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## SURVEY OF A GALLERY FOREST PRIMATE COMMUNITY IN THE CERRADO OF THE DISTRITO FEDERAL, CENTRAL BRAZIL

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### Introduction

The Cerrado biome occupies 2,064,676 km<sup>2</sup> of the central plateau of Brazil (Pereira *et al.*, 1997). It is the largest of the Neotropical savannas and the second largest biome in South America after the Amazon forest. The vegetation is largely scleromorphic, with an intergrading mosaic of pure grassland to closed woodlands, gallery forest and dry seasonal forest (Eiten, 1972).

Ten primate species have been recorded from the Cerrado (Eisenberg and Redford, 1999). A recent revision of the taxonomy of *Cebus* by Groves (2001) indicated that the capuchin monkey occurring through the majority of the region is *Cebus libidinosus*, but *C. nigritus* is the species in the southern and eastern fringes, and *C. apella* occurs along the Cerrado – Amazon forest interface in the north. The tufted capuchins (*Cebus*), the black howler (*Alouatta caraya*) and the black-tufted-ear marmoset (*Callithrix penicillata*) are widely distributed throughout the biome (Mares *et al.*, 1989; Queiroz, 1991; Rylands *et al.*, 1993).

Little information has been published on the ecology of these primates in the Cerrado; most reports are lacking detail and present only lists of species and the habitats they occupy. All studies of wild populations in the Cerrado have been restricted to central Brazil. Lacher *et al.* (1984; see also Fonseca and Lacher, 1984) reported on the gum-feeding behavior of *Callithrix penicillata* in gallery forest and *cerradão* (scleromorphic woodland), and Faria (1989a, 1989b; Miranda and Faria, 2001) studied the feeding, ranging and social behavior of *C. penicillata* in gallery forest. The first survey of a primate community in gallery forest was carried out by Queiroz (1991), who studied a community of only three species, with low population densities and biomass.

Here we review the pertinent literature and present the results of a transect census of a primate community in a wet gallery forest in central Brazil. Our specific objectives were to: (1) identify species; (2) estimate density and biomass of component populations and the full community; and (3) record data on group size and sex ratio for each species.

## Methods

### Study area

The study area was the Fazenda Água Limpa, 25 km SW of Brasília (DF), at the ecological and agricultural field station of the University of Brasília (15°56'S, 47°54'W). The climate there, recorded over 22 years, is markedly seasonal: the dry season extends from May to August, when precipitation is <10% of the annual total, and the rainy season is from September to April. The average temperature is 21.9°C, typical of a continental subtropical climate, and the mean annual rainfall is 1,534 mm.

We conducted a survey of the primate community in a humid gallery forest, 1.8 km long and approximately 100 m wide, along the Córrego da Onça (Fig. 1). The vegetation of this gallery forest was described by Ratter (1980). The trees are 14–20 m tall, providing 70–100% canopy cover with an understory of small trees. The forest floor has a sparse herbaceous and sapling cover. In the better-drained areas the most abundant tree species are *Pseudolmedia laevigata*, *Emmotum nitens* and *Copaifera langsdorfii*. Where boggy conditions prevail, the most abundant species are *Calophyllum brasiliense*, *Protium* spp. and *Talauma ovata*.

### Line transect census

The survey was conducted during the rainy season and early dry season (11 September 1992 to 5 May 1993) using a strip-census technique (Robinette *et al.*, 1974). During each census we walked a 1.8 km trail at an average speed of 1 km/hr, between 0700 and 1100 hr, 2–6 times per month, resulting in a total of 29 census walks and a cumulative total distance of 52 km surveyed. This cumulative total distance is in the range of similar studies in the Amazon forest (Peres, 1997). For each primate sighting we recorded the species,



**Figure 1.** Location of the Córrego da Onça gallery forest in the SW of the Distrito Federal (DF) (see map insert), central Brazil. Gallery forest in black.

group size and composition, and perpendicular distance from the trail of the first animal sighted. We calculated mean group size for all groups with more than two individuals, while individuals encountered alone were recorded as solitary.

