POPULATION DENSITY AND VERTICAL STRATIFICATION OF FOUR PRIMATE SPECIES AT THE ESTAÇÃO BIOLÓGICA DE CARATINGA/RPPN-FMA, MINAS GERAIS, BRAZIL

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Abstract

In 2003, we carried out a line-transect sampling for all the primates (*Alouatta guariba clamitans, Brachyteles hypoxanthus, Cebus nigritus*, and *Callithrix flaviceps*) at the Estação Biológica de Caratinga (EBC) to estimate the sizes of their populations. Our goal was to examine whether the trend in population growth observed in the northern muriqui population was accompanied by similar trends in the other three species, or if there was a decline which could indicate the possible effect of competition with northern muriquis. In addition, we studied stratification to verify if the different species use the forest strata in different ways to avoid direct competition. We registered a total of 78 sightings of primates: 33 for *A. guariba clamitans*, 23 for *C. nigritus*, 18 for *B. hypoxanthus* and four for *C. flaviceps*. Our results indicated that *A. guariba clamitans* continued to be the most abundant primate at the EBC. *Cebus nigritus* and *B. hypoxanthus* occur at almost the same abundances, being half of that of brown howlers. *Callithrix flaviceps* is the least common primate in this forest fragment. Compared to previous studies, our census shows a decline in the abundance of howlers. This study confirms the prediction that larger primates use higher strata of the forest while smaller species move in the lower strata.

Key Words – Abundance, distance-sampling, mammals, space use of space, Atlantic forest, Neotropical primates

Introduction

The Brazilian Atlantic Forest has one of the highest primate diversities in the Neotropical Region, including two endemic genera, muriquis (*Brachyteles*) and lion tamarins (*Leontopithecus*) (Pinto *et al.*, 1993; Rylands *et al.*, 1996). This biome has been severely ruined over the last five hundred years to the extent that, today, only 7% of its original area remains (Myers *et al.*, 2000). As a result, the endemic primate populations have been drastically reduced. Since the early 1980s, Strier and collaborators, have been monitoring an isolated population of northern muriquis *B. hypoxanthus* in a 957-ha forest fragment in Minas Gerais previously known as the Caratinga Biological Station (EBC), but now the Private Natural Heritage Reserve Feliciano Miguel Abdala (RPPN-FMA) (Strier *et al.*, 2006; Strier and Boubli, 2006).

In the early 1980s, only 50 northern muriquis, in two social groups, were known to inhabit the EBC (Valle *et al.*, 1984). Since then, there has been a remarkable increase in the size of this population, now numbering 226 muriquis (Strier *et al.*, 2006). Three other primates occur there: the buffy tufted-marmoset, *Callithrix flaviceps*; the brown howler monkey, *Alouatta guariba clamitans*; and the tufted capuchin *Cebus nigritus*. Little is known about the demographic trends of these other primate populations at the EBC, but several studies have attempted, at different times, to determine their sizes (Valle *et al.*, 1984; Fonseca, 1983; Ferrari, 1988; Mendes, 1989; Hirsch, 1995; Strier *et al.*, 1999, 2002).

In 2003, we carried out a line-transect sampling of all primates at the EBC to estimate the sizes of their populations. Our goal was to examine whether the trend in population growth observed in the northern muriqui population was accompanied by similar trends in the other three species. In addition, we studied stratification to verify if the different species use the forest strata in different ways. Forest strata selection has been identified as an important form of niche partitioning by sympatric species to reduce direct competition (MacArthur, 1958; Cunha and Vieira, 2004 and references therein).

Methods

Study area

The EBC is a 957-ha Brazilian Atlantic forest fragment, in the municipality of Caratinga, Minas Gerais, Brazil (19°44'S, 41°49'W). The area is surrounded by pasture and

plantations of coffee, sugar cane and other crops. The altitude ranges from 400 m to 680 m, and the topographic relief is a series of hills and valleys. The forest is mostly secondary and is composed of a mosaic of habitats in different stages of regeneration (Hatton *et al.*, 1984; Boubli *et al.*, 2003).

Data collection: the line transect census

The census was carried out over 20 days in July and August of 2003, during the middle of the dry season in this region. Thirteen trails from the Jaó Valley were chosen for the census work. Eight were along hillsides, following the topographic contours, with lengths ranging from 280 m to 2,700 m (mean = 750.76 m; SD = 812.73 m). Three trails were along the hilltops and ranged from 260 to 1,000 m in length (mean = 753.33 m; SD = 427.24 m). The remaining two trails were along the valley floor and ranged from 800 m to 960 m in length. The choice of trails was based on our decision to: 1) cover the largest area possible in one day; and 2) insure that trails were far enough apart to prevent the observer from counting the same individuals twice during the same sampling period. Trails were walked daily at an average speed of 1 km/h between 0600 and 1700 h, with a rest from 1200 to 1400 h, when primates tend to be least active and thus less detectable by the observer. The following data were collected when we sighted a primate group: 1) time at beginning of the observation; 2) species; 3) location; 4) number of individuals; 5) perpendicular distance from the trail of the individual seen; 6) height in the forest of the first individual seen; and 7) the time when observation finished. Observations did not exceed 10 minutes. A total of 100 km was walked over the 20 day sampling period.

