionally subjected to disturbances by fire. Lorenzi (1996) also described the occurrence of this species in both conditions. The higher percentage of dead standing individuals in the lower and upper sections, compared with the middle, is also an indication of disturbances in both these sections.

The species with highest IVI differed between the sections, and only *Tetragastris altissima* had high IVI in both upper and middle sections. It appears to be a species well adapted to a steep relief with rock outcrops.

Conclusion

The Bacaba forest has many species in common with other gallery forests of the cerrado biome and shows strong floristic links with the Amazonian (Hylaean) forest. This reflects its position in the ecotonal zone between the cerrado and Amazonian forest biomes in the Mortes–Araguaia–Amazon basin.

Occurrence and relative importance of species in the vegetation mosaic sampled in the plots are related to environmental conditions, particularly humidity gradients.

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