We estimated the population density for each species by calculating the number of animals within the transect area, using: (1) the numbers of animals seen (both solitary and groups); (2) the length of the transect; and (3) an estimate of the effective width of the transect surveyed. The total width sampled is the perpendicular distance from the center of the transect to the limits of effective detection on either side.

In our surveys, the numbers of sightings were insufficient to generate species-specific detection functions to determine the effective width of the transect (Defler and Pintor, 1985). Instead, we derived the effective width using the maximum reliable transect to an animal's perpendicular distance, a method originally set forth by Kelker (1945) and later modified by Robinette *et al.* (1974). This method is less robust than models using detection functions (Burnham *et al.*, 1980), but it is appropriate for our relatively small dataset, and has been used for primate surveys in Amazon forests (Johns, 1985; Peres, 1997).

We lumped the sighting records for each species and determined the maximum reliable distance, the point beyond which no animals were detected. Because of our small sample size, and the animals' restriction to a strip of gallery forest narrower than the effective distance, the data clumped at a certain distance from the transect, presenting a sudden dropoff with no outliers. In this case, the effective width is the same as that of the maximum-distance method (Struhsaker, 1981). Using this method, we estimated an effective width of 26.1 m for *Cebus libidinosus*, 19.7 m for *Alouatta caraya* and 32.8 m for *Callithrix penicillata*.

We then calculated the population density ( $N$ ) of each primate species using the sum of all sighted animals ( $n$ ) from the 29 census walks, divided by twice the strip width ( $2w$ ), to account for both sides of the transect and the cumulative transect length surveyed ( $l = 52$  km). This yields the equation  $N = n/(2lw)$  (Struhsaker, 1981). To calculate the crude population biomass, we used a value of 80% of the average body mass of an adult male and adult female (Peres, 1997). Based on data presented in Ford and Davis (1992), we derived the following estimates of average body mass: *Callithrix penicillata*, 163 g; *Cebus libidinosus*, 2164 g; *Alouatta caraya*, 4562 g.

## Results

We recorded 17 primate sightings from 52 km of cumulative transect surveys (0.32 sightings/10 km) in the Córrego da Onça gallery forest. We observed *Alouatta caraya*, *Cebus libidinosus* and *Callithrix penicillata* (Table 1), but we did not conduct night-time surveys to check for the occurrence of night monkeys (*Aotus*). For this diurnal primate

community, the estimated density and biomass were 19.5 ind./km<sup>2</sup> and 51.4 kg/km<sup>2</sup>, respectively.

#### Capuchin monkey

*Cebus libidinosus* was the most frequently sighted species, with a total of nine sightings. Group size averaged 4.4 individuals (range 2–9) with a density of 2.0 groups/km<sup>2</sup>. Solitary individuals were recorded in four of the nine sightings. The density of capuchin monkeys is estimated to be 9.8 individuals/km<sup>2</sup> with a biomass of 21.2 kg/km<sup>2</sup> (Table 1).

#### Black howler monkey

Two groups of black howler monkeys were sighted: one with four individuals (two males and two females) and another with three (one male and two females). Other groups

recorded in gallery forests near the area (Rodrigues and Marinho-Filho, 1995; R. P. B. Henriques, pers. obs.) included two with one male and one female each, one of two males and three females, and one of one male and six females. The average size for all six groups was 3.8 individuals, with an average sex ratio of 0.53 males/females. From the transect data, we calculated a group density of 1.7 groups/km<sup>2</sup>, a population density of 6.5 individuals/km<sup>2</sup>, and a crude biomass of 29.7 kg/km<sup>2</sup> (Table 1).

#### Black-tufted-ear marmoset

We recorded six sightings of black-tufted-ear marmosets, four of which were of solitary individuals. In the remaining two sightings, the average group size was 2.5 individuals (range 2–3). Group density in this species was less than 1 group/km<sup>2</sup>. This species was the least abundant, with a

**Table 1.** Mean group size, sample size (n), group density, population density and biomass of primate species and census method in the Córrego da Onça gallery forest in the Cerrado of central Brazil and other Neotropical sites.

