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 km² 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
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
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 × 10m)
were established, giving a total sampling area of 1.41 ha. 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) ≥ 15 cm were labelled with permanent aluminium tags, identified, and measured. Girth was measured to the nearest 1 mm 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 ($H' = -\sum (p_i \ln p_i)$, where $p_i = n_i/N$, $n_i$ is the number of individuals of species $i$ and $N$ is the total number of individuals) and Simpson’s index ($\lambda = \sum n_i(n_i - 1)/N(N - 1)$), 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:

\[ \frac{2 \times \text{No. of spp. in common}}{\text{No. of spp. at locality A} + \text{No. at locality B}} \]

**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 20.44m²/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 22.28m²/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     |        | x     |
| 2. Acosmium sp.                          | Fabaceae           | x     |        |       |
| 3. Agonandra brasiliensis Miers          | Opiliaceae         |       |        |       |
| 4. Aiouea saligna Meiss.                 | Lauraceae          | x     | x      | x     |
| 5. Alibertia elliptica (Cham.) K. Schum. | Rubiaceae          | x     | x      | x     |
| 6. Amaioea guianensis Aubl.              | Rubiaceae          | x     |        |       |
| 7. Anadenanthera colubrina (Vell.) Brenan| Mimosaceae         | x     |        |       |
| var. cebil (Griseb.) Altschul            |                    |       |        |       |
| 8. Andira vermiculata Mart. ex Benth.   | Fabaceae           | x     |        |       |
| 9. Apeiba tibourbou Aubl.                | Tiliaceae          | x     |        |       |
| 10. Apocynaceae – indet.                 | Apocynaceae        | x     |        |       |
| 11. Apuleia leioarpa (Vog.) Macbr. var. molari (Spruce ex Benth.) Koeppe | Caesalpiniaceae | x     | x      | x     |
| 12. Arrabidaea cf. brachypoda (DC.) Bur.| Bignoniaceae       |       |        | x     |
| 13. Aspidosperma macraron Mart.          | Apocynaceae        | x     |        |       |
| 14. A subincanum Mart.                   | Apocynaceae        | x     | x      | x     |
| 15. A. tomentosum Mart.                  | Apocynaceae        | x     |        |       |
| 16. Astrocaryum vulgare Mart.            | Arecales           | x     | x      | x     |
| 17. Astronanthes fraxinifolia Schott.    | Anacardiaceae      | x     | x      | x     |
| 18. Bauhinia longifolia (Bongard) Steud. | Caesalpiniaceae    | x     | x      | x     |
| 19. B. ouimouta Aubl.                    | Caesalpiniaceae    | x     | x      | x     |
| 20. Bauhinia sp.                         | Caesalpiniaceae    | x     |        |       |
| 21. Bowdichia virgilioides Kunth         | Fabaceae           | x     |        |       |
| 22. Byrsonima laxiflora Griseb.          | Malpighiaceae      | x     | x      | x     |
| 23. Callisthene fasciculata (C.K. Spreng.| Vochysiaceae       | x     |        |       |
| Mart.                                    |                    |       |        |       |
| 24. Calophrum brasiliense Cambess.       | Clusiaceae         | x     | x      | x     |
| 25. Camponanthesia eugenioides Blume     | Myrtaceae          | x     |        |       |
| 26. Cananiana rubra Gardner ex Miers     | Lecythidaceae      | x     |        |       |
| 27. Casearia arborea (L.C. Rich.) Urban  | Flacourtiaceae     | x     | x      | x     |
| 28. C. sylvestris Sw.                    | Flacourtiaceae     | x     | x      | x     |
| 29. Cecropia pachystachya Tréch.         | Cercropiaceae      | x     | x      | x     |
| 30. Cheiloclinium cognatum (Miers) A.C. Smith | Hippocrateaceae   | x     |        |       |
| 31. Combretum vernicosum Rusby           | Combretaceae       | x     |        |       |
| 32. Copajera lungsdorffii Desf.          | Caesalpiniaceae    | x     |        |       |
| 33. Cordia glabratu (Mart.) A. DC.       | Boraginaceae       | x     |        |       |
| 34. C. sellowiana Cham.                  | Boraginaceae       | x     | x      | x     |
| 35. Coussarea platypylus Muell. Arg.     | Rubiaceae          | x     | x      | x     |
| 36. Curatella americana L.               | Dilleniaceae       | x     | x      | x     |
