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The Ecology and Conservation of the Muriqui (*Brachyteles*) Reports from 2002–2005

Guest Editors
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Front cover: Adult female northern muriqui (*Brachyteles hypoxanthus*) at the RPPN–Feliciano Miguel Abdala. Photo by Carla B. Possamai.

In collaboration with Conservação Internacional do Brasil, Avenida Getúlio Vargas 1300, 7° andar, Savassi, Belo Horizonte 30112-021, Minas Gerais, Brazil. Website: <http://www.conservation.org.br>.

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IN MEMORY OF EDUARDO MARCELINO VENTURA VEADO, 1960–2006

The muriquis at the RPPN – Feliciano Miguel Abdala (previously, the Estação Biológica de Caratinga, or EBC), lost one of their greatest champions when Eduardo and his wife, Simone, were killed by a hit-and-run driver while they were taking an evening walk on the outskirts of Ipanema, Minas Gerais on 5 October 2006.

Eduardo's long history with the EBC began when he was a student of Célio Valle, Professor of Vertebrate Zoology at the Federal University of Minas Gerais (UFMG). Célio was sponsoring Karen's doctoral research at Caratinga, and knew that she needed a field assistant. He encouraged Eduardo, who showed up at the EBC in August 1983, and ended up working with Karen through July 1984. He then returned to Belo Horizonte to complete his university studies, and soon afterward, he married Simone.

Eduardo was hired by the Fundação Biodiversitas to be the Director of the EBC in 1986, and he and Simone moved to Santo Antônio de Manhuaçu, a small town nearby, to facilitate his work. He hosted many visitors, developed conservation education programs, and dedicated his life's work to helping maintain the field station of the EBC in the Fazenda Montes Claros of Sr. Feliciano Miguel Abdala and his family, with its forest and its muriquis. Eduardo's son, Lucas, was born in 1989, and a few years later, Eduardo and his family moved to Caratinga, where his daughter, Bruna, was born. Eduardo led campaigns in Caratinga to involve the city in preserving the muriquis. Despite his successful activities there, Eduardo felt that Caratinga was too far from the forest, so he and his family moved to Ipanema, where he visited with Sr. Feliciano, checked on the researchers, and administered the field station and its personnel almost daily.

Over the years, Eduardo built an impressive team of dedicated assistants to help him, many of whom are still working with us today. In 1993, Eduardo received a prestigious recognition award from the American Society of Primatologists, and an ongoing subscription to the *American Journal of Primatology*, which the researchers at the EBC still value greatly. In 1994, after his position with the Fundação Biodiversitas ended, Eduardo obtained support from the Liz Claiborne and Art Ortenberg Foundation to initiate conservation efforts among the farmers in the region surrounding the EBC. By then, our long-term research had shown that the muriqui population was growing, and would eventually need more forest. Eduardo developed a strong relationship with Sr. Feliciano, who agreed to let some of the coffee fields and pastures surrounding the forest regenerate. Eduardo also built a nursery, where the seeds from fruits in the diet of the muriquis could be cultivated to supply seedlings for reforestation. Throughout all of this, he continued to manage the EBC, providing the infrastructure necessary for maintaining the long-term muriqui research there, and the logistical support for visitors and the researchers themselves.

By 1998, Eduardo's conservation efforts had expanded and were generating important results. He created the Associação Pró-Estação Biológica de Caratinga, an environmental organization with the aim of establishing strategies for the conservation of the muriqui and the forests in the entire region. He served as the Executive Director of this organization. The Associação Pró-Estação Biológica de Caratinga became a partner of Conservation International – Brazil, which funded Eduardo's ongoing activities at the EBC.

With his extensive experience and accumulated knowledge of muriqui management, Eduardo was invited to serve as a member of the Committee for Management and Conservation of Muriqui when it was established in 2002. The Committee's purpose is to develop strategies for the conservation of this species and to provide technical advice to IBAMA about decisions concerning muriquis. Eduardo's participation was highly valued.

Following the death of Sr. Feliciano in 2000, Eduardo was diligent in accompanying the discussions among the Abdala family about the future of their forest. It was through Eduardo that many of us learned that the Abdala family had made the historic decision to convert their family's forest to a Private Reserve (RPPN) in 2001.

By April 2005, the Preserve Muriqui, which administers the RPPN – Feliciano Miguel Abdala, was well-established, and Eduardo's long-term service as Director of the EBC came to an end. During his tenure as Director, he oversaw the electricity that was brought to the EBC, the expansion of the research house, the construction of the Visitors Center "Célio Valle", and the inauguration of the Field Laboratory "Dra. Karen B. Strier", in celebration of 20 years of muriqui research at EBC. Eduardo encouraged and coordinated the visits of hundreds of bus loads of students from schools in the region, as well as numerous groups of Brazilian and foreign eco-tourists, and visiting researchers, photographers, and film crews from around the world.

Eduardo was employed by the Mayor of Ipanema until his death, and was full of new ideas to expand conservation efforts in the region. Among the most important of these was his plan to fulfill his long-time dream of establishing a forest corridor to link the RPPN forest with the forest in Ipanema, and ultimately, with the Mata do Sossego Private Reserve, inhabited by another isolated population of muriquis.

All of us who have worked with Eduardo know the depth of his commitment to the forest and its muriquis. Eduardo was a colleague to everyone involved with muriqui conservation, and a close friend to many of us. Most of all, he was a friend of the muriquis.

We will always remember Eduardo, and his many contributions, with great appreciation.

Karen B. Strier and Luiz Paulo de Souza Pinto
June 2007

THE ECOLOGY AND CONSERVATION OF THE MURIQUI (*BRACHYTELES*): REPORTS FROM 2002–2005. INTRODUCTION

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This special issue of *Neotropical Primates* is dedicated to the muriqui (genus *Brachyteles*), the largest of the New World primates and one of the flagships for conservation efforts worldwide. Two species are now recognized, the southern muriqui (*B. arachnoides*) and the northern muriqui (*B. hypoxanthus*). Southern muriquis are classified as Endangered, while northern muriquis rank among the 25 most Critically Endangered primates on the planet (Strier *et al.*, 2006). They are endemic to the Atlantic Forest of southeastern Brazil, one of the "hottest" of the biodiversity hotspots; very highly threatened regions with exceptionally large numbers of endemic species (Myers *et al.*, 2000).

The Atlantic Forest hotspot is distributed over more than 23 degrees of latitude and encompasses parts of three countries — Brazil, Argentina, and Paraguay. The forest once covered nearly 1, 360,000 km^2 in Brazil alone; nearly 15 percent of the nation's territory and spanning all or part of 15 states (Galindo and Câmara, 2003). The Brazilian Atlantic Forest shows impressive biodiversity gradients, with extraordinary levels of biological diversity in a varied set of landscapes and socioeconomic contexts. Eighty (80 percent) of the 24 primate species and subspecies in the Brazilian Atlantic Forest are endemic, including two endangered endemic genera — the lion tamarins (*Leontopithecus*) and the muriquis. It is unquestionably one of the most threatened regions, not only in Brazil but worldwide. Less than 8 percent of the original forest persists, much of which is fragmented, degraded and polluted, and still hunted. More than 60 percent of the animals and the vast majority of plants threatened with extinction in Brazil are found in this biome alone (Paglia, 2005).

Muriquis were first described by naturalists in the 19th century (1806), but it was Aguirre's (1971) pioneering monograph that brought their plight to the attention of Brazilian scientists and conservationists, such as Adelmar F. Coimbra-Filho (1972) and Célio Valle (Valle *et al.*, 1984). Since the late 1970s, research on primates and protected areas in the Atlantic forest carried out by these scientists, together with Russell Mittermeier, Gustavo Fonseca and others, showed that this region ranks among the most diverse and most endangered on Earth. The initial focus on primates has now blossomed into a number of internationally and nationally supported conservation projects. Work on the lion tamarins (Kleiman and Rylands, 2002) and the muriquis, and the importance of the Atlantic forest to the survival of these endemic genera, provide some of the best examples of the use of flagship species to achieve broader conservation objectives.

The results of these efforts are evident in the new discoveries about muriquis and conservation initiatives described in this volume. Contributors include researchers and conservationists from academic and both governmental and nongovernmental organizations. Some have devoted the greater part of their professional careers to muriquis; others are more recent partners who bring comparative perspectives from their work in other ecosystems and on other primates and nonprimate fauna to ongoing muriqui research and conservation efforts.

Among the many advances in research have been the insights from captive management of muriquis at the Centro de Primatologia do Rio de Janeiro (Pissinatti), and from field studies that describe newly contacted populations in the states of Minas Gerais (Melo and Dias), Rio de Janeiro (Garcia), Espírito Santo (Mendes, Santos and Carmo.; Vieira and Mendes) and Paraná (Koehler *et al.*) and new research on previously studied populations in São Paulo (Martins; Talebi and Soares). Long-term data on the northern muriquis at the Estação Biológica de Caratinga/ Feliciano Miguel Abdala Private Reserve

(hereafter, RPPN-FMA) in Minas Gerais have provided insights into reproductive ecology and demography (Strier) and the populations of sympatric primates in this forest (Almeida-Silva *et al.*). Other studies also contribute with new insights into the genetics of wild populations (Fagundes), and directives for the conservation and management of this species (Mendes *et al.*; Pontual and Boubli; Oliveira, Marini-Filho and Campos).

Conservation efforts have increasingly involved local human communities in primate conservation programs, as exemplified in a recent initiative in Caratinga (Pontual and Boubli). The government has also become more involved in supporting conservation, as is clear with the efforts of the Coordination for the Conservation of Threatened Fauna and Migratory Species (*Coordenação de Conservação da Fauna Ameaçada de Extinção e Migratória – COFAU*) of Brazil's Institute for the Environment (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA*), and the associated Center for the Protection of Brazilian Primates (*Centro de Proteção de Primatas Brasileiros – CPB*), also part of IBAMA, created in 2001 (Oliveira, Marini-Filho, and Campos). IBAMA created an international advisory committee for the conservation of the muriqui in 2003, involving many of the authors in this special issue. Consideration of the Atlantic forest brown howler monkey was later deemed essential too, and in 2005 the committee became the "International Committee for the Conservation and Management of the Atlantic Forest Atelids." All issues concerning research, monitoring and conservation of these species are now discussed, and given direction and resolution, through this government committee.

Nearly all of the advances described in this volume build on what has been a long-standing and ongoing commitment to the dual priorities and synergistic dynamics between research and conservation programs. Thus, knowledge obtained from basic research is as necessary for the development of informed conservation and management plans as effective conservation and management plans are for the continuity of research.

In an historical act, in 2003 the Brazilian Ministry for the Environment (MMA), through its Project for the Conservation and Sustainable Use of Brazilian Biological Diversity (*Projeto de Conservação e Utilização Sustentável de Diversidade Biológica Brasileira – PROBIO*) (in partnership with The World Bank and the Global Environment Facility) approved, simultaneously, three large conservation projects to work on different northern muriqui populations (one in Espírito Santo and two in Minas Gerais). The total amount approved for the three projects was the record-breaking sum of 1 million reais (roughly equivalent to U$500,000); never in Brazil had a species attracted such large funds from the government. This was strong evidence of the growing awareness of, and concern for, the critical state of *Brachyteles hypoxanthus* and its Atlantic Forest habitat.

The three projects were complementary, and formed a coordinated a strategy to increase our understanding of the species, and contribute to its conservation. The first of the projects assumed responsibility for the development both of a conservation program in Espírito Santo State and of comparative analyses of the conservation genetics of all northern muriquis. The second was responsible for developing a long-term field study of a wild population of muriquis inhabiting possibly the only large non-fragmented forest for the species — the Rio Doce State Park, Minas Gerais — in addition to locating other remnant populations of northern muriquis. The third project involved a synthesis of the ecology of the genus *Brachyteles*, and conservation measures for the northern muriqui population at the RPPN-FMA, Caratinga, now estimated to support approximately 25% of the remaining animals of the species. Muriquis at this site have been intensively studied since the early 1980s, and the analyses of Strier (1993/1994) have shown that the only factor now hampering the continued growth and expansion of the RPPN-FMA muriqui population, and thus its long-term survival, is the availability of habitat. The RPPN-FMA is an island surrounded by open pastures, and a major goal now is to regenerate forest within and around the Reserve and to establish faunal corridors to connect it to neighboring forests.

The RPPN-FMA is one of the five protected forests encompassed by the "Muriqui Nucleus," an area of nearly 1 million ha that contains the largest remaining northern muriqui populations in the species' entire range. The four other protected areas are a national park that extends across the state borders of Minas Gerais and Espírito Santo (Caparaó), two state parks (Rio Doce and Serra do Brigadeiro), and a second private reserve in Minas Gerais (Mata do Sossego). The Muriqui Nucleus was conceived by researchers Luiz Paulo Pinto and Adriano Paglia at Conservation International – Brazil, which, with the participation of government officials, NGOs and private landowners, are now actively engaged in the challenge of expanding and linking these protected areas. The product of these efforts will be the establishment of conservation connectivity across the Muriqui Nucleus, providing critical habitat for the healthy expansion of populations of muriquis and other species.

This initiative and several others were discussed during a workshop held in Belo Horizonte in May of 2005, with the support of Conservation International – Brazil and PROBIO. Jean Philippe Boubli organized the workshop with the goal of developing a global perspective for future discussions on the conservation and management of the two muriqui species. Some of the presentations given at this workshop are included in this volume.

Another recent product is the completion of a management plan for northern muriquis, coordinated by Sérgio L. Mendes and discussed and revised at the May 2005 meeting of the Committee for the Atlantic Forest Atelids. The plan suggests a number of measures, including biomonitoring studies of demography, genetics, parasites, and hormones, as well as practical activities such as management in captivity, environmental education, and habitat restoration. This Management Plan constitutes the basis for the preparation of an Action Plan, which will be the next step in organizing an integrated system for monitoring and conserving the northern muriqui.

The articles in this special issue of *Neotropical Primates* are a sample of the diversity of approaches being taken for the conservation of muriquis. Clearly, tremendous advances in our knowledge of this species and its conservation needs have been made. Yet, this collection also emphasizes the simultaneous need for ongoing efforts on behalf of northern muriquis, and greater investment in comparative studies on southern muriquis. Our ability to develop an informed conservation management strategy for both species of muriqui will depend upon the continuity of integrated research and conservation efforts that involve partnerships among universities, government, and nongovernmental organizations. There is also an urgent need to incorporate more extensive assessments of local population genetics into management plans, and to establish priorities among protected populations to ensure they have the habitat they need to expand to sizes which can provide some guarantee for their long-term health and survival.

The future of muriquis looks more promising today than it did a quarter century ago, but it is still, by no means, secure. Our task for the next 25 years is clear.

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DIRECTIVES FOR THE CONSERVATION OF THE NORTHERN MURIQUI, *BRACHYTELES HYPOXANTHUS* (PRIMATES, ATELIDAE)

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Abstract

There are two species of muriqui, *Brachyteles* — the northern muriqui (*B. hypoxanthus*) and the southern muriqui (*B. arachnoides*). The northern muriqui is the most endangered of the two. The species originally occurred through most of the Atlantic forest in the south of the state of Bahia, eastern Minas Gerais, and south central Espírito Santo. Hunting and widespread loss of its native forest means that today just a few small and isolated populations remain, with poor chances of survival in the long term. Currently the northern muriqui can be found in 12 places, six on private land, three in state protected, and three in federal protected areas. Combined, these areas total about 160,000 ha and a minimum known number of 855 individuals. The known population has increased significantly in the last five years, but the total is still very small and fragmented for long-term viability — no single population exceeds 500. In this article we report on the areas where they are known to occur, the main threats to them, and the conservation measures that have been proposed to avoid the premature extinction of the species.