Species Site, country	Mean group size (N)	Group density (groups/km <sup>2</sup> )	Population density (individuals/ km <sup>2</sup> )	Biomass (kg/km <sup>2</sup> )	Census method <sup>a</sup>	Reference
<i>Alouatta caraya</i>						
Puerto Bermejo, N. Argentina <sup>b</sup>	7.2 (11)		130.0		HR	Thorington <i>et al.</i> (1984)
Puerto Bermejo, N. Argentina <sup>c</sup>	8.9 (11)		131.0		HR	Thorington <i>et al.</i> (1984)
Islands of Río Paraná, N. Argentina	7.9 (17)					Pope (1966)
Acurizal, Pantanal, W. Brazil	7.2 (21)	1.0	11.0	49.5	BS	Schaller (1983)
Río Paraná, N. Argentina	4.6 (? ) <sup>d</sup>		50.0		SC	Zunino <i>et al.</i> (1996)
Chaco, Paraguay	5.0 (10)					Kreig (1928)
Riacho Fundo, Central Brazil	1.5 ( 2)	1.8	2.6	16.9	SC	Queiroz (1991)
Córrego da Onça, Central Brazil	3.8 ( 6) <sup>e</sup>	1.7	6.5	24.3	SC	This study
<i>Cebus libidinosus</i>						
Chaco, E. Paraguay	7.0 ( 4)	4.0	28.0		SC	Stallings (1985)
Acurizal, Pantanal, W. Brazil	8.0 (24)	1.7	13.3	27.9	BS	Schaller (1983)
Riacho Fundo, Central Brazil	4.0 ( 6)	5.2	23.2	51.7	SC	Queiroz (1991)
Córrego da Onça, Central Brazil	4.4 ( 9)	2.0	9.8	13.2	SC	This study
<i>Callithrix penicillata</i>						
Riacho Fundo, Central Brazil	4.0 ( 5)	10.3	38.7	10.1	SC	Queiroz (1991)
Córrego Capetinga, Central Brazil	7.5 ( 5)		40.0		HR	Faria (1989a, 1989b)
Córrego Capetinga, Central Brazil	4.0 ( 4)	11.5	49.8	12.9	SC	R. P. B. Henriques (unpubl. data)
Cerradão A, RECOR, Central Brazil	4.6 ( 3)	12.1	57.0		HR	Miranda and Faria (2001)
Cerradão B, RECOR, Central Brazil	7.3 ( 3)	5.4	40.0		HR	Miranda and Faria (2001)
Dry forest, Botanical Garden, Central Brazil	9.8 ( 3)	8.3	81.3		HR	Miranda and Faria (2001)
Cerradão, RECOR, Central Brazil	4.5 ( 2)				HR	Fonseca and Lacher (1984)
Córrego da Onça, Central Brazil	2.5 ( 2)	0.5	3.2	0.7	SC	This study

<sup>a</sup> Census method: HR = home range; SC = strip census; BS = broad survey

<sup>b</sup> 1978

<sup>c</sup> 1979

<sup>d</sup> sample size not included

<sup>e</sup> including 4 groups from nearby gallery forest

population density of 3.2 individuals/km<sup>2</sup> and a biomass of 0.5 kg/km<sup>2</sup> (Table 1).

## Discussion

### *Capuchin monkey*

The results of this study are compared with data from other sites in Table 1. The average group size for *Cebus apella* in the Córrego da Onça gallery forest was similar to the mean value reported by Queiroz (1991) in another gallery forest in the Distrito Federal in central Brazil, but lower than in the dry seasonal forests of Paraguay (Stallings, 1985) or the Pantanal (Schaller, 1983), and half the value for the western Amazonian forest surveyed by Peres (1988). The percentage of solitary individuals observed in this study (45.5%) was much greater than the 14.7% recorded in the Pantanal by Schaller (1983), 5% for Peru by Janson (1984) and < 2% in Colombia by Izawa (1980).