| 37. Cuspidaria sp.                       | Dilleniaceae       | x     |        |       |
| 38. Davilla elliptica St. Hil.           | Dilleniaceae       | x     |        |       |
| 39. Dendropanax cuneatum (DC.) Decne. & Planch. | Araliaceae | x     | x      |       |
| 40. Dilodendron bipinnatum Radl.         | 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     | 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. | Dilleniacae | x     |        |       |
| 48. *Duguetia maregraviana* Mart. | Annonaceae  | x     | x      | x     |
| 49. *Emmutom nitens* (Benth.) Miers | Icacinaceae | x     | x      | x     |
| 50. *Endlicheria paniculata* (Spreng.) Macbr. | Lauraceae | x     |       | x     |
| 51. *Enterolobium contortisiliquum* (Vell.) | Mimosaceae   | x     |        |       |
| 52. *Ephedranthus parviflorus* Mart. | 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     |        |       |
| 69. *Ilex affinis* Gardner      | Aquifoliaceae| x     | x      | x     |
| 70. *Inga heterophylla* Wild.   | Mimosaceae   | x     | x      | x     |
| 71. *I. thibaudiana* DC.        | Mimosaceae   | x     | x      | x     |
| 72. *Jacaranda eucalyptifolia* 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 candidans* 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.                  | Arecaeeae       |       |        | x     |
| **83.** Mauritiella armata (Mart.) Burret     | Arecaeeae       |       |        |       |
| **84.** Maytenus cf. floribunda Reiss.        | Celastraceae    |       |        | x     |
| **85.** Micropholis venulosa (Mart. & Eichl.) | Sapotaceae      | x     |        | x     |
| **86.** Mnmosa laticifera Rizzini & Mattos   | Mimosaceae      | x     | x      | x     |
| **87.** Moutbea exoriata Mart. ex Miq.        | Polygalaceae    |       |        |       |
| **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.            | Arecaeeae       | x     |        | x     |
| **92.** Ormosia coarctata Jacks.              | Fabaceae        |       |        | x     |
| **93.** Ouratea castanecofolia (DC.) Engl.    | Ochnaceae       | x     | x      |       |
| **94.** Paragonia pyramidata (L. Rich.) Burea | Bignoniaceae    |       |        |       |
| **95.** Pelogyne conferiflora (Hayne) Benth.  | Caesalpiniaeae  | x     |        |       |
| **96.** Physocalymma scaberrimum Pohl         | Lythraceae      | x     | x      | x     |
| **97.** Plathymenia reticulata Benth.         | Mimosaceae      | x     |        |       |
| **98.** Platypodium elegans Vog.              | Fabaceae        | x     | x      |       |
| **99.** Psooqueria aff. macropus Mart.        | Rubiaceae       | x     |        |       |
| **100.** Pouteria cf. macrophylla (Lam.) Eyma | Sapotaceae      | x     | x      | x     |
| **101.** P. torta (Mart.) Radlk.              | Sapotaceae      |       |        | x     |
| **102.** Protium heptaphyllum (Aubl.) March.  | Burseraeeae      | x     | x      | x     |
| **103.** P. spruceanum (Benth.) Engl.         | Burseraeeae      | x     | x      | x     |
| **104.** Pseudobomax 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.** Scheffera morotoloni (Aubl.)         | Araliaceae      | x     | x      | x     |
| B. Maguire, Steyerm, & D.G. Frodin           |                 |       |        |       |
| **110.** Sclerolobium paniculatum Vog.       | Caesalpiniaeae  | x     | x      | x     |
| **111.** Serjania glitmosa Radlk.              | Sapindaceae     | x     |        |       |
| **112.** Siparuna guianensis Aubl.            | Monimiaceae     | x     | x      | x     |
| **113.** Soroea klotzhchiana Baill.           | Moraceae        | x     |        |       |
| **114.** Sterculia exelsa Mart.               | Sterculiaceae   | x     | x      | x     |
| **115.** S. striata St. Hil. & Naud.          | Sterculiaceae   | x     |        |       |
| **116.** Tabebuia impetiginosa (Mart. ex DC.) | Bignoniaceae    | x     | x      | x     |
| Standl.                                      |                 |       |        |       |
| **117.** Tapirira guianensis Aubl.            | Anacardiaceae   | x     | x      | x     |
| **118.** Tapura amazonica Poepp. & Endl.      | Dichapetalaceae |       |        | x     |
| **119.** Tetragastris alissima (Aubl.) Swart. | Burseraeeae      | 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. | Amonaceae  | x     | x      | x     |
| 128. X. emarginata Mart.  | Amonaceae       | x     |        | x     |
| 129. Zanthoxylum riedelianum Engl. | Rutaceae   |       |        | x     |