Key Words – primates, *Brachyteles*, conservation, Atlantic forest, Brazil

Introduction

Muriquis are endemic to the Brazilian Atlantic forest, occurring in a number of forest types, from the humid coastal formations of the Serra do Mar to the semideciduous forests inland in the states of São Paulo and Minas Gerais, extending from the south of the state of Bahia to northern Paraná (Aguirre, 1971). Two species are recognized — the southern muriqui (*Brachyteles arachnoides*) and the northern muriqui (*B. hypoxanthus*) — differentiated by the presence of a vestigial pollex and spotty pigmentation on the face and perineum in *B. hypoxanthus* (Aguirre, 1971; Rylands *et al.*, 2000; Groves, 2001).

The range of the northern muriqui (*B. hypoxanthus*) covers the Atlantic forest of the states of Minas Gerais, Espírito Santo and Bahia, excluding the lowland forests in the extreme south of Bahia and northern Espírito Santo. According to Aguirre (1971), the northern limit to its range was probably the Rio Jequiriçá basin, which flows into the Baía de Todos os Santos, and including the forests of the right bank of the Rio Paraguaçu. The southern limit is more poorly defined, but it probably extended to the Serra da Mantiqueira, in southern Minas Gerais, near to the state boundaries with Rio de Janeiro and São Paulo.

Almost all of the information we have on the ecology, behavior, reproduction and demography of the northern muriqui comes from a single population at the Caratinga Biological Station (*Reserva Particular do Patrimônio Natural Feliciano Miguel Abdala*), Minas Gerais. There, muriquis have been systematically monitored and researched since 1982 (Fonseca, 1985; Strier, 1987a, 1987b, 1993/1994, 1999, 2000; Strier *et al.*, 2002, 2006).

The extinction of the muriqui throughout a large part of its range is a result of the destruction of its forests and, with its large size, hunting (Aguirre, 1971; Mittermeier *et al.*, 1987; Lane, 1990). The Atlantic forest, originally extending for more than 1,300,000 km² along the Brazilian coast, has been reduced to fragments that today total a mere 7.5% of its original cover (Myers *et al.*, 2000). The population growth rate of the muriqui is at best slow (Strier, 1996) contributing to its vulnerability to extinction. Its capacity

to use secondary forests, even those in relatively early successional stages, however, has allowed for the survival, and even recovery, of small, isolated populations. Eliminating the causes of decline such as hunting and epidemic diseases, muriqui populations can grow and thrive in regenerating, remnant forests.

Protected Areas for the Northern Muriqui

The northern muriqui is today known to survive in 12 localities, six on private land, three in state protected areas, and three in federal protected areas (Table 1, Fig. 1.). The 12 areas total approximately 160,000 ha, providing forest for at least 855 individuals. Although, the numbers of wild muriquis known to be surviving have increased considerably in the last five years, the total population is still small, and no single population is considered to be viable in the long-term, none even close to 500 or more in size. Here we describe each of 12 known populations and discuss their conservation status.

1. Alto Cariri

This forest, of about 18,000 ha, is in the extreme northeast of Minas Gerais, extending across the border with the state of Bahia (16°24'S, 40°03'W). It has been identified as of high priority for biodiversity conservation, and both the State Forestry Institute of Minas Gerais (*Instituto Estadual de Florestas – MG*) and the Brazilian Institute for the Environment (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA*) are considering the creation of a protected area there. The vegetation is predominantly dense evergreen forest; much of it well preserved, even though some areas have suffered selective logging. Alto Carirí takes in parts of the municipalities of Santa Maria do Salto, in Minas Gerais, and Guaratinga, in Bahia. At least seven muriquis were seen there, but due to the large size of the forest (in relative terms) it is probable there are many more, and a census is needed to determine the exact size of the population (Mendes *et al.*, 2004). The creation of protected areas is the major priority for this region.

2. Mata Escura Biological Reserve

The Mata Escura Biological Reserve covers some 50,890 ha in the municipalities of Jequitinhonha and Almenara, in the Rio Jequitinhonha valley, Minas Gerais (16°20'S, 41°00'W). Two muriquis were seen there in April 1999 at the headwaters of a stream called Córrego Duas Barras (Melo *et al.*, 2002). Three were seen there on a subsequent occasion, but in 2000 a second group of about 15 muriquis was located along the banks of the Córrego Mata Escura (Melo, 2004). This group was later found to have 25 members. It is possible that further groups will be found in other valleys in the reserve. The Córrego Duas Barras has about 1,500 ha of forest in the municipality of Jequitinhonha, and the Mata Escura valley has about 1,000 ha. The principal threats are fire, hunting, selective logging, and unregulated and destructive tourism. The priority measures for the implementation of the biological reserve include building some physical infrastructure, increasing the policing of the area, resolving landownership and indemnities, and counting, mapping and studying the muriqui groups.

3. Fazenda Córrego de Areia

There is about 450 ha of seasonal semideciduous forest at the Fazenda Córrego de Areia. It is near the transition zone of the Cerrado and Atlantic forest (18°26'S, 42°25'W, altitude 388–805 m above sea level), in the municipality of Peçanha, Minas Gerais. The farm is privately owned, and

Table 1. Confirmed populations of the northern muriqui*.

#	Locality	State	Owner	Area (ha)	Minimum population
1	Alto Cariri	MG/BA	Private	18,000	7
2	Mata Escura Biological Reserve	MG	IBAMA	50,890	28
3	Fazenda Córrego de Areia	MG	Private	494	13
4	Rio Doce State Park	MG	IEF-MG	35,976	124
5	Caratinga Biological Station (RPPN Feliciano Miguel Abdala)	MG	Private	957	226
6	Augusto Ruschi Biological Reserve and vicinity	ES	IBAMA	3,573	14
7	Santa Maria de Jetibá	ES	Private	+2,000[1]	84
8	Fazenda Esmeralda	MG	Private	44	3
9	RPPN Mata do Sossego	MG	Fundação Biodiversitas	180	41
10	Caparaó National Park	ES	IBAMA	31,853	82
11	Serra do Brigadeiro State Park	MG	IEF-MG	13,210	226
12	Ibitipoca State Park	MG	IEF-MG	1,488[2]	7
	Total			**158,665**	**855**

*Data from October 2005.

BA = Bahia, MG = Minas Gerais, ES = Espírito Santo, IBAMA = Brazilian Institute for the Environment, IEF-MG = Minas Gerais State Forestry Institute.

[1]In Santa Maria de Jetibá the area (+2,000 ha) encompasses a group of 13 partially isolated forest fragments.

[2] The muriqui population of Ibitipoca is largely in forest fragments outside the state park.

about 230 km from the state capital, Belo Horizonte. The forest is surrounded by coffee plantations and cattle pasture. The main threats are fire and selective logging. Hirsch *et al*. (2002) registered 13 muriquis there in 2001. Priority measures for this area include a monitoring program for the few muriquis remaining on the farm, the provision of incentives for less harmful uses of the soil (organic cultivation and agroforestry, for example), and the creation of a private natural heritage reserve (*Reserva Particular do Patrimônio Natural – RPPN*) to protect the remaining forest patch.

4. Rio Doce State Park

The Rio Doce Park covers parts of the municipalities of Marliéria, Timóteo and Dionísio, in Minas Gerais (42°38'W

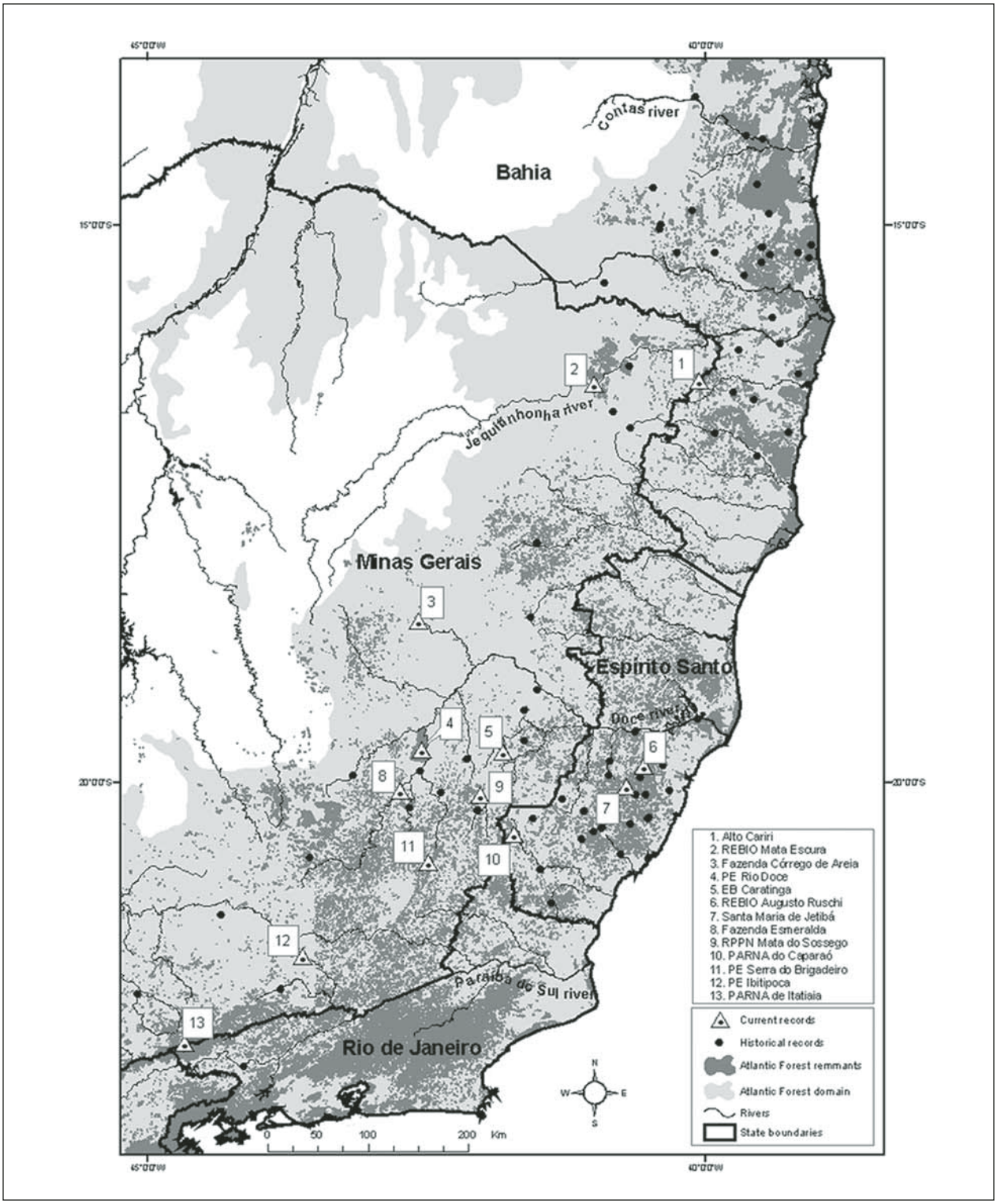

Figure 1. Historical and current records of the northern muriqui. Muriquis occur in Itatiaia National Park (#13), but the species has yet to be confirmed there.

and 48°28'W, 19°45'S and 19°30'S). It is one of the most important remnants of Atlantic forest in the entire state, with 35,976.43 ha, limited to the north by the Rio Piracicaba, to the east by the Rio Doce, and to the south and west by extensive eucalyptus plantations and cattle pasture. Past surveys have indicated a very low population density for the muriquis (Hirsch, 1995). However, studies in recent years have shown that there are at least 12 groups there, totaling a minimum of 124 individuals (Dias *et al*., 2005). Despite the considerable infrastructure in the park for fire detection, big forest fires continue to be the greatest threat to the wildlife there. Hunting is also still significant, especially in the north of the park, close to large urban centers, and along the 22-km road which bisects the park, connecting Pingo D'água to Timóteo. Long-term measures for action in the park include research on the ecology and behavior of the muriqui groups there, resolution of landownership and indemnities, improved policing, and the upgrading of the municipal fire brigade to combat the forest fires, besides a broad environmental awareness and education program for the communities, farms and towns around the park.

5. Caratinga Biological Station – Reserva Particular do Patrimônio Natural Feliciano Miguel Abdala (EBC/RPPN-FMA)

The privately-owned, semideciduous, 957-ha forest of the EBC/RPPN-FMA is in the municipality of Caratinga in Minas Gerais (19°50'S, 41°50'W). It is mostly secondary, in different states of succession, surrounded by pasture and coffee plantations. In 2001, the forest was turned into the Private Natural Heritage Reserve "Feliciano Miguel Abdala" (RPPN-FMA). The ecology, behavior, reproduction, and demography of the largest of the groups there (Grupo do Matão) have been studied consistently since 1982 (Strier *et al*., 2002). It has more than tripled in size in 20 years, from 22 to more than 70 individuals, due to low mortality and high fecundity, and the increase in births and survival of offspring. The same growth evidently occurred in a second group (Grupo do Jaó) that had about 18 individuals in the early 1980s, but numbered 73 in 1999 (Strier *et al*., 2002). In January of 2005, the muriqui population at the EBC/RPPN-FMA reached 226 individuals, in four mixed groups of 37 to 77 and a group of eight males that associates with two of the mixed groups (Strier *et al*., 2006). Besides the long-term studies coordinated by Karen B. Strier, Jean. P. Boubli has been leading a project supported by the nationwide Project for the Conservation and Sustainable Use of Brazilian Biological Diversity (*Projeto de Conservação e Utilização Sustentável de Diversidade Biológica Brasileira – PROBIO)* of the Ministry of the Environment (MMA), coordinated through the Instituto Dríades. The aims of the PROBIO/MMA project are (1) to synthesize our understanding of the ecology of *Brachyteles*, mainly of those at the EBC/RPPN-FMA, so as to develop a global perspective that can support decisions and plans for the conservation of muriquis throughout their geographic range, (2) to set up a pilot project for the recuperation of degraded areas, promoting their return to forest habitat for the muriquis at the EBC/RPPN-FMA, and (3) to formulate a proposal to expand forest recuperation and natural habitat conservation to areas neighboring the EBC/RPPN-FMA, that will allow for conditions to create wildlife corridors to support a metapopulation of muriqui groups extending across the region. Future measures that we suggest include a more intensive biomonitoring of the population, habitat restoration with a view also to provide connectivity with forest fragments on neighboring farms, and the synthesis of a formal action plan for the RPPN.

6. Augusto Ruschi Biological Reserve

In the municipality of Santa Teresa, Espírito Santo, the then Nova Lombardia Biological Reserve was created by Decree number 87.589 of 20 September 1982 (19°45'S and 20°00'S, 40°27'W and 40°38'W). The reserve is 3,573 ha of dense montane evergreen gorest (*Floresta Ombrófila Densa Montana*), on very high relief with steep slopes, valleys and rocky outcrops, at altitudes that range from 780 m to 1,050 m above sea level (Brasil, 2007). Aguirre (1971) recorded the presence of muriquis there, estimating about 150–180 individuals. Visiting the reserve, Mittermeier *et al*. (1987) only heard vocalizations, but were able to confirm a minimum of 10 individuals through reports of sightings by the park guards. Pinto *et al.* (1993) found two groups there, each of four to seven individuals. The only information we have had since then that indicates the continued presence of muriquis comes from the park guards. With the lack of more precise information, we can only indicate a population of about 10. In April 2005, Vieira and Mendes (2005) reported another group of four muriquis in a privately-owned forest near to the biological reserve, suggesting that the reserve and the neighboring forests have more muriquis than we have suspected to date. Suggested actions: a detailed census of the population, intensified policing of the reserve, and the development of an environmental awareness and education program for the buffer zone.