Likewise, the population density in the Córrego da Onça gallery forest was lower than the value recorded in the Pantanal (Schaller, 1983), for seasonal dry forest in Paraguay (Stallings, 1985) and in another gallery forest of central Brazil (Queiroz, 1991). This value is at the lower end of the range for *terra firma* forest in the western Brazilian Amazon (range 2.9–12.9 individuals/km<sup>2</sup>; Peres, 1997). The population biomass of capuchin monkeys in Córrego da Onça is less than half of the value reported from the Riacho Fundo gallery forest, also in the Distrito Federal (Queiroz, 1991).

### *Black howler monkey*

The average group size for black howler monkeys recorded in this study was well below the average reported from Argentina by Thorington *et al.* (1984) and Pope (1966), and in the Pantanal by Schaller (1983) in Brazil (Table 1). The estimate in this study is similar to averages recorded in Argentina by Zunino *et al.* (1996) and in the Paraguayan Chaco by Kreig (1928). Other studies also reported a small group size for this species in gallery forests in the Cerrado (Queiroz, 1991; Flesher, 2001).

The density was higher than that recorded by Queiroz (1991) in the Riacho Fundo gallery forest, and lower than the estimate of Schaller (1983) for his site in the Pantanal. All three density estimates are low when compared with those for gallery forest and dry seasonal forest in northern Argentina (Thorington *et al.*, 1984; Brown and Zunino, 1994).

### *Black-tufted-ear marmoset*

The average group size for the common marmoset was smaller than the mean value recorded in other studies (Table 1). Group size recorded in gallery forests in central Brazil ranged from a minimum of four individuals (Queiroz, 1991; R. P. B. Henriques, unpubl. data) to 7.5 individuals (Faria, 1989a, 1989b). In dry forest and scleromorphic woodland (*cerradão*), well away from gallery forest and surrounded by *cerrado* vegetation (*sensu stricto*), group sizes were also higher than at Córrego da Onça (Fonseca

*et al.*, 1984; Miranda and Faria, 2001). Possibly the small group size of the common marmoset in Córrego da Onça indicates foraging units rather than social units. There is a record of social groups of common marmosets of up to 10–12 individuals, but Faria (1989a) suggested that these large social groups can split to forage in small sub-groups of three to four animals. The results of our study reflect a higher presence of small foraging subgroups and solitary animals. The high percentage of solitary animals is also consistent with this hypothesis, but our number was higher than the value of 18% observed by Faria (1989a, 1989b) in another gallery forest in the same region. Another factor is the difference in the food availability. Córrego da Onça has a lower abundance of tree species (Ratter, 1980) used as exudate sources compared to other sites where the group size and density of common marmosets were higher (Faria, 1989a, 1989b). Since exudate-producing trees are an important food source for this species, we can expect a difference in animal abundance between these sites (Rylands and Faria, 1993; Miranda and Faria, 2001; Vilela, 1999).

The density of marmosets in Córrego da Onça was quite low when compared with the Riacho Fundo gallery forest (Queiroz, 1991) and the Capetinga gallery forest in the same region (49.8 individuals/km<sup>2</sup>; R. P. B. Henriques, unpubl. data).

### *Community characteristics*

The Córrego da Onça gallery forest presents a primate community with species richness similar to other gallery forests in Neotropical savannas (Peres, 1989; Eisenberg *et al.*, 1979; Queiroz, 1991; Flesher, 2001), but low when compared to other Neotropical continuous forest sites (9–14 species; Peres, 1997; Kay *et al.*, 1997). Low species richness has been recorded for gallery forest in the Pantanal (Schaller, 1983) and the Chaco in Paraguay (Stallings, 1985).