Total

- 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 23.46m²/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) × 100. Total density: 1023 individuals/ha; total basal area: 20.44m²/ha; total sampling area: 4700m²

| Species                     | Density | Dominance | Frequency |
|-----------------------------|---------|-----------|-----------|
|                            | 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 heptaphyllan     | 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 courbari var.  | 10.6    | 1.04      | 1.288     | 6.30     | 10.64   | 1.40  | 8.74  |
| stilbocarpa                 |         |           |           |          |         |       |       |
| 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. Ornmosia 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 ≤ μ ≤ 1177] = 0.95; basal area: CI = P[17.24 ≤ μ ≤ 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: 22.28 m²/ha; total sampling area: 4700 m².

| Species                        | Density | Dominance | Frequency |
|--------------------------------|---------|-----------|-----------|
|                                | 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. Protrium 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      | 0.214     | 0.96     | 12.77     | 1.72      | 5.56      |
| 13. Protrium spruceanum         | 25.5    | 2.65      | 0.479     | 2.15     | 14.89     | 2.01      | 6.82      |
| 14. Uptonopsis lindmanii        | 27.7    | 2.88      | 0.602     | 2.70     | 17.02     | 2.30      | 7.88      |
| 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. Copajera langsdorffii       | 4.3     | 0.44      | 0.878     | 3.94     | 4.26      | 0.57      | 4.96      |
| 21. Ceitropia 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 guanensis           | 23.4    | 2.43      | 0.067     | 0.30     | 10.64     | 1.44      | 4.17      |
| 27. Astronium fraxinfolium       | 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 laevidaga      | 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. Ocneocarpus 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 = μ ± 1.96σ = 962 ± 1085 = 0.95; basal area: CI = μ ± 1.96σ = 22.28 ± 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: 23.46m²/ha; total sampling area: 4700m²

| 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          | 35.2   | 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 ≤ μ ≤ 1467] = 0.95; basal area: CI = P[19.84 ≤ μ ≤ 27] = 0.95.

For Mauritia 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 Tapirira 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 Mauritia flexuosa stood out as an emergent, reaching 25m, while some individuals of Physocalymma scaberrimum and Tapirira guianensis reached 20m. All individuals of Cecropia pachystachya and Astrocaryum vulgare were under 10m and the Acosmium sp. was restricted to the understory, 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 ($C_l = 0.66$) for comparison of upper with middle sections, but this fell to $C_l = 0.41$ for upper with lower and to $C_l = 0.36$ 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
soils are represented by Anadenanthera colubrina var. cebil, Aspidosperma subin-canum, 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 tiboumbou, 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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