7. Santa Maria de Jetibá

Santa Maria de Jetibá is a municipality in the central, montane region of the state of Espírito Santo. The municipal capital is 20°02'S and 40°41'W. It lies in a geomorphological formation known as the Crystalline Complex, with altitudes ranging from 600 to 1,200 m, in the phytogeographic domain of montane and submontane Atlantic forest. The region was colonized in the 19th century by European immigrants, many from what was then Pomerania, establishing a system of small farms and family agriculture. Despite the intense fragmentation of the forests in the region, about 30 to 40% still has native forest in middle to advanced stages of succession. The situation in the municipality of Santa Maria de Jetibá is unusual in that the muriquis are surviving in small forest fragments of 60 to 350 ha, because, it would seem, the human population of the region has no tradition of hunting, and frowns upon anybody who does. The muriquis have been found in at least 13 forest fragments throughout the entire municipality of Santa Maria

de Jetibá, with a minimum population estimated at 84 individuals (Mendes *et al.*, 2005). The number of muriquis seen in these fragments varies from one to 16. The solitary individuals seen are females, and solitary females have been seen even in fragments with groups of muriquis. Reports of muriquis occurring in another 11 fragments have yet to be confirmed but suggest a total population of more than 100 individuals. Suggested actions: Further surveys and censuses in the region, development of an environmental education program, promotion of ecotourism, development of a program to carry out studies necessary for population management, studies of dispersal using field data and spatially-explicit models, work towards the creation of protected areas, and help promote socio-economic activities compatible with biodiversity conservation.

8. Fazenda Esmeralda, Rio Casca, Minas Gerais

The only forest fragment of the Fazenda Esmeralda that still has muriquis is 44 ha. The forest, about 30 km north of the town of Rio Casca, is seasonal and semideciduous and surrounded by monocultures and pasture. On the top of a small hill, the maximum altitude is 480 m above sea level. The forest has suffered a long history of depredation and disturbance during the economic cycles driven by coffee and maize and, most recently, by sugar-cane, besides selective logging for timber and charcoal during the 1960s and 70s. A few sparse forest fragments remain on the farm, isolated by crops and open fields. The fragment containing the muriquis is a mosaic of different successional stages, and dense in lianas. The first record of their occurrence there was provided by Aguirre (1971), who indicated 7–8 individuals. Subsequent studies on the single group from 1983 to 2003 witnessed a decline in the population from 18 to just three: two adult males and an adult female, all old (Melo *et al.*, 2005). The population was considered no longer viable, and in 2003 the Committee for the Conservation and Management of the Muriqui recommended that they be removed and taken into captivity. The main threats to the muriquis have been hunting, forest fires, selective logging, predation and harassment by farm dogs and, besides, the very small size of the forest. Suggested action: capture and remove the remaining muriquis and incorporate them into a captive breeding program.

9. RPPN Mata do Sossego

The Mata do Sossego Private Natural Heritage Reserve (RPPN) is in the municipality of Simonésia (42°05'W, 20°04'S). Although the registered area for the RPPN is 180 ha, there are forests around it which form a single block of forest of about 800 ha. Use of the soil around the reserve is mainly dedicated to coffee plantations, and the major threat to the muriquis comes from fires set in the dry season by hunters. In 1984, the population was estimated to be about 21 individuals (Mittermeier *et al.*, 1987). Petroni and Steinmetz (2000) indicated a minimum number of 20, and the most recent census counted a group of 41 (Dias *et al.*, 2005). Suggested actions: a long-term study on their ecology and behavior; demographic monitoring of the muriquis in the reserve; negotiation with the landowners to consider the creation of further private reserves or the acquisition of the forested areas; establishment of forest corridors; population management.

10. Caparaó National Park

The park extends across the state border of Espírito Santo and Minas Gerais in a montane region, part of the Serra da Mantiqueira (20°19' and 20°37'S, 41°43' and 41°53'W). The park is 31,853 ha, 60% (18,200 ha) of which is in southwestern Espírito Santo, and the rest is in Minas Gerais. Predominantly montane, vegetation types include dense evergreen forest, montane forest, semideciduous seasonal forest and high altitude grassland (*campos de altitude*). The occurrence of muriquis there was reported by Mittermeier *et al.* (1987) based on information from the park guards of a group of at least 12. Further research is underway that is indicating the presence of muriquis in nine locations on the Espírito Santo side of the park. They have been confirmed for four of the valleys: Vale do Ribeirão Calçado, Vale do Córrego Jacutinga, Vale do Córrego Santa Marta, and Pedra do Facão. In the first of these, there are at least two groups, with a minimum population of 40 individuals, seen at altitudes of 1,000 to 1,800 m above sea level. Muriquis have been seen 18 times in the Vale do Jacutinga, indicating the presence of one group with a minimum size of 42. We don't know the number of muriquis in other valleys. The data from the Caparaó National Park are still preliminary, and suggest the population may be very much larger. Worrying, however, are the signs of hunters inside the park. The hunting of muriquis was reported in the park a few years ago. Suggested actions: carry out a systematic census of the entire park; set up an environmental education program; and invest in improving the policing of the park in the part on the Espírito Santo side.

11. Serra do Brigadeiro State Park

The Serra do Brigadeiro State Park in southern Minas Gerais is 13,210 ha. It has a perimeter of 156.9 km, and altitudes range from 1,000 to 2,000 m above sea level (20°33' to 21°00'S; 42°40' to 40°20'W). The forest there is fragmented. The majority is seasonal semideciduous forest, but there are some areas above 1,400 m altitude that show characteristics of dense montane evergreen forest. Records from the last two years show that there are at least seven groups of muriquis, and a minimum population of 226 (Dias *et al.*, 2005). The principle threats include forest fires, hunting, selective logging, squatters, unregulated tourism, and subsistence cattle-farming. Suggested actions: more regular and systematic monitoring of the muriqui population; resolution of landownership issues; strengthening of the policing of the park; improvement in capacity to prevent and combat forest fires; and the development of an environmental education program.

12. Ibitipoca State Park

This park, of 1,488 ha, lies between the plateaus of Itatiaia and Andrelândia (21°40' to 21°43'S, 43°52' to 43°54'W,

altitudes 1,050–1,784 m above sea level). The predominant vegetation is high altitude grassland, with gallery forest along the rivers and streams. In 1995, Fontes *et al.* (1996) saw a female muriqui three times in a forest of 80 ha in the center of the park. In 2002, Mendes *et al.* (2003) saw a group of nine in a small forest called the Mata dos Luna on the property of Carlos Repetto near to the northern boundary of the park. They were also told of a group in another area, aptly called the Mata dos Monos. Oliveira (2003) also mentioned a group of 10 muriquis in a forest neighboring the park, believed to be the same as was seen by Mendes *et al.* (2003). Ferraz *et al.* (2005), however, indicated that the group consisted of only seven individuals. The vegetation found in most of the park is not ideal for muriquis, and it is evident the preservation of the muriqui in this region will depend on protecting the forest fragments on the properties around the park. The priority, therefore, for this area is to carry out a more precise and systematic census of the muriquis, and to adopt measures for the protection of the forest fragments and to increase the connections among them. The presence of solitary females in a small fragment of forest in the park indicates that there is a lack of opportunities for dispersal and reproduction elsewhere. Suggested actions: a census of muriquis around the park; expansion of the park to include neighboring forest fragments; the creation of private natural heritage reserves (RPPNs); and the promotion of conservation measures by the local landowners and farmers.

13. Itatiaia National Park

The Itatiaia National Park (28,155 ha) is in southern Minas Gerais, in the municipalities of Alagoa, Bocaina de Minas, and Itamonte, extending across state border into southeast Rio de Janeiro in the municipalities of Resende and Itatiaia (22°16' to 22°28'S, 44°34' to 44°42'W). It is the oldest national park in Brazil (1937), located in the Serra da Mantiqueira, with altitudes ranging from 650 to 2,780 m above sea level. Five vegetation types have been described in the park: dense montane, high montane, and mixed evergreen forest, seasonal, semideciduous forest, and high altitude grasslands at elevations above 1,600 m. The main threats to the fauna and flora of the park are fires, destructive tourism, illegal clearings and construction, and palm heart collectors. It has not been possible to clearly define whether the muriquis there are northern or southern. The very few sightings have not even allowed for a minimum population estimate. This makes a thorough census of the park and its muriquis a very high priority. Suggested actions: a census to determine the species occurring there; to map the groups and count their numbers; set up a long-term monitoring program for the groups; and resolve issues still pending concerning landownership and domain.

Priority Actions

A Population and Habitat Viability Assessment (PHVA) workshop for the muriqui was held in Belo Horizonte in May 1998 (Rylands *et al.*, 1998), and in 2002, the Brazilian Institute for the Environment (IBAMA) set up the Committee for the Conservation and Management of the Muriqui (Oliveira *et al.* 2005). From 2001 to 2003 the Project for the Conservation and Sustainable Use of Brazilian Biological Diversity (*Projeto de Conservação e Utilização Sustentável da Diversidade Biológica Brasileira – PROBIO*), of the Ministry of the Environment (MMA), approved financing for three projects for the conservation and management of the northern muriqui. Two important meetings resulted from this, the first in January 2003 in Santa Maria de Jetibá, Espírito Santo, and the second in March 2004 in Belo Horizonte. They provided the information and directives for the elaboration of a management plan for the species. As such, the following discussion of the priority measures for the conservation of muriquis is the result of the thoughtfulness, dedication and expertise of the numerous institutions and people who took part in these meetings.

Monitoring: Surveys and censuses

Recent studies have resulted in the discovery of new populations of muriquis. In the last 10 years, our estimate of the total population of the species has increased from about 300 to at least 855, and from seven to 12 localities. We owe this to more systematic surveys and to new technologies such as the use of playback — playing recordings of their vocalizations in the forest so as to increase the chances of locating them. New found areas in eastern Minas Gerais, and the montane regions of Espírito Santo and Bahia require further surveys, and we recommend GIS modeling tools to orient and prioritize the areas to be surveyed.

Monitoring and conservation status assessment

Currently there are research programs on, and conservation initiatives for, muriquis being carried out in six locations, four in Minas Gerais (RPPN Feliciano Miguel Abdala, RPPN Mata do Sossego, and Serra do Brigadeiro and Rio Doce state parks) and two in Espírito Santo (Caparaó National Park and Santa Maria de Jetibá). These studies and initiatives cover about 90% of the entire population of *B. hypoxanthus*. Continuity for these projects is vital. The definition of a basic protocol for the collection of ecological and behavioral data is important to allow us to compare the results of the programs in the different areas; essential if we are to evaluate their contributions and efficacy in improving the status of the species. Initially we need to have estimates of the total population and some definition of the population structure in the localities where long-term studies have been set up. The first is possible with the knowledge that we already have, provided that some additional information can be obtained as outlined below. An understanding of population structure and demography will be possible based on the few groups which have been subject to long-term studies. It is vital that some guarantees be put into place for the continuity of these long-term studies. We suggest that the six localities mentioned above be targeted for funding to this end. One or two groups should be closely monitored for their social structure in each of the six areas — either continuously or at least through detailed

counts every five years. The total population, of course, should also be closely monitored over the long-term, with censuses every five years. Monitoring the total population will allow us to track population changes, and monitoring population structure and demography will allow us to understand the nature of the changes. The causes can only be tracked by understanding the availability of resources in terms of food and habitat, and the threats to them both indirect (forest degradation and loss) and direct (hunting). Changes in habitat availability can be assessed every five years using satellite imagery, and monitoring the quantity and quality of the remaining forests in the areas where the muriquis still occur.

Genetic studies

The analysis of intra- and inter-population genetic diversity is the first step to identifying what we may consider "evolutionarily significant units"; genetically distinct populations which need to be protected. Currently there are genetic samples available from only three of the twelve known northern muriqui populations; all in the DNA Bank of the Department of Biological Sciences of the Federal University of Espírito Santo. Of the three, two have been subjected to genetic studies using a mitochondrial DNA marker, demonstrating genetic differences between the muriquis of Santa Maria de Jetibá and the EBC/RPPN-FMA (Paes, 2005). The identification of variable genetic loci will provide a useful means to measure genetic variation and population differentiation, and allow for an understanding of the evolutionary relationships which need to be conserved. As such, we consider that a knowledge of the genetic profiles of all of the known muriqui populations, using at least two genetic markers (one mitochondrial, the other nuclear), is vital for the conservation and management of the species. This is also vital when using the genetic profiles of individual muriquis to guide translocations and reintroductions whenever they are deemed expedient. The Laboratory of Animal Genetics of the Federal University of Espírito Santo has developed a protocol for the extraction of fecal DNA in *Brachyteles* that is already being applied in genetic studies of the muriquis at Santa Maria de Jetibá and the Caratinga Biological Station (Chaves *et al*., 2006). We propose the establishment of a single protocol for genetic studies using fecal material for all of the muriqui populations (Fagundes, 2005).

Parasitological studies

Parasitological studies can provide a good understanding of the state of health of the muriquis, and monitoring parasite loads in the different populations is an essential element for their conservation and management (Stuart and Strier, 1995; Santos *et al.*, 2004a, 2004b). Important too is to monitor the muriquis for the presence of parasites of humans and domestic animals. The northern muriqui is largely limited now to forest fragments, with more or less frequent intrusion and interference by people and their animals, both by their presence and the pollution of the streams which run through them, where muriquis sometimes drink (Santos *et al*., 2004a, 2004b). The disease risks are high, making frequent parasitological monitoring a must. This can only be done by institutions which have experience in the collection and identification of primate parasites. With the appropriate protocols for collection and preservation, however, all researchers and field teams should carry out campaigns for the collection of fecal material (systematically to allow for the detection of any trends), and send them to appropriate participating laboratories. Ideal would be the establishment of a muriqui parasite data bank, accessible to all who work on the species. When infection with human or domestic animal parasites is detected, measures should be taken which would include health and environmental education for the local communities, reducing or, better, eliminating the sources of contamination of the streams, and stopping domestic animals entering the forest.

Hormonal monitoring

The hormonal studies of the muriquis at the EBC/RPPN-FMA by Strier and Ziegler (1997, 2000; also Strier *et al.*, 2003; Strier, 2005) have contributed enormously to our understanding of the reproductive strategies of these primates, of immense utility for wise management and conservation. The data they can obtain allow us to assess the reproductive potential of the small populations, besides providing insights regarding stress levels, experienced by the muriquis for whatever reasons. As hormonal analyses are expensive, however, widespread monitoring is impractical in the short term, but they can provide significant insights concerning questions about the reproductive health of specific populations and groups. For example, we can study the variation in cortisol levels in different muriqui populations to understand how they may relate to ecological or demographic stress.

Population management

Some of the muriqui populations are very small, and probably not viable in the long term. This is the case for the Fazenda Córrego de Areia, Ibitipoca State Park, the Fazenda Esmeralda, and a number of fragments at Santa Maria de Jetibá. It is possible the viability of some can be maintained, if only minimally, with some sort of population management, such as the introduction of animals from elsewhere (reintroduction or translocation). Solitary females have been found in forest fragments in Santa Maria de Jetibá. They have dispersed from their natal groups and, for lack of other groups to join, end up remaining alone. In these cases, we should consider translocating muriquis from other groups to join them — females not reproducing are a significant loss to a species so threatened. The management of wild populations is a complex task, requiring caution in terms of the medical and genetic health, and the social stability of the animals involved.

Populational viability simulation

The risks of local extinction need to be assessed using the population viability models now available. It is possible to predict the persistence of the populations based on a variety

of parameters, and also to model the basic structure for the metapopulation for the purposes of management planning. Strier (1993/1994), for example, assessed the persistence likelihoods of the muriquis at the EBC/RPPN-FMA over 100 years, using the program VORTEX, and concluded that the probability of extinction was low. The chances of error are there, however, especially as the program used only the first 12 years of data from the site. The analysis showed that the carrying capacity (area of forest available) was the main factor limiting population growth. Running a similar model for the muriqui population at Santa Maria de Jetibá, P. De Marco Jr., using the same biological parameters as those of the simulations made by Strier (1993/1994) but including the real initial population sizes of each area, found that the persistence probabilities were higher than 95% over 100 years in forests of more than 120 ha. The simulation also indicated that if hunting pressure, endogamic depression, and the probabilities of catastrophes are low, the population tends to grow and reach stable levels quite quickly. Even if the parameters used are to some extent unreal, the simulations are of enormous value in defining management priorities, and should be done for all the existing populations being studied.

Captive breeding program

The establishment and maintenance of a captive breeding program for muriquis should be seen as an important measure complementary to efforts for their conservation *in situ* (Pissinatti *et al*., 1998; Pissinatti, 2005). The aim would be to rescue the muriquis being kept as pets and in illegal menageries and zoos, as well as solitary females in isolated forest fragments otherwise lacking a reproductive future. Isolated groups too small to be viable could also contribute as founders. There needs, of course, to be institutions with the conditions in terms of both personnel and infrastructure to receive these animals and to collaborate in a formal breeding program. For *B. hypoxanthus*, the Rio de Janeiro Primate Center (*Centro de Primatologia do Rio de Janeiro – CPRJ/FEEMA*), the first institution to breed muriquis in captivity (Coimbra-Filho *et al*., 1993; Pissinatti, 2005), and the Belo Horizonte Zoo (*Fundação Zoo-Botânica de Belo Horizonte*) are already fully capable of initiating a program of this sort. The principal aims of these institutions with the capacity to maintain muriquis in captivity would be rehabilitation and research.

Environmental awareness and education

Due to its charm, its size (the largest of the Neotropical monkeys), and the fact that it is endemic, the muriqui is a flagship species for the conservation of the Atlantic forest (Valladares-Padua *et al*., 2003; Pinto *et al*., 2005). It can be used very effectively for the 'call to arms' to conserve a location or promote conservation actions in a region. The rural communities where muriquis still survive interfere to a greater or lesser degree just with their presence and their use of natural resources, and in the case of parks and reserves, tourists and visitors do the same. And there is still clandestine hunting in many of the muriqui localities. Awareness campaigns and environmental education programs are vital, and networking is important to exchange experiences, success and failures in what are by their nature, extremely creative initiatives, consistently requiring renewal and modification. Another important aspect is advertising the plight of the muriquis and their forests with all the rich propaganda material and gadgets available today. Costs can be reduced if the different partners share the material they need. One model of a muriqui T-shirt for all, for example. A third line of action is working with the media, reaching a broader public, and more directly influencing the opinions and attitudes of the local and regional communities: something which of course needs careful and measured planning so as to instill a lasting and solid appreciation for the conservation measures that are required not just for the muriquis but for the health of the natural landscapes as a whole, benefiting the people living there.

Socioeconomic alternatives

In many cases the probabilities of the muriquis surviving in the long term is low; because of their isolation or because of the limited forest available to them. Landscape management, providing for the permanence and expansion of the forests of the region, along with connectivity between them, is as such vital. Interference in the natural landscape requires socio-economic measures often sensitive and complex. For this reason, the socio-economic realities of all the regions where muriquis occur should be studied so as to obtain the basic understanding of the context and potential for promoting initiatives which will favor biodiversity conservation. One example is ecotourism and scientific tourism that, when set up appropriately, can provide for income and livelihoods but with low impacts on the wildlife and forests. These activities can even provide incentives and income for conservation measures such as habitat restoration. Businesses and sources of livelihoods can become the allies, not the enemy, in working for the conservation of the region. Besides its economic contribution, tourism is educational, making landowners see the value of preserving their forests and the muriquis. Small-scale tourism projects need to be planned in collaboration with the people studying the muriquis, with clear protocols to minimize the impact on the muriquis and their forests, avoiding stress to the animals, disease risks (zoonoses), and the potential for pollution and degradation of their habitats.

Habitat restoration

Habitat restoration is clearly an essential measure for the muriqui populations residing in small and isolated forest fragments. As mentioned, socio-economic considerations are paramount in this case, besides thorough evaluations of the technical and financial commitments involved, so as to maximize the benefits to both the muriquis and local communities. Studies in the EBC/RPPN-FMA, in Santa Maria de Jetibá, Córrego de Areia and the RPPN Mata do Sossego, have shown that increasing the habitat available, not just by planting and restoration but by providing corridors to neighboring forest patches, is fundamental for the

survival of the muriquis. Ample research and preparation has to be made in each case, however, not just to develop the appropriate reforestation techniques, but taking into account the socio-economic and agropastoral context and vocation of the land and the region.

Integration of results

We suggest that a formal information, data-sharing, network be established among muriqui researchers and the institutions involved (NGOs and universities, for example). This would make the transfer of, and access to, relevant information and data more efficient and agile, and would involve the commitment of researchers and institutions to take on specific roles in compiling, organizing, and synthesizing information for the benefit of all. The first step would be the integration/connection of various specific data banks already existing. A researcher or institution would take on the responsibility for the maintenance of specific sections of the overall data bank — one on the size and demography of muriqui populations, another on ecological data, on genetic data and analyses, on protected areas, and on regional socioeconomics of different muriqui locations, for example. The data can be classified in two distinct groups — one for public access through a web site, and another for limited access by qualified researchers and conservationists, members of a muriqui conservation network.

Institutional Articulation

Any initiative to produce a management strategy for a threatened endemic species must include collaboration and partnerships of the institutions necessarily involved — government, non-governmental organizations, teaching and research institutions, and the private sector. It is necessary to secure the enthusiasm of the local and working communities. Combining forces and expertise, and eliminating duplication of efforts, it is possible to develop an inclusive approach for the protection of the muriqui with a strong scientific underpinning. A significant step was the Population and Habitat Viability Analysis (PHVA) workshop (Rylands *et al*., 1998). The PHVA gave rise to the Committee for the Conservation and Management of the Muriqui (*Comitê para a Conservação e Manejo do Muriqui*), the role of which is to discuss and suggest strategies for *ex situ* and *in situ* conservation of the genus as an advisory body to the Brazilian Institute for the Environment (IBAMA). In 2001, IBAMA created the Center for the Protection of Brazilian Primates (*Centro de Proteção de Primatas Brasileiros*), which also has a most important role in providing for institutional articulation in relation the conservation of the muriqui. The Center's mission is the compilation, management and analysis of relevant information concerning Brazilian primates to enable appropriate decisions on, and measures for, their conservation.

In recent years, numerous non-governmental organizations have been addressing issues and elaborating global and regional conservation strategies, focusing on aspects of landscape ecology and biogeographic patterns for identifying priority areas for the conservation of threatened and restricted range species (Fundação Biodiversitas, 1998; Conservation International do Brasil *et al*., 2000; Brazil, MMA, 2002). A number of NGOs have set up partnerships within the campaign for "Zero Biodiversity Loss", and current conservation initiatives for the northern muriqui provide a good example. They are supported by three subprojects of the Ministry of the Environment's Project for the Conservation and Sustainable Use of Brazilian Biological Diversity (*Projeto de Conservação Sustentável da Diversidade Biológica Brasileira – PROBIO*) coordinated by three NGOs, the Instituto de Pesquisas da Mata Atlântica – IPEMA, the Fundação Biodiversitas, and the Instituto Dríades, in partnership with other NGOs and public and private institutions, all of which have made a commitment to produce a comprehensive action plan for the northern muriqui.

Universities and research institutions have also played a fundamental role in generating information, in capacity building, and in the design and execution of research and conservation projects for the species. Notable is the University of Wisconsin, which, in partnership with the federal universities of Minas Gerais (UFMG) and Espírito Santo (UFES), has been supporting studies of the muriquis at the EBC/RPPN-FMA since 1982; the longest-running of any primate field research program (Strier, 1999, 2005). The muriqui conservation projects are also contributing to progress in training researchers in population genetics and its application to conservation biology. Universities and NGOs are establishing centers for molecular biology as applied to biodiversity conservation within the geographic range of the northern muriqui.

It is important to point out the need for integration between research and *in situ* conservation with *ex situ* conservation measures, as exemplified in the work of the Rio de Janeiro Primate Center (CPRJ/FEEMA). *In situ* conservation initiatives must work together with zoos and other research centers to maintain representative sample collections of the genetic variation of the species *ex situ*, to allow for future interventions in depleted wild populations. Information exchange is fundamental to establish the appropriate partnerships among the zoos, research centers and universities, both in an outside of Brazil. Institutional articulation has too been an essential element of private and public funds for species protection.

Besides the PROBIO of the Ministry of the Environment mentioned above, and the primate conservation projects financed by the Margot Marsh Biodiversity Foundation, there is also the more recent "Program for the Protection of Threatened Species of the Atlantic Forest" (*Programa de Proteção das Espécies Ameaçadas de Extinção da Mata Atlântica Brasileira*), a component of the Critical Ecosystems Partnership Fund (CEPF) for biodiversity conservation in the hotspots that have been identified by Conservation International (Myers *et al*., 2000; Mittermeier *et al*.,

2004) — a partnership of Conservation International, the Global Environment Facility (GEF), the MacArthur Foundation, The World Bank, and the Japanese Government, that promotes alliances among organized communities, NGOs, teaching institutions and the private sector. The threatened species program of the CEPF, coordinated by the Fundação Biodiversitas and Centre for Environmental Research of the Northeast (*Centro de Pesquisas Ambientais do Nordeste*), was created to support projects for the protection and management of threatened species in the Atlantic forest, with initial investments of about US$450,000. The northern muriqui received funding for three projects within the program. Lastly, the Committee for the Conservation and Management of the Muriqui coordinated by IBAMA has already approved the creation of a fund to support the conservation of *Brachyteles*. The fund will be managed by the committee itself, and will strive to obtain both private and institutional donations from Brazil and overseas (Oliveira *et al*. 2005).

We have information sufficient to indicate the measures necessary to maximize the chances of the local and regional persistence of the northern muriqui populations in the Atlantic forest of Bahia, Espírito Santo and Minas Gerais, but this will serve for little if we cannot move forward now and carry them out, combining forces, as we have to, to promote the changes necessary for protection and conservation of the species.

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MURIQUI POPULATIONS REPORTED IN THE LITERATURE OVER THE LAST 40 YEARS

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Abstract

Aguirre (*O mono* Brachyteles arachnoides *(E. Geoffroy). Situação Atual da Espécie no Brasil.* Acad. Brasil. Ciênc., Rio de Janeiro, 1971) identified 61 localities for the occurrence of the muriqui (*Brachyteles arachnoides*) in the states of Bahia, Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo and Paraná. He estimated a total population of 2,791–3,226 muriquis, contrasting with a population of about 400,000 he reckoned would have existed in 1500. Accepting the position that there are two species, Aguirre's (1971) data suggested a maximum of 996 individuals for the northern muriqui (*Brachyteles hypoxanthus*) and about 2,230 for the southern muriqui (*B. arachnoides*). Current population estimates for the northern muriqui have indicated at least 864 individuals in the wild. Data available for the southern muriqui, suggest a minimum population of about 1,300. These numbers combined approximate to the total population of 2,230 estimated by Aguirre (1971). Further population surveys for muriquis in the states São Paulo, Rio de Janeiro and Bahia are urgently needed, along with comparative studies on their basic ecology, diet and behavior in the different-sized forest fragments and the more extensive forests. Although stochastic effects could rapidly eliminate the very small isolated populations of the northern muriqui, in larger forests, persistent threats, such as hunting, could gradually but invidiously reduce those of the southern muriqui.

Key Words – primates, muriqui, *Brachyteles*, population, distribution, conservation, Atlantic forest, Brazil

Introduction

Aguirre (1971) identified 61 localities for the occurrence of the muriqui (*Brachyteles arachnoides*) in the states of Bahia, Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo and Paraná. Twenty-eight of them were based on museum specimens that had precise collection locations. Of these 61 localities, Aguirre (1971) considered that muriquis could still be found in only 30 at the time of his survey: seven in the state of Bahia, seven in Espírito Santo, four in Minas Gerais, six in Rio de Janeiro and six in São Paulo. Aguirre (1971) had no information on any possible remaining populations in Paraná. He estimated a total population of 2,791–3,226 muriquis, contrasting with a population of about 400,000 he reckoned would have existed in 1500. Accepting the position that there are two species (Rylands *et al.*, 2000), Aguirre's (1971) data suggested a maximum of 996 individuals for the northern muriqui (*Brachyteles hypoxanthus*) and about 2,230 for the southern muriqui (*B. arachnoides*).

Approximately 10 years later, Mittermeier *et al.* (1982) revisited some of the areas cited by Aguirre (1971). They were doubtful that *B. hypoxanthus* had survived in two of them, the Rio Doce State Park in Minas Gerais and the Nova Lombardia Biological Reserve in Espírito Santo, and were able to confirm just two populations, those of the Caratinga Biological Station (EBC) (now the Private Natural Heritage Reserve "Feliciano Miguel Abdala" (RPPN-FMA)), in Minas Gerais, and the Fazenda Barreiro Rico, in São Paulo (*B. arachnoides*). The total numbers actually recorded did not exceed 100 individuals (Mittermeier *et al.*, 1982). They failed to locate any new populations. That same year, Kinzey (1982) provided a general review of the Atlantic forest primates, but mentioned no new localities for *Brachyteles*. His study examined particularly primate biogeography in relation to the Pleistocene refuge theory then in vogue, looking at evidence for centers of primate endemism in eastern, south-eastern and southern Brazil (Kinzey, 1982; for a review see Rylands *et al.*, 1996). Alves (1986) found two populations which had not been reported previously; the first a forest in the municipality of Manhuaçu, Minas Gerais, now the Mata do Sossego Private Natural Heritage Reserve (RPPN), with 21 individuals counted, and the second in the Caparaó National Park, where 19 muriquis were seen at the Córrego do Calçado, in the municipality of Ibitirama in Espírito Santo.

On the basis of the accumulating literature on muriquis, Mittermeier *et al.* (1987) estimated a minimum population of 386 (northern and southern forms combined), in 11 localities, all previously cited by Aguirre (1971) except for Cunha State Park in São Paulo, (contributing 16 individuals). The review by Nishimura *et al.* (1988) provided a synthesis of what was then known of the populations and

distribution of the genus. Their population estimate, based on the same sources, was similar — 385.

Rylands *et al*. (1988) identified two places in the Rio Jequitinhonha valley in Minas Gerais and Bahia, where local people reported that muriquis were present until the 1970s or 80s. They indicated further forest patches where local people reported that muriquis could still be found, but they remained unconfirmed. Oliver and Santos (1991), likewise, indicated two localities in the far south of Bahia — the Boca do Córrego, in the municipality of Belmonte, and the Serra da Onça, near Arataca and Jussari — where muriquis might still survive. Oliver and Santos (1991) concluded from their extensive surveys that the muriqui was virtually extinct in Bahia. On the basis of interviews, Mendes (1991), suggested that muriquis could be found in some parts of the mountainous interior of central Espírito Santo, in the region of Domingos Martins (district of Pedra Azul) and Itarana, but reported that a large part of the populations reported by Aguirre (1971) had been lost (Forno Grande State Park, for example). Mendes (1991) also indicated the extinction of muriquis in the Santa Lúcia and São Lourenço biological stations, in the municipality of Santa Teresa, even though both were cited by Aguirre (1971).

Paccagnella (1991) carried out a census of the muriquis in the Carlos Botelho State Park (PECB), in the municipalities of São Miguel Arcanjo, Capão Bonito and Sete Barras. Walking 214 km of trails in the park, Paccagnella (1991) estimated a population of 500 to 800 muriquis, taking into consideration 24,152 ha of the 37,432 ha of the park (about 65% of the PECB) that was believed to provide suitable habitat.

Pinto *et al*. (1993) reported the presence of muriquis in the Augusto Ruschi Biological Reserve (formerly called Nova Lombardia), municipality of Santa Teresa, Espírito Santo, even though in very low numbers) (see Vieira and Mendes, 2005). A year later, Martuscelli *et al*. (1994) indicated 14 new locations for muriquis in São Paulo, Paraná and Rio de Janeiro, noting the first record for an oceanic island, in the Ilha do Cardoso State Park off the coast of São Paulo), where five muriquis were seen on two occasions. Martuscelli *et al.* (1994) made further attempts to find the muriquis there, but considering that hunting on the island has always been intense, and despite the fact that it is now a State Park, they believed the species was already extinct there. Martuscelli *et al*. (1994) summed 303 "new" muriquis in the state of São Paulo, but were unable to see any in Rio de Janeiro, even though they discovered two localities not reported by Aguirre (1971): Bocaina National Park and Cairuçu Environmental Protection Area (APA). Martuscelli *et al*. (1994) also found evidence for the presence of muriquis in two localities in Paraná: Jaguariaíva and Guaraqueçaba Environmental Protection Area (APA). Two muriquis were seen in this latter locality, providing the first register for the state of Paraná. Martuscelli *et al*. (1994) also collected a skull and partial skeleton of a recently hunted animal in Guaraqueçaba.

A number of new records appeared in the years following, most especially of the southern muriqui (*B. arachnoides*). Antonietto and Mendes (1994), for example, saw 15 individuals in the municipal Environmental Protection Area (APA) São Francisco Xavier, in São Paulo. Câmara (1995) obtained an entire skeleton from Itatiaia National Park, Rio de Janeiro), and Oliveira and Manzatti (1996) counted 22 muriquis in the Fazenda São Sebastião do Rio Grande, em Pindamonhangaba, São Paulo.

Strier and Fonseca (1996–1997) re-assessed the numbers of muriquis seen in the wild and counted 19 areas for the occurrence of the two species; eight new areas since the listing Mittermeier *et al*. (1987). Strier and Fonseca (1996–1997) summed 1,158 individuals in all; 234 northern muriquis and 924 southern muriquis — numbers still far lower than were estimated by Aguirre (1971).

Auricchio (1997) found three dead muriquis in the Serra da Escorregosa, municipality of Sertão do Poruba, São Paulo. Auricchio and Silva (2000) subsequently saw a group of at least 10 in the Cubatão section (municipality of Cubatão) of the Serra do Mar State Park. Koehler *et al*. (2002, 2005) recorded eight muriquis in the municipality of Castro, Paraná, later confirmed as part of the only group in the area, totaling 23 individuals (Pereira *et al*., 2005).

In Rio de Janeiro, Garcia and Andrade Filho (2002; Garcia, 2005) counted 17 muriquis, in two groups in the Serra dos Órgãos National Park (municipalities of Teresópolis, Guapimirim, Magé and Petrópolis). They were seen at the highest altitude ever recorded for the species (2,000 m above sea level). Cunha (2003, 2004) again recorded *B. arachnoides* in the park, counting 16 individuals in one group. Romanini-Oliveira *et al*. (2005) also attempted, unsuccessfully, to habituate a group of 20–40 muriquis resident in the Serra dos Orgãos National Park.

In 2006, Macedo (2006) confirmed the record of Câmara (1995) sighting a group of at least 35 adults and 10 juveniles and infants in the Itatiaia National Park, although still unable to ascertain which of the two species they belonged. A skin kept in the Visitor's Center of the park is identifiable as *B. hypoxanthus* (S. L. Mendes, pers. comm.), but this being at the supposed limits of the ranges of both species, further surveys are needed.

It is evident that *B. hypoxanthus* is the more threatened of the two muriquis, even though a number of new populations have been found in recent years. Fontes *et al*. (1996) saw two lone females in a forest fragment in the Ibitipoca State Park, in Lima Duarte, Minas Gerais, one of them in a group howler monkeys (*Alouatta guariba*). The population estimate for *B. hypoxanthus* increased somewhat with its discovery in Santa Maria do Jetibá, Espírito Santo,

Table 1. Locality records for *Brachyteles* registered by Aguirre (1971) and Martuscelli *et al.* (1994), compared with those listed in the review of Strier and Fonseca (1996–1997) and findings in the last decade.

Aguirre (1971)	Marstucelli *et al.* (1994)	Strier and Fonseca (1996–1997)	New localities: 1997 to 2006
Minas Gerais (4) 1. Fazenda Rochedo, Rio Casca 2. Serra do Brigadeiro, Ervália & Carangola 3. Rio Doce State Park, Coronel Fabriciano 4. Fazenda Montes Claros, Caratinga ***Espírito Santo (7)*** 1. Brejetuba, Afonso Cláudio 2. Córrego São Fernando, Domingos Martins 3. Nova Lombardia, Santa Teresa 4. Pico do Tamanco and Pedra Azul, Domingos Martins & Alfredo Chaves 5. Forno Grande, Castelo 6. Jatibocas, Itarana 7. Barra Encoberta, Itarana ***Rio de Janeiro (6)*** 1. Matas Morumbeca, Santa Maria Madalena, São Fidélis & Campos 2. Rio Bonito, Silva Jardim, Cachoeiras de Macacu, Casimiro de Abreu & Friburgo 3. Fazenda do Subaio & Fazenda do Carmo, Cachoeiras de Macacu 4. Serra dos Órgãos National Park, Magé & Teresópolis 5. Itatiaia, Rezende 6. Horto Florestal Mambucaba, Angra dos Reis ***São Paulo (6)*** 1. Fazenda do Veado & Serra da Bocaina, São José do Barreiro & Bananal 2. Alto Paraibuna, Ubatuba, São Luís de Paraitinga & Parati (Rio de Janeiro) 3. Serra Paranapiacaba, Iporanga, Eldorado, Capão Bonito, Sete Barras, Juquiá, Itanhém & others 4. Nascentes dos rios Pardo, Jacupiranga & Serra Negra, Jacupiranga, Barra do Turvo & Guaraqueçaba (Paraná) 5. Dep. Água e Esgoto (DAE), Santos, Mogi das Cruzes & Salesópolis 6. Fazenda Barreiro Rico, Anhembi ***Bahia (7)*** 1. Chapori, Una 2. Córrego Mundo Novo, Pau Brasil 3. Riacho Duas Barras, Caatiba 4. Serra Couro d'Anta, Itapetinga 5. Serra Pateirão, Encruzilhada 6. Serra da Gabiarra, Santa Cruz de Cabrália 7. Farinha Lavada e Água Limpa, Guaratinga & Jucurucu	***Rio de Janeiro (2)*** 1. APA Cairuçu, Parati 2. Bocaina Natinal Park, Parati, São José do Barreiro & Angra dos Reis ***São Paulo (10)*** 1. APA Municipal de São Francisco Xavier, Pindamonhangaba 2. Monganguá Nucleus, Serra do Mar State Park 3. Nucleus Curucutu, Serra do Mar State Park 4. Núcleo Pedro de Toledo/ Itariri, Serra do Mar State Park 5. Jurupará State Park, Ibiúna 6. Ilha do Cardoso State Park, Cananéia 7. Turístico do Alto Ribeira State Park, Iporanga, Apiaí 8. Jacupiranga State Park, Cananéia, Jacupiranga, Barra do Turvo & Eldorado 9. Maciço da Juréia, Juréia-Itatins Ecological Station 10. Maciço Itatins, Juréia-Itatins Ecological Station ***Paraná (2)*** 1. Jaguariaíva, Jaguariaíva 2. APA Guaraqueçaba, Guaraqueçaba	***Minas Gerais (7)*** 1. Ibitipoca State Park[1], Lima Duarte 2. Sossego Private Reserve (RPPN) Simonésia[2] 3. Rio Doce State Park, Marliéria 4. Serra do Brigadeiro State Park, Araponga 5. Feliciano Miguel Abdala Private Reserve (RPPN) (former Caratinga Biological Station – EBC), Caratinga 6. Fazenda Esmeralda, Rio Casca 7. Fazenda Córrego de Areia, Peçanha ***Espírito Santo (2)*** 1. Augusto Ruschi Biological Reserve, Santa Teresa 2. Caparaó National Park[2], Divino de São Lourenço ***São Paulo (10)*** 1. Fazenda São Sebastião do Rio Grande[3], Pindamonhangaba 2. Serra do Mar State Park 3. São Francisco Xavier, Pindamonhangaba 4. Fazenda Barreiro Rico, Anhembi 5. Juréia-Itatins Ecological Station, Iguape 6. Jacupiranga State Park, Cananéia 7. Jurupará State Park, Ibiúna 8. Carlos Botelho State Park, São Miguel Arcanjo 9. Intervales State Park, Capão Bonito 10. Turístico do Alto Ribeira State Park, Iporanga, Apiaí	***Minas Gerais*** 1. Fazenda Duas Barras[4], Santa Maria do Salto 2. Mata Escura Biological Station[4], Jequitinhonha ***Espírito Santo*** 1. Santa Maria do Jetibá[5], Santa Maria do Jetibá ***São Paulo*** 1. Serra da Escorregosa[6], Sertão do Poruba 2. Núcleo Cubatão[7], Serra do Mar State Park ***Paraná*** 1. Castro[8]
30 localities	7 new localities	4 new localities	6 new localities

Obs.: [1] Fontes *et al.* (1996); [2] Alves (1986); [3] Oliveira & Manzatti (1996); [4] Melo *et al.* (2004); [5] Mendes (este volume); [6] Auricchio (1997); [7] Auricchio & Silva (2000); [8] Koehler *et al.* (2002).

where Mendes *et al*. (2005b) found groups in a number of partially isolated forest fragments, 15 in all, with numbers ranging from one to 20 individuals, providing an estimate of at least 115 overall. Recently, Melo *et al*. (2004) located two new populations in the Rio Jequitinhonha valley, one with a minimum of 28 individuals, Mata Escura Biological Reserve, municipality of Jequitinhonha, Minas Gerais, another, with seven individuals in large remnant forest covering the state limits of Minas Gerais and Bahia, in the Fazenda Duas Barras, between Santa Maria do Salto, Minas Gerais and Guaratinga, Bahia. This last is currently the only known population in Bahia (Melo *et al*., 2004).

An intensive survey carried out by Strier *et al*. (2002) in the Feliciano Miguel Abdala Private Reserve (RPPN-FMA) resulted in a population count of 157. More recently, Strier and Boubli (2006) confirmed four groups, totaling 230 muriquis. The occurrence of muriquis in the Fazenda Córrego de Areia in the municipality of Peçanha, Minas Gerais, was reported by Aguirre (1971), but the fate of the population remained unknown (Mittermeier *et al*., 1987) until Hirsch *et al*. (2002) visited the area and counted 13 muriquis there, including some infants.

Mendes *et al*. (2003) identified a group of 12 muriquis in the vicinity of the Ibitipoca State Park, an area known as the Mata dos Luna, in Santa Rita do Ibitipoca, Minas Gerais. This population has been studied by Ferraz *et al*. (2005), who accompanied its decline to just five males. More critical has been the situation of the small group of the Fazenda Esmeralda, Rio Casca Minas Gerais, where Melo *et al.* (2005) found only three individuals remaining. Aguirre (1971) had estimated seven or eight muriquis there, and there were 18 in the group when Lemos de Sá (1991) was studying them in 1986 and 1987. In 2006, only one male remained, who was living with a band of capuchin monkeys (*Cebus nigritus*) (F. R. de Melo, unpublished data).

Further studies in Minas Gerais have allowed for a recount of the key populations of the northern muriqui in three key areas. Dias *et al*. (2005) estimated a minimum of 370 in: the Serra do Brigadeiro State Park, the RPPN Mata do Sossego Private Reserve (RPPN) in Simonésia and, despite the fears of Mittermeier *et al*. (1982), the Rio Doce State Park. Marliéria. Gomes and Melo (2005) have also confirmed the occurrence of at least three groups, a total of 135 individuals, in the Caparaó National Park, all in the part in Espírito Santo.

Conclusions

Current population estimates for the northern muriqui are examined in more detail by Mendes *et al*. (2005a), who have indicated at least 864 individuals in the wild. Data available for the southern muriqui, suggest a minimum population of about 1,300. These numbers combined approximate to the total population of 2,230 estimated by Aguirre (1971). Table 1 compares the populations listed by Aguirre (1971) and Strier and Fonseca (1996–1997) and the most recent information we report here.

Further population surveys for muriquis in the states of São Paulo, Rio de Janeiro, and Bahia are urgently required for a better understanding of the conservation status of the two species. Comparative studies are needed on their basic ecology, diet and behavior in the different-sized forest fragments and more extensive forests, to better understand how they occupy degraded forests and the relation of these aspects, especially diet, to their demography and, hopefully, population growth and stability in protected areas (Talebi *et al*., 2005a, 2005b). Lacking long-term studies of this sort, along with regular population monitoring, it will be difficult to revert the constant threat of imminent extinction that both species faces. They are present in numerous protected areas — national, state and private — that should at least provide some protection from forest loss and hunting. The Carlos Botelho, Serra do Mar and Intervales state parks, in São Paulo, and the Serra do Brigadeiro and Rio Doce state parks in Minas Gerais now hold the largest populations of the two species. Stochastic effects could rapidly eliminate the very small isolated populations of the northern muriqui, and albeit in larger forests, persistent threats, such as hunting, could gradually but invidiously reduce those of the southern muriqui.

Brito and Grelle (2006) have analyzed the northern muriqui populations using the program VORTEX. They concluded that they need areas larger than 11,570 ha to maintain genetic viability. Their results indicated that the majority of the populations are currently too small (even though they are able to persist for some time) to be genetically viable in the long term, due to the inevitable gradual loss of heterozygosity.

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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").

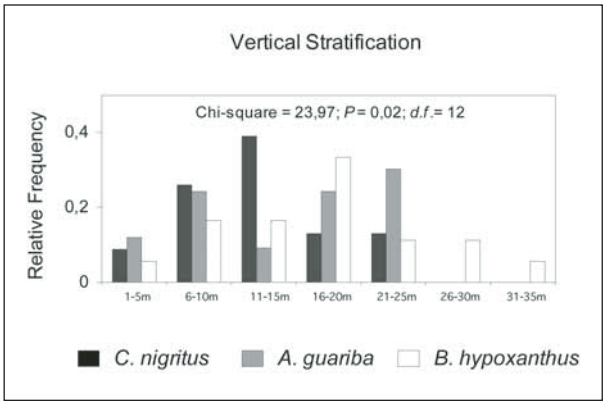

Figure 1. Relative frequencies of sightings of *Cebus nigritus*, *Alouatta guariba*, and *Brachyteles hypoxanthus* at different heights in the forest at EBC. Chi-square values were calculated with absolute numbers and Yates correction. *Callithrix flaviceps* was not included due to the low number of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

Acknowledgments

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CONSERVING THE NORTHERN MURIQUI IN SANTA MARIA DE JETIBÁ, ESPÍRITO SANTO

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Abstract

The northern muriqui is known to occur in only 12 localities, with small populations restricted to isolated forest fragments. In the state of Espírito Santo the species is currently confirmed in only three localities: in and around the Augusto Ruschi Biological Reserve; the Caparaó National Park (which extends into the state of Minas Gerais); and forests in the municipality of Santa Maria de Jetibá. We are studying the muriquis in these last two areas. Both are in the central-southern montane region of the state. In the Caparaó Natoinal Park the aim is to census the population and to estimate its social and demographic composition. The muriquis have been found in part of the 18,200 ha on the Espírito Santo side of the park, and we believe that this population is the largest in the state. In Santa Maria de Jetibá, we hope to improve the prospects for the survival of the muriquis through the following activities: 1) monitoring and managing the populations; 2) studying genetic variability and endogamy; 3) developing a conservation education program, 4) testing the potential for ecotourism; and 5) promoting actions to improve the conservation and restoration of Atlantic Forest fragments. To date, we have found 84 individuals living in 13 fragments, with subpopulations varying from 1 to about 16 individuals. We have information on their presence in another 11 fragments. We have successfully translocated one young female and are monitoring its behavior. The current population and genetic data suggest that we need to improve the forest connectivity in order to reduce the fragmentation and isolation of the muriqui groups. The combined efforts of scientists, government, and the local people will be fundamental to achieve this.

Key Words – primates, muriqui, *Brachyteles*, Atelidae, conservation, Atlantic Forest, Espírito Santo

Introduction

The northern muriqui, *Brachyteles hypoxanthus*, is listed as Critically Endangered on the IUCN Red List of Threatened Species, and by the Brazilian list of animals threatened with extinction (Brazil, MMA, 2003) and is considered to be among the world's 25 most endangered primates (Strier *et al*., 2006). Until recently considered a monotypic genus, *Brachyteles* is treated now as having two species based on differences in the facial pigmentation (spotty and lacking pigmentation in *hypoxanthus* but darkly pigmented in *arachnoides*) and the presence (*hypoxanthus*) or absence (*arachnoides*) of a vestigial thumb (see Vieira, 1944; Lemos de Sá *et al*., 1990, 1993; Leigh and Jungers, 1994). There may also be genetic differences (Pope, 1998).

Prior to the widespread destruction of the eastern Brazilian Atlantic forest that has taken place largely over the last century, the geographical distribution of muriquis was almost continuous, from the state of Bahia to Paraná, including eastern Minas Gerais, Espírito Santo, Rio de Janeiro and São Paulo. It ranged from the coastal hills, to the western limits of the Atlantic forest where it is replaced by the Cerrado or bush savanna of central Brazil. The northern muriqui's range extended from southern Bahia, near to Salvador, to southern Minas Gerais, at least to the Serra da Mantiqueira that accompanies the state border with Rio de Janeiro and São Paulo. It seems that it never occurred in the lowland forests of extreme southern Bahia and northern Espírito Santo (Aguirre, 1971). In Espírito Santo, the historical and current records restrict it to the southern montane forests (Fig. 1).

Hunting and deforestation mean that today the species is known to occur in only 12 localities, with a total population minimum of about 855 individuals. Many of these muriquis are restricted to small isolated forest fragments (Mendes *et al*., 2005). The largest known population has about 200 individuals, and even in the larger fragments, the populations are small. In this paper we present a strategy to conserve the muriqui in the forest fragments of Santa Maria de Jetibá, Espírito Santo, where muriquis can be found in very small fragments. Their survival depends on the cooperation of scientists, government and the local people.

Muriquis in the State of Espírito Santo

We are studying the muriquis in two places in the state of Espírito Santo: the Caparaó National Park and in

the municipality of Santa Maria de Jetibá, both in the central-southern mountainous region. Besides these areas, the muriquis occur also in the Augusto Ruschi Biological Reserve and surrounding forests (Fig. 1; Vieira and Mendes, 2005), and have been reported for a number of other localities that have yet to be confirmed (Mendes and Chiarello, 1993). This mountainous region is characterized by an enormous number of small forest fragments, more or less connected to each other, and surrounded by different forms of land use, creating as such a complex landscape. The project in the Caparaó National Park is just beginning. The aim is to census the population and to estimate its social and demographic composition. The Park encompasses 31,853 ha, straddling the state border with Minas Gerais. The muriquis have been found in part of the 18,200 ha of the park on the Espírito Santo side. The muriqui population there is certainly the largest in the state and is, consequently, the least threatened.

The project in Santa Maria de Jetibá began in 2001 with a preliminary survey that revealed a peculiar situation in which several small muriqui populations live in almost isolated forest patches, relatively close to each other. Considering that all the forest fragments are in a mosaic of private properties, it was evident that the conservation of their muriquis would require a more complex strategy than one of just creating and managing a protected area.

Conserving the Muriquis in Santa Maria de Jetibá

We are carrying out a plan to improve the prospects for the survival of the muriqui that involves five distinct but integrated activities: 1) Monitoring and managing the muriqui populations; 2) studying genetic variability and endogamy; 3) developing a conservation education program; 4) testing the potential for ecotourism; and 5) promoting actions to improve the conservation and restoration of Atlantic Forest.

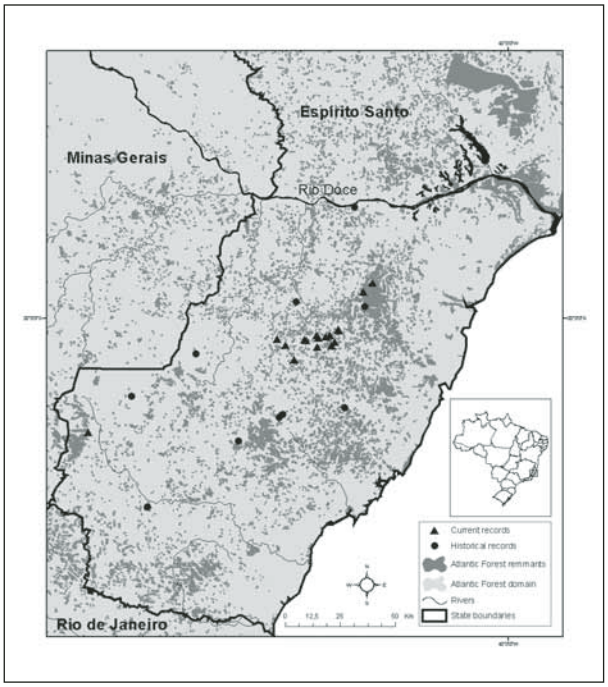

Figure 1. Historical and current records of muriquis in Espírito Santo State.

In our efforts to census and monitor the population, we found 84 individuals, living in 13 fragments, with subpopulations varying from 1 to about 16 individuals (Table 1; Fig. 2). These numbers will tend to increase, not only as we get more information about the presence (or otherwise) of muriquis in 11 other fragments, but also because more intensive censuses are necessary in a number of areas. In general, there is only one social group in each forest fragment, and, sometimes, only a solitary individual. Strier (1996) and Printes and Strier (1999) found that young female muriquis disperse from their natal group to another group where they reproduce. We have observed that although in Santa Maria de Jetibá females leave their natal groups, they become solitary when they reach adulthood, probably because of the lack of opportunities to disperse to other social groups. For this reason, we plan to translocate solitary females to forest fragments where other muriqui groups

Table 1. The muriqui population in Santa Maria de Jetibá, Espírito Santo. The estimated population is based largely on information from local people. The numbers correspond to the localities shown in Figure 2.

#	Locality	Confirmed population	Estimated population
1	Rio Plantoja	05	13
2	Córrego Simão	05	06
3	Rio Lamego	01	01
4	Alto Santa Maria	10	11
5	Alto Rio Posmousser	05	05
6	Córrego do Ouro 1	11	12
7	Córrego do Ouro 2	05	07
8	Rio Claro / Rio Triunfo	03	03
9	Rio das Pedras 2	09	09
10	Rio das Pedras 1	11	11
11	Rio das Pedras / Jequitibá	02	02
12	Jequitibá	01	01
13	São Sebastião de Belém	16	16
-	Rio Sabino	0	01
-	Rio das Pedras / Rio Triunfo	0	01
-	Rio das Pedras 3	0	01
-	Alto Rio Lamego	0	?
-	Rio Claro	0	?
-	Alto Jequitibá	0	?
-	Garrafão	0	?
-	Alto São Sebastão	0	?
-	Rio das Pedras 4	0	?
-	Rio das Pedras 5	0	?
-	Rio das Pedras 6	0	?
	Total	**84**	**100**

live. If this works well, then we can predict that this will be beneficial to the metapopulation as a whole, increasing the reproductive component of the population and promoting gene flow. Our first attempt to capture a solitary female, using darts delivered by an air rifle, has indicated that the task is not easy, however. Having dispersed, the then solitary female was more secretive and shy than when she was a part of our study group, and she avoided the capture team. We reasoned that it might be easier to capture and translocate a female just before her dispersal. In our second attempt, we chose a young female from our study group, estimated to be 6 years old, and in this case we were successful. The female was fitted with a radio collar, and taken to another forest fragment about 10 km away, where there was another muriqui group with only two adult females and four adult males. We are presently monitoring the female to evaluate the effectiveness of this management procedure.

Analyzing the distribution of the muriqui groups in the landscape (Fig. 2), we concluded that we needed a better knowledge of the sizes and shapes and the connectivity of the forest patches, as well as a better understanding of the use of the land surrounding them. We, therefore, selected a core area to take aerial photographs and classify the land use. The analyses demonstrated the complexity of the landscape and showed that the forest fragments remained mainly on the middle-sized hills and higher, while crops and roads dominated the foothills and valleys. We estimated that 36% of the forest fragments in this core study area were surrounded mainly by coffee plantations, followed by pasture, and other crops. There is some connectivity between the fragments where muriquis live, but in some cases the groups are isolated, not only by non-forested areas, but also because the distance is too far to disperse.

Simulating the viability of the populations in nine forest fragments using Vortex (Lacy *et al.*, 1995), we found that that the probability of extinction over the next 100 years was high for the smaller fragments (less 150 ha), but low in the larger ones. The simulation used somewhat optimistic demographic data based on Strier (1994/1995), however, and did not take into account the effects of endogamy and the loss of young females that disperse from their groups. The results did show that the species persistence in such a landscape is mainly determined by the fragment size and connectivity, emphasizing the importance of maintaining a metapopulation system.

To analyze the genetic traits of the muriqui populations we are extracting DNA from their feces. The work is coordinated by V. Fagundes, from the Federal University of Espírito Santo, in collaboration with A. Di Fiori, from

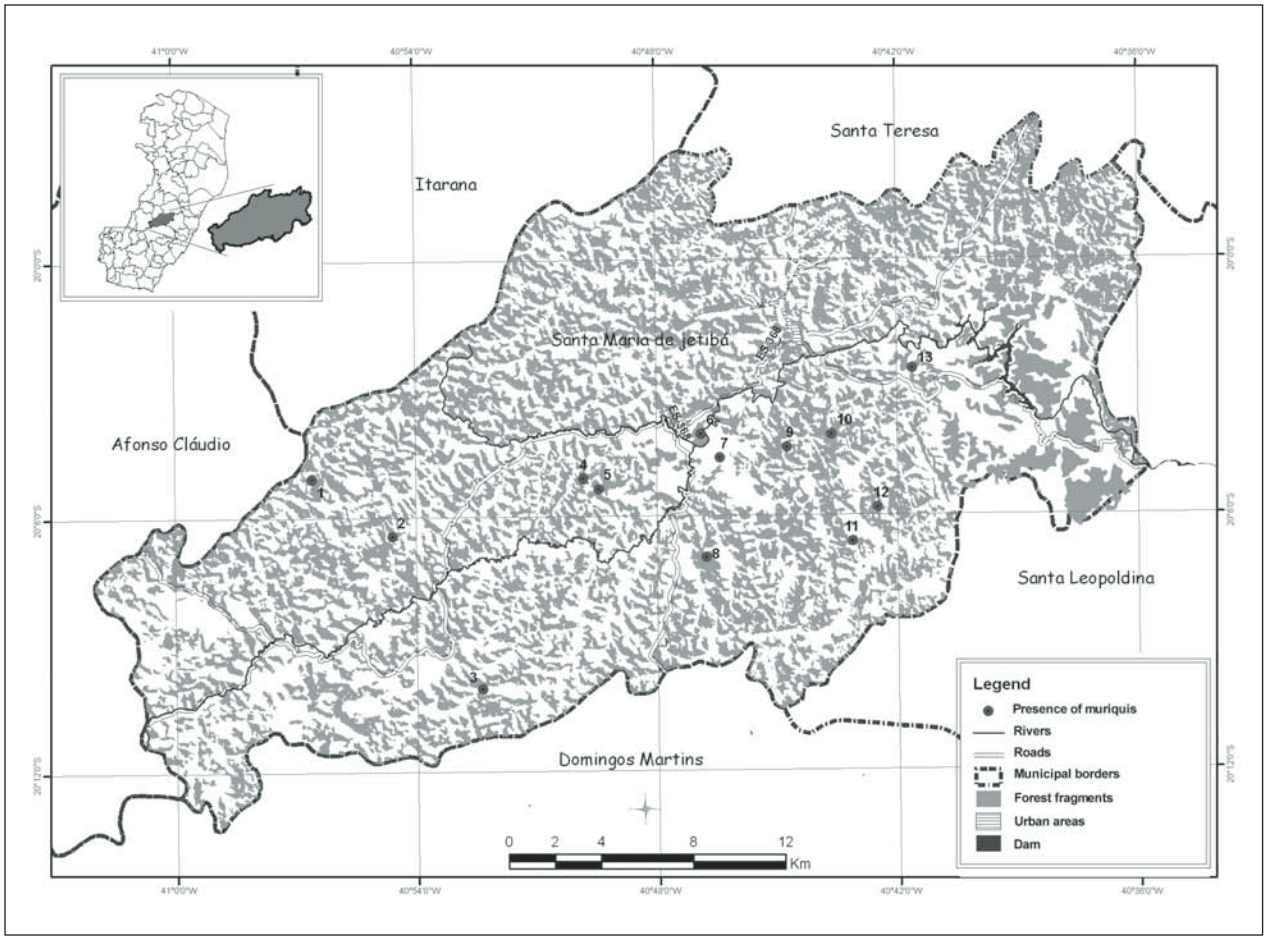

Figure 2. Current records of muriquis in Santa Maria de Jetibá, Espírito Santo. The numbers correspond to the localities listed in Table 1.

New York University. To develop protocols and standardize techniques and make comparisons, we are using feces collected in Santa Maria de Jetibá, as well as feces from of the muriqui population at the Feliciano Miguel Abdala Private Reserve (RPPN) in Caratinga, Minas Gerais, in collaboration with K. B. Strier, J. P. Boubli, and C. Possamai. To date, we have extracted and analyzed DNA from the feces of 20 individuals from Santa Maria and of 126 from Caratinga, and the first data, using mitochondrial DNA, indicates the presence of specific markers between the Santa Maria de Jetibá and Caratinga populations (Fagundes, 2005).

Our project is in a region where the human community is composed of Pomeranian descendants, which migrated from Europe to Brazil about 100 years ago. They usually have holdings farmed by the entire family. Because a single forest fragment is often shared among different farms, we have to deal with numerous people in order to work with muriquis. Fortunately, Pomeranians in general do not have hunting traditions, which may explain the survival of muriquis in such small fragments. We believe that conservation education will help us to study the muriquis, and also to promote actions to conserve and restore the Atlantic Forest in this region.

In addition to working with schools, training teachers and young people, and cooperating with the local government, we are also trying to develop good relationships with the farmers. In order to reach a broader audience, we are using the local radio station to transmit information about muriquis, producing and distributing t-shirts, posters and folders, and presenting the project to different kinds of local and national media. The experimental plan for ecotourism is focusing on the development of a low impact tourism, bringing small tourist groups to see the muriquis and other threatened mammals of interest, such as the brown howler monkeys, titi monkeys, buffy-headed marmosets and maned sloths, which are also easy to see in these forest fragments. We plan to analyze whether this kind of tourism is viable, and whether it can bring advantages to the project and to the local communities. We have prepared a trail for tourists and a guide about the threatened birds and mammals in the region. We are testing an itinerary with volunteers and also establishing setting up a partnership with a travel agency.

The project's main challenge is to conserve and restore the remnant patches of Atlantic Forest, improving the connectivity between the fragments and reducing the risk of extinction. To promote forest conservation we have a middle to long-term goal, which involves actions including: 1) diagnosing the social-economic profile of the region; 2) identifying alternative forms of land use; 3) stimulating local youth to learn techniques to help in combating forest fires; 4) conducting a program of reforestation in public and private areas; 5) proposing the creation of protected areas; and 6) prioritizing partnerships with the local society in the search for solutions. In summary, to conserve the muriqui over the long term in such a fragmented landscape, we need a strategic plan that draws on scientific knowledge and community participation, and promotes the training of personnel, and institutional partnerships, aiming at a broader perspective for biodiversity conservation, that fully considers the socio-economic particularities of the region.

Acknowledgments

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PRESENCE OF THE MURIQUI (*BRACHYTELES HYPOXANTHUS*) IN A RURAL PROPERTY IN THE VICINITY OF THE AUGUSTO RUSCHI BIOLOGICAL RESERVE, SANTA TERESA, ESPÍRITO SANTO

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Abstract

This note reports on three sightings, in 2005, of muriquis in a forest on private land to the north of the Augusto Ruschi Biological Reserve. The forest there is dense montane evergreen forest. The sightings were of four, three and four individuals respectively, one of them including a female with an infant. We emphasize the importance of maintaining forest patches on private land and their role in enhancing the survival of populations of threatened species in small protected areas such as the Augusto Ruschi Biological Reserve.

Key words – muriqui, *Brachyteles*, Augusto Ruschi Biological Reserve, Atlantic forest, Espírito Santo

The occurrence of the muriqui in the montane region of the state of Espírito Santo was documented by Aguirre (1971), who registered their presence in five municipalities, including Santa Teresa, for which he estimated a population of about 150 to 180 individuals in and around the Augusto Ruschi Biological Reserve (originally called Nova Lombardia). Over the last two decades it has been possible to record only about 10 individuals in the biological reserve (Mittermeier *et al*., 1987; Pinto *et al*., 1993), along with unconfirmed reports from park guards of the continued presence of muriquis in a private property just to the north (Mendes and Chiarello, 1993).

The Augusto Ruschi Biological Reserve is a federal protected area of 3,573 ha of dense montane evergreen forest. The relief is of steep mountain slopes and valleys at altitudes ranging from 780 to 1,050 m (IPEMA, 2005). About 280 families live in the vicinity, their livelihoods dependant on plantations of coffee, banana, and eucalyptus. There are a number of forest patches on these private properties. Many of them, of small to medium size, are still well preserved and extend to the biological reserve, and are important as such for the conservation of the local wildlife.

In this note we report on the occurrence of *Brachyteles hypoxanthus* in a forest on private land to the north of the Augusto Ruschi Biological Reserve. They were seen three times on a forested slope on the property of Sr. Nelson Furlani, in a location called Alto Santo Antônio. The forest there has a number of small streams which converge to form a waterfall, the Cachoeira do Stork, flowing into the Rio Lombardia, one of the main tributaries of the Rio Piraquê-Açu. The sightings of the muriquis were all within two kilometers of the coordinates 19º49'S and 40º32'W (Fig. 1).

The first time they were seen was in the afternoon of 17 February 2005, during fieldwork for the project "Planning Sustainable Landscapes in the Central Corridor of the Atlantic Forest" (*Planejando Paisagens Sustentáveis no Corredor Central da Mata Atlântica*). They were on a slope leading to a forested valley bottom. An individual was heard calling and four muriquis were then seen in the canopy at around 15 m. They remained there for four minutes before they saw the observers and fled to the top of the hill where the forest was denser. The second record was in the morning of 19 February 2005, about 300 m from where they had been seen two days earlier, in a tree of about 17 m. On this occasion, it was possible to identify a male, a female with an infant, and two others. The male was very agitated giving alarm calls, and rapidly moved away (A. C. Cornélio, pers. comm.). The third occasion was in the morning of 25 August 2005 during a bird census. A group of three individuals was spotted in the canopy of a tree on the slope across a small valley. They continued feeding quietly, apparently unworried by the presence of the observers.

The local farmers reported seeing these muriquis quite frequently, always in small groups of three or four, feeding and moving through the trees along the mountain slopes. Two of our sightings were documented: the first with a tape recording of the alarm call ("mpg" file), and the third by photographs. The photographs and the mpg file are in the possession of the first author. These records emphasize the importance of conserving the forest patches on the private lands around the Augusto Ruschi Biological Reserve.

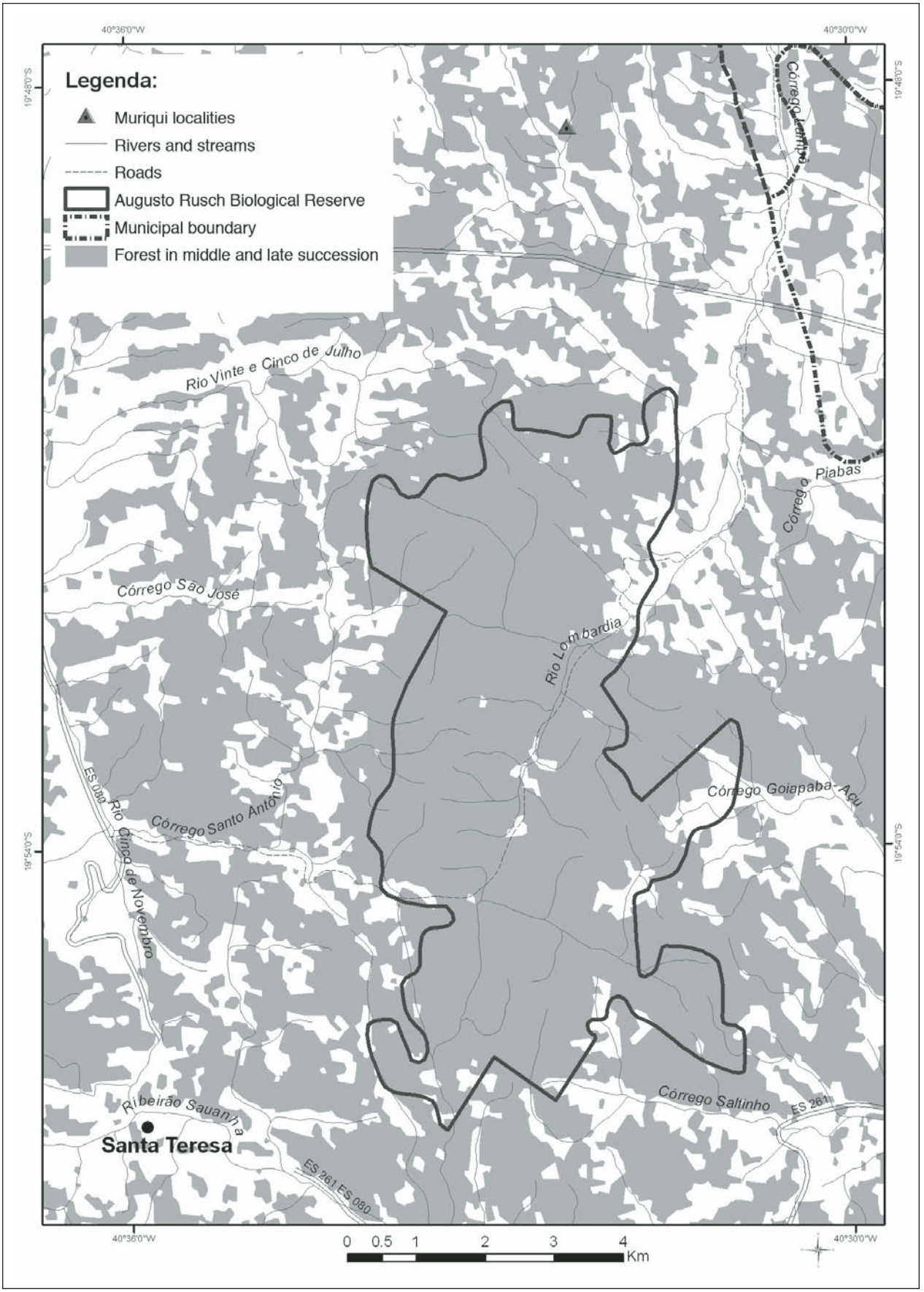

Figure 1. Location of the records of muriquis (*Brachyteles hypoxanthus*) to the north of the Augusto Ruschi Biological Reserve, Santa Teresa, Espírito Santo.

They evidently serve as refuges for remnant populations of threatened species such as the muriqui, and contribute significantly to the conservation potential of such relatively small reserves as that of Augusto Ruschi. Maintaining and increasing the connectivity of these forest patches, especially with the larger forest of the biological reserve, is vital to avoid the isolation of their populations and their inevitable resulting extirpation. The discovery of these muriquis also underlines the need to carry out research and wildlife surveys on private lands as a complementary strategy to the creation of public protected areas.

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REPRODUCTIVE BIOLOGY AND CONSERVATION OF MURIQUIS

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Abstract

This paper summarizes some of the major findings on the reproductive biology of one group of northern muriquis (*Brachyteles hypoxanthus*) at the RPPN Feliciano Miguel Abdala (previously known as the Estação Biológica de Caratinga). Long-term monitoring of individual members of the Matão group, combined with non-invasive fecal sampling to measure hormone levels, provide insights into ovarian function, reproductive seasonality, and factors that influence individual and population reproductive rates. All of these parameters have direct applications for assessing the long-term viability of this population, and for conservation of this critically endangered species. These findings were presented at the first meeting of the Committee for the Conservation and Management of the Muriqui (IBAMA), held in Teresópolis, Rio de Janeiro, in October 2002; more recent data have been added or are included in the references.

Key Words – primates, *Brachyteles*, reproductive biology, conservation

Introduction

Systematic research on muriquis at the Estação Biológica de Caratinga (EBC) in Minas Gerais, Brazil, has been underway since 1982. The goals of the long-term project have always been two-fold: i) To collect basic data on the behavior, ecology, and reproduction of muriquis for the development of informed conservation efforts on their behalf; and ii) to train Brazilian students in methods of non-invasive field research and its applications to conservation (Strier, 1999). Publications generated from this research through 1997 are included in the PHVA Briefing Book (Rylands *et al.*, 1998). A list of publications from the project from 1998 to the present can be obtained from the author. A list of the students who have participated in the field study of the Matão group from its onset is provided in the Appendix.

In 2001, the forest was officially transformed into a protected reserve, now known as the RPPN Feliciano Miguel Abdala (RPPN-FMA). The muriquis there are now considered a species distinct from populations to the south: *Brachyteles hypoxanthus* (Kuhl, 1820) is the northern muriqui of Minas Gerais and Espírito Santo, and *B. arachnoides* (É. Geoffroy, 1806) is the southern muriqui, occurring in the states of Rio de Janeiro, São Paulo and Paraná.

Northern muriquis have been ranked among the World's 25 Most Critically Endangered primates (Strier *et al.*, 2006a), and the population at the RPPN-FMA is one of the largest populations known (Strier *et al.*, 2002, 2006b). The Muriqui Project of Caratinga has documented the remarkable recovery of this population, which has nearly quadrupled in size to more than 226 individuals over the past 23 years (Strier *et al.*, 2006b). Demographic data obtained from the Matão group provided the basis for the first Population Viability Analysis (PVA) (Strier, 1993/94), and the subsequent Population and Habitat Viability Analysis (PHVA) Workshop on Muriquis in May 1998 (Rylands *et al.*, 1998).

The success of the RPPN-FMA muriquis to date can be attributed to the low mortality and female-biased infant sex ratio documented in the main study group (the Matão group), which increased in size from 22 to 84 individuals from July 1982 to October 2005. Here, I summarize new findings on the reproductive biology and demography of the Matão group, and discuss their implications for the conservation of the northern muriquis at the RPPN-FMA.

Reproductive Biology

Typically, females in this population transfer out of their natal groups when about six years old (prior to becoming sexually active), and give birth to their first infants at about nine years old (Strier and Ziegler, 2000). Births are concentrated during the dry season months, from May to October, with a peak from June to August (Strier *et al.*, 2001). Females begin to wean their infants some 12–24 months post-partum, and resume sexual activity during their infants' second year of life. The annual mating season usually begins at the end of the dry season to early rainy season, and the median interbirth interval is three years when infants survive to weaning age. Extrapolating from what we now know to be the age at first reproduction in females at the RPPN-FMA, females that were carrying infants in 1982 are now estimated to be more than 30 years old. They are still sexually, and in most cases reproductively, active.

Results from non-invasive fecal steroid analyses have provided additional insights into the reproductive biology of wild female and male muriquis (Strier and Ziegler, 1994, 1997, 2000, 2005a; Strier *et al.*, 1999, 2003; Ziegler *et al.*, 1997). Specifically:

- The seasonal onset of copulations coincides with the onset of female ovarian cycling. Intervals between periovulatory periods average 21.0 ± 5.4 days (n = 7), and females experience from 2–7 ovarian cycles prior to their conception cycles.
- Gestation length averages 216.4 ± 1.5 days, or 7.2 months (n = 5).
- Females disperse from their natal groups prior to the onset of puberty. The onset of sexual activity in their new group coincides with the onset of their ovarian cycles.
- Inexperienced females do not conceive before their second mating season.
- There is no evidence of seasonal fluctuations in male testosterone levels, despite the seasonal concentration of copulations, conceptions, and births.
- Cortisol levels in males, but not females, exhibit seasonal elevations that coincide with the conception season.
- Females appear to require minimum levels of estradiol to resume post-partum cycling and to conceive.

Fecal steroid analyses are time-consuming and costly, and numerous samples from specific, recognized individuals have been necessary to yield meaningful results to address the kinds of questions we have examined in muriquis (Strier and Ziegler, 2005b). Nonetheless, they emphasize the importance of hormonal data to the accurate interpretation of behavioral observations. For example, we now know that females frequently copulate during the intervals between their ovulations when conceptions are unlikely to occur. Thus, although observations of mating behavior may be a reliable indicator of the onset of ovarian cycling at the onset of the mating season, they do not necessarily coincide with ovulation over the duration of the mating season. Moreover, although all of the oldest females in our study group still cycle and copulate, two of them appear to be experiencing reduced fertility similar to that of inexperienced females during their first mating seasons. This indicates the importance of considering female age and reproductive history when evaluating variance in female muriqui fecundity from behavioral observations alone.

Demography of the Matão Group

Despite the late age at which female muriquis reproduce and their relatively slow (3-year) rate of reproduction, the Matão group has increased steadily in size (Fig. 1). This increase can be attributed primarily to their low mortality rates relative to birth rates.

Mortality has been low for all age-classes, but particularly among infants, immature males and adult females. Until recently, 94% of all infants survived their first 12 months of life (Strier *et al.*, 2001), but in recent years first-year survival has dropped in this group (Strier *et al.*, 2006b). Two 13-month-old infants (1 male, 1 female) are suspected to have died due to predation (Printes *et al.*, 1996).

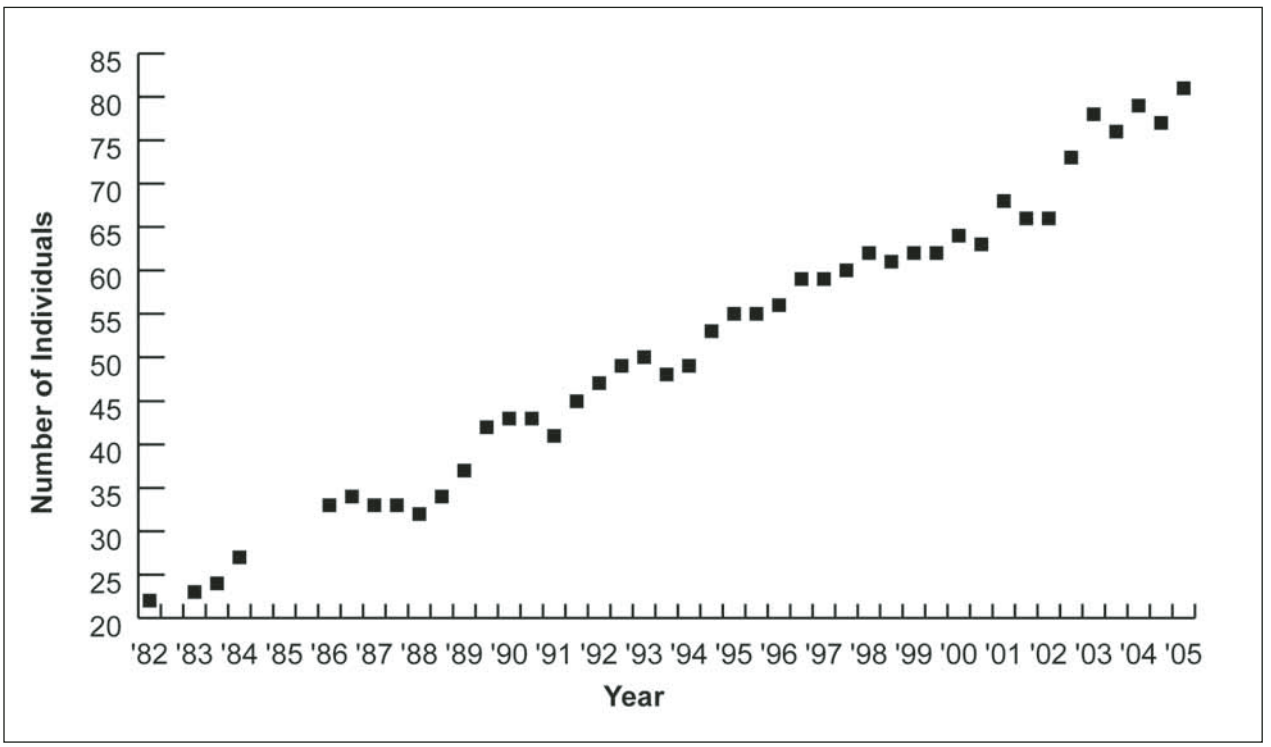

Figure 1. The Matão study group, RPPN-Feliciano Miguel Abdala, Caratinga, Minas Gerais. Growth in size from July 1982 to 2005.

All of the males born since 1982 that have survived to 3 years of age are still alive and present in their natal group. Survival rates of immature females are more difficult to document because only three of the natal females that survived to six years of age have remained and reproduced in this group (Strier *et al*., 2006b; updated from Martins and Strier, 2004). Data on female survivorship after dispersing from the Matão group are limited for females that dispersed prior to 1994. However, 17 of the 22 natal Matão females that dispersed between 1994 and 2004 have been confirmed in their new groups, and 16 of these 17 females are still alive as of October 2005 (Strier *et al*., 2006b). Ages at first birth are now known for six of these females, and are consistent with those estimated for females that immigrated into the Matão group (Strier *et al*., 2006b, updated from Strier *et al*., 2002).

Seven of the eight adult females present in 1982 are still alive. By contrast, all of the six adult males and both of the old juvenile/subadult males present in 1982 have died, with the longest surviving of these adult males dying in September 2005.

The number of female immigrations into the Matão group matched or exceeded that of Matão emigrants until 1993. Since then, however, female emigrations have outpaced immigrations (Fig. 2).

There are a number of possible explanations for this phenomenon, each of which requires close and continuous monitoring of infant and immature females in the entire population. For example, the higher emigrant-to-immigrant ratio for the Matão group might reflect a high mortality rate (~43%) characteristic of dispersing females. To evaluate whether this is the case, we need to monitor all females that disperse from their natal groups to determine whether they succeed in joining another group, or die during the process of dispersing. Alternatively, it could reflect differences in infant sex ratios and survivorship in different groups. The high emigrant-to-immigrant ratio would then be a product of the disproportionate number of females born and surviving in the Matão group relative to other groups in the forest. It will be important to document the long-term survivorship of Matão emigrants, including those that are confirmed to have joined new groups. Until recently, the Matão group appeared to be a "source" of females in this population, but it was not possible to determine whether natal Matão females were dispersing into a "sink." We now know that a disproportionate number of dispersing females from other natal groups prefer to transfer into the Matão group, and that most recent Matão emigrants survive and reproduce in their new groups (Strier *et al*., 2006b).

One of the strongest results to emerge from the long-term demographic data is the female-biased infant sex ratio that has characterized the Matão group since the onset of the study (Strier, 2000). A total of 118 infants have been born from June 1982 to October 2005, of which 114 have been sexed. Of these 114 infants, 65, or 55.26%, were female. The number of females born was equal to or greater than the number of males born in most of the annual birth cohorts until 2000, when this female-bias in infant sex ratios began to reverse (Fig. 3).

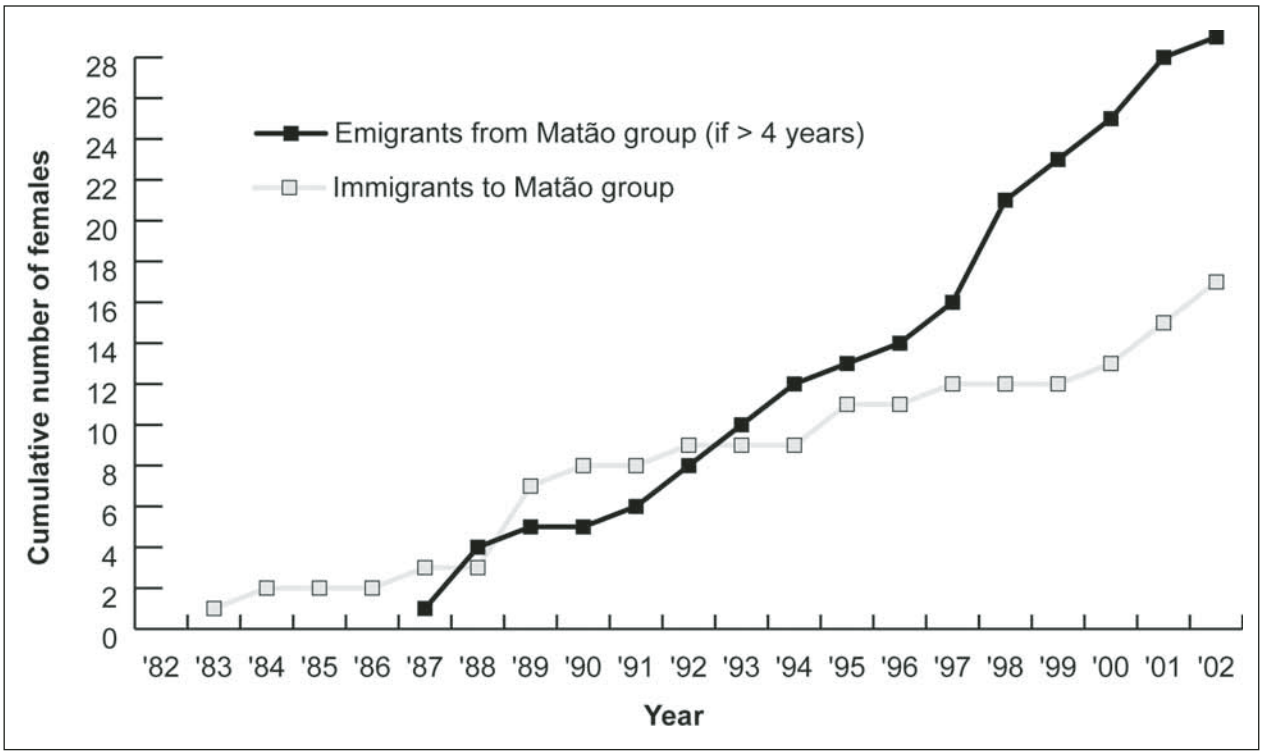

Figure 2. Dispersal patterns of females, Matão study group, RPPN-Feliciano Miguel Abdala, Caratinga, Minas Gerais. 1982–2002.

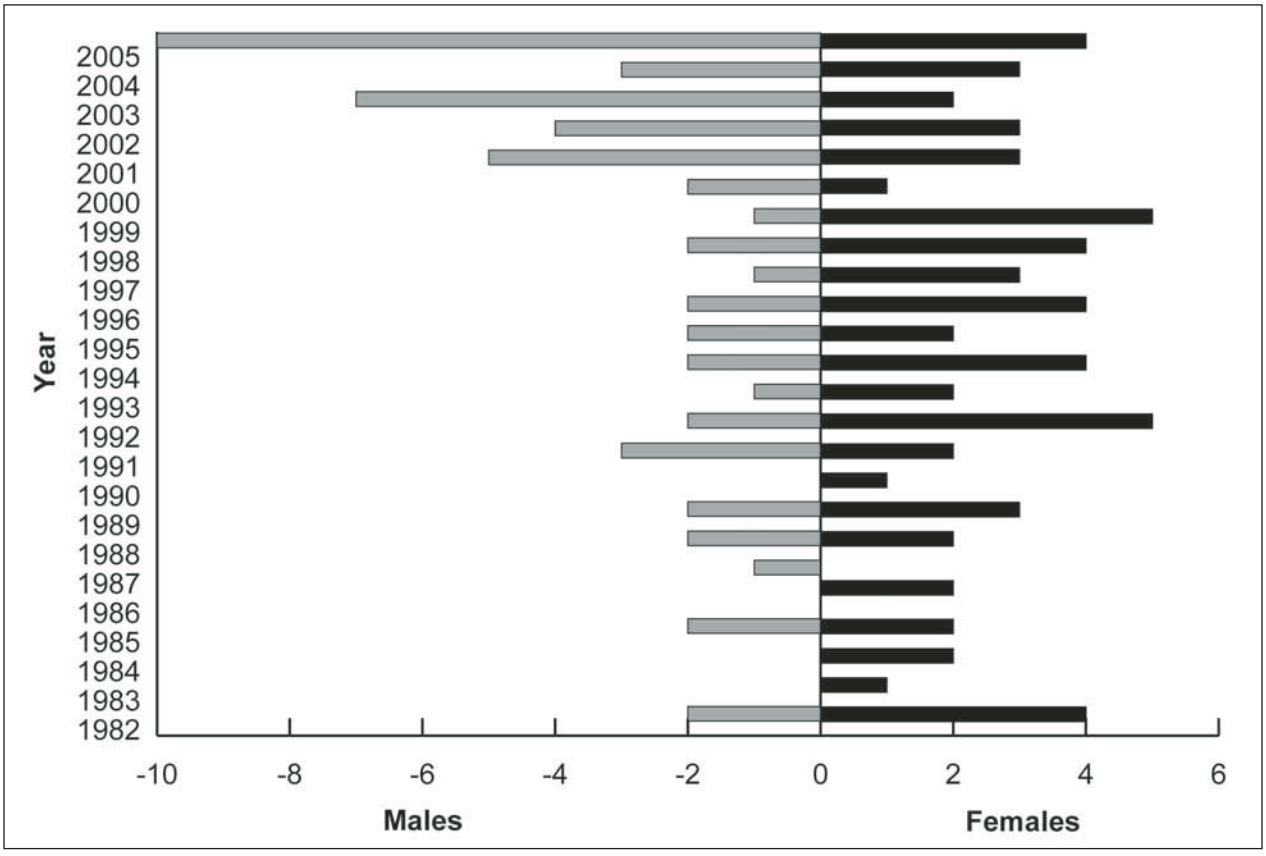

Figure 3. Sex by birth cohort in the Matão Group, RPPN-Feliciano Miguel Abdala, Caratinga, Minas Gerais. 1982–2005.

It is too soon to evaluate whether this recent shift from female to male-biased infant sex ratios will persist over time. Nonetheless, if this trend continues, it will have a dampening effect on the RPPN-FMA muriquis' population growth (Strier *et al.*, 2006b). This effect will not be evident for another 10 years or so, when females from these birth cohorts begin to reproduce, as the PVA analyses indicated (Strier, 1993/94). Nonetheless, it may be an early indication that this population is beginning to stabilize.

Monitoring the behavioral changes that accompany changes in the demography of the RPPN-FMA muriquis is now a priority for our ongoing research on the Matão group (for example, Dias and Strier, 2003). The demographic database is particularly important to maintain, not only for the insights on infant sex ratios and survivorship, but also because of the indications of declining fertility among some of the oldest females (>30 years) in this group. At the same time, understanding the ecological variables that contribute to the carrying capacity of the forest at the RPPN-FMA is a priority of the recent collaborative project initiated on the Jaó group in 2001 (Strier and Boubli, 2006).

The long-term viability of the RPPN-FMA muriquis is critical to the future survival of this species. Our ongoing studies here will continue to provide valuable insights into the reproductive ecology and population demography of this vital population.

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Appendix

Student participation in the Muriqui Project of Caratinga, Matão Project. Strier and Boubli (2006) provide a list of all student participants in muriqui research at the RPPN-FMA through 2005.

2005–2006	Fernanda Tabacow (Bachelors from Universidade Federal de Espírito Santo)
2005–2006	Maíra de Loucenço Assunção (Undergraduate at Pontifícia Universidade Católica de Minas Gerais)
2004–2005	Janaina Fidelis de Oliveira (Undergraduate at Pontifícia Universidade Católica de Minas Gerais)
2004–2005	Danusa Guedes (Bachelors from Pontifícia Universidade Católica de Minas Gerais)
2003–2004	Karynna T. de Souza (Bachelors from Pontifícia Universidade Católica do Paraná; currently MA student)
2003–2004	Vagner de Souza (Bachelors from Universidade Federal de Espírito Santo; currently MA student)
2002–2003	Fernanda P. Paim (Bachelors from Universidade do Vale do Rio dos Sinos, Rio Grande de Sul)
2002–2003	Maria Fernanda F. F. Iurck (Bachelors from Pontifícia Universidade