Data Analysis

We used the software DISTANCE 3.5 (Thomas *et al.*, 1998) to run the analysis. All models with respective adjustments were tested. When necessary, data were grouped in classes and truncated to a better model fit. After goodness-of-fit test acceptance, model selection was based on the minimum values of the Akaike Criterium Information (AIC) and of the Percent Coefficient of Variation (CV%) of the density estimates. Due to the small number of sightings (n = 4), for the density estimate of *C. flaviceps* we used a general Estimated Standard Width (ESW) calculated from all observations of all species, after testing that there were no differences in the perpendicular distances between species with ANOVAs (all with $p>0.05$).

Differences in the use of the forest strata by the primates were evaluated using a Chi-square test with Yates correction, using absolute number of observations in each class of 5 m, between one and 35 m. *Callithrix flaviceps* was again excluded from this analysis due to the small number of observations.

Results

A total of 78 sightings of primates were registered in the 100 km of transects walked: 33 for *A. guariba clamitans*, 23 for *C. nigritus*, 18 for *B. hypoxanthus* and four for *C. flaviceps*. The best model and adjustment to estimate primate abundances were the uniform-cosine, grouped into four classes with AIC = 87.48 and CV% = 24.47 and seven classes with AIC = 76.06 and CV% = 27.01, respectively for *A. guariba clamitans* and *C. nigritus*. For *B. hypoxanthus* the best model was uniform-polynomial, with data grouped in four classes with an AIC = 30.44 and CV% = 33.2. Despite the fact that the statistical distribution of these model criteria values was not ideal, particularly in the Coefficient of Variation, they were considered valid for basic estimates and comparisons.

Our results indicated that the brown howler monkey (*A. guariba clamitans*) continues to be the most abundant primate in EBC. The capuchin monkey (*C. nigritus*) and the northern muriqui (*B. hypoxanthus*) occur at almost the same abundances, being half of that of brown howlers. The buffy-headed marmoset is the least common primate in this forest fragment, with an estimated population size of one quarter of that of howlers (Table 1).

The EBC primates occupy a wide range of heights in the forest; from one to 35 m. There is a clear relation between body size and the height of the forest strata occupied (Fig. 1). *C. nigritus* was seen mostly in the understorey and

Table 1. Estimates of population densities and population size with confidence intervals (95%) for the four primates at the Estação Biológica de Caratinga (EBC), Minas Gerais, Brazil. n = number of observations; ESW = Effective Strip Width; Density = individuals per km²; N = population size for 900 ha of EBC forest fragments.

Species	n	ESW (m)	Density (ind./km²)	N
Alouatta guariba clamitans	33	8.71 (6.55–10.1)	50 (38–68)	480 (365–643)
Brachyteles hypoxanthus	18	13.18 (9.99–17.38)	29 (22–39)	279 (212–369)
Callithrix flaviceps	4	8.93* (7.32-10.91)	13 (11–16)	123 (101–150)
Cebus nigritus	23	8.12 (6.53–11.55)	29 (23–36)	277 (223–344)

*Estimated from all primate sightings combined (see "Data analysis").

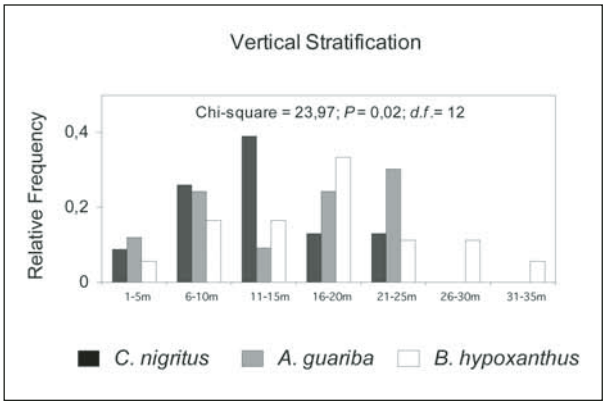

Figure 1. Relative frequencies of sightings of *Cebus nigritus*, *Alouatta guariba*, and *Brachyteles hypoxanthus* at different heights in the forest at EBC. Chi-square values were calculated with absolute numbers and Yates correction. *Callithrix flaviceps* was not included due to the low number of sightings.

lower canopy (6–15 m) (65%), *A. guariba clamitans* occupied mainly the canopy (16–25 m) with 55% of sightings in this stratum, and *B. hypoxanthus* was found mostly in the canopy and emergent trees (16–35 m; 61%). All of the species were observed in more than one strata, but only the northern muriqui was observed above 26 m.