The species-poor primate communities of the gallery forests of Neotropical savannas are characterized by a strong separation of species by food niches. In communities with lower primate species richness, folivores (*Alouatta*) predominate, as in the gallery forest of Masaguaral West in Venezuela (Eisenberg *et al.*, 1979). An increase in species richness is achieved by the addition of frugivores (*Cebus*, *Aotus*, *Callicebus*; Stallings, 1985), gummivores (*Callithrix*; Schaller, 1983; Queiroz, 1991; Flesher, 2001; this study), or insectivores (*Saimiri*; Peres, 1989). This pattern of species occurrence is consistent with Eisenberg's (1979) suggestion that *Alouatta* is a pioneer species in Neotropical habitats.

We suggest that the low primate species richness in gallery forests may be due to the highly fragmented nature of this habitat, when compared with continuous forest areas on the same latitude in Neotropical forests. Another constraint on the number of primate species in savanna gallery forest is the low and highly seasonal fruit productivity (Oliveira and Paula, 2001). Frugivores are the principal dietary guild that contributes to increasing species richness in Neotropical primate communities (Kay *et al.*, 1997). Fruit

**Table 2.** Species richness, density and biomass of primate communities surveyed in gallery forests in six Neotropical savanna formations.

Habitat/ Locality	No. of species	Density (ind./km <sup>2</sup> )	Biomass (kg/km <sup>2</sup> )	Reference
Acurizal (Brazil)	3	8.7	19.6	Schaller (1983)
Córrego da Onça (Brazil)	3	19.5	51.4	This study
Masaguaral West (Venezuela)	1	41.0	176.3	Eisenberg <i>et al.</i> (1979)
Masaguaral East (Venezuela)	2	39.0	136.0	Eisenberg <i>et al.</i> (1979)
Riacho Fundo (Brazil)	3	50.4	78.6	Queiroz (1991)
Rio Jutuba (Brazil)	3	71.0	122.6	Peres (1989)

productivity declines with an increase in the seasonality of rainfall and the length of the dry season, producing a predictable period of severe fruit scarcity (Schaik *et al.*, 1993). Seasonality, in turn, becomes sharply defined when rainfall is less than  $\approx 2500$  mm/year (Kay *et al.*, 1997); and as Neotropical savannas show annual precipitation well below this value, pronounced seasonality may play a role in limiting primate species richness in gallery forests.

Primate abundance in gallery forests is highly variable between sites, with Acurizal and Córrego da Onça showing the lowest values of density and biomass (Table 2). This variation cannot be attributed to hunting pressure, since these sites occur in habitats with a complete absence of hunting of primate species (e.g., Acurizal, Córrego da Onça). Primates are not considered edible by indigenous hunters in the Pantanal and the Cerrado of central Brazil (Becker, 1981; R. P. B. Henriques, pers. obs.).

Between-site variation in abundance could be attributed to differences in methodology, forest structure, and/or composition and phenology (Peres, 1997). It is unknown how these latter factors interact to determine primate species richness and abundance in gallery forest, nor how they affect full primate communities.

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## RESULTADOS DA ENQUETE SOBRE OCORRÊNCIA DE PRIMATAS NO RIO GRANDE DO SUL, BRASIL

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### Introdução

O Rio Grande do Sul é o estado mais extenso da Região Sul do Brasil, com uma área total de 282.184 km<sup>2</sup>. Como é de conhecimento geral, a crescente destruição do habitat caracteriza-se como a principal causa da redução das populações silvestres de primatas em todo o mundo. No Rio Grande do Sul essa questão vem tornando-se um fato cada vez mais preocupante, justamente pelo desconhecimento dos refúgios naturais das espécies.

São poucas as florestas nativas originais que ainda existem no estado, mantendo uma rica biodiversidade e com registro de ocorrência de primatas: *Alouatta guariba clamitans* (bugio-ruivo), *Alouatta caraya* (bugio-preto) e *Cebus nigritus* (macaco-prego). Entretanto, pouco se conhece sobre a distribuição dessas espécies, por não haver ainda um mapeamento dos habitats onde se encontram. Os dados disponíveis são de trabalhos isolados. Prates *et al.* (1993) registraram a ocorrência desses primatas em Unidades de Conservação (UCs)