Table 2. Density estimates for the EBC primates over the last two decades (1981–2004). Estimates with 95% confidence intervals between parentheses for the present study.

Species	Density (ind/ha)	Reference
Alouatta guariba clamitans	1.17	Mendes (1989)
Alouatta guariba clamitans	0.922 and 1.493	Hirsch (1995)
Alouatta guariba clamitans	0.502 (0.381–0.672)	This study
Brachyteles hypoxanthus	0.047	Valle *et al.* (1984)
Brachyteles hypoxanthus	0.034	Fonseca (1983)
Brachyteles hypoxanthus	0.072 and 0.762	Hirsch (1995)
Brachyteles hypoxanthus	0.292 (0.221–0.385)	This study
Cebus nigritus	0.197 to 0.35	Hirsch (1995)
Cebus nigritus	0.289 (0.233–0.360)	This study
Callithrix flaviceps	0.4	Ferrari (1988)
Callithrix flaviceps	0.019 to 0.699	Hirsch (1995)
Callithrix flaviceps	0.13 (011–0.16)	This study

Discussion

Comparing our results to those of previous studies (Table 2), our findings suggest that *C. nigritus* is as abundant as it was in the previous census, eight years ago. For *A. guariba* and *C. flaviceps* there appears to be a drop in population, although our results for *C. flaviceps* may well be underestimates given the small number of sightings. In contrast to *A. guariba*, however, *B. hypoxanthus* shows a clear increase in numbers (Table 2). Despite the high CV% of density estimates (33.2%), the point estimate (N = 279) for the northern muriqui was very close to the actual number of individuals known to be alive at the time of the survey (N = 226; Strier *et al.*, 2006), confirming the efficiency of distance sampling in population abundance studies for Neotropical primates such as this.

It is possible that the opposing trends — a decline in howler monkeys and an increase in the abundance of muriquis (since at least the last forest-wide census carried out by Hirsch (1995) — result from competition between the two species. They overlap considerably in their diets and preferred habitat (Mendes, 1989; Hirsch, 1995), and Dias and Strier (2000) have reported that muriquis were dominant in interspecific agonistic interactions, which occur primarily in food patches. Thus, one could make a case for either or both scramble and interference competition. However, we are presently unable to test this hypothesis as we have data for only one site and at one point in time, thus static or dynamic regression approaches commonly used to estimate competition coefficients from census data are not applicable in our study (Pfister, 1995; Fox and Luo, 1996).

The detection of a drop in the population of *C. flaviceps* could simply be an artifact of poor sampling, and also due to the possibility that this primate shows a very patchy distribution throughout the forest, being more abundant in very disturbed areas where bamboo and 'angico' trees (*Anadenanthera* sp.) are abundant (Ferrari, 1988). Such areas tend to be located on the forest edges, which were not sampled in this study. The evident stability in the population of *C. nigritus* is also consistent with the idea that muriqui and howler monkey densities are more directly related to one another than to those of the other species, as discussed above. The capuchin monkeys at EBC have a very distinct feeding ecology, and do not appear to be in as much direct competition with the two atelids as the two atelids are with each other (Dias and Strier, 2000).

The positive relationship between body size and the vertical strata used by the primates at the EBC is consistent with the general patterns observed in other Neotropical primate communities in Amazonia (Fleagle *et al.*, 1981; Mittermeier and Van Roosmalen, 1981; Charles-Dominique, 1983; Terborgh, 1983; Peres, 1993), and in the Atlantic forest (Rylands *et al.*, 1996; Cunha *et al.*, in press). This relationship results in some partitioning of strata according to body size, and may contribute to the stronger effects of the two largest species (muriqui and howler monkey) on one another.

In conclusion, we observed the same general pattern of abundance in the primate community at the EBC recorded by previous researchers, with *A. guariba clamitans* the most abundant species, followed by *B. hypoxanthus*

and *C. nigritus* almost equally abundant, and *C. flaviceps* continuing to be the rarest primate in this forest fragment. Additionally, we recorded a decline in *A. guariba clamitans* abundance, in contrast to the increase in *B. hypoxanthus* abundance. This study confirms that larger primates use higher strata while smaller species move on lower strata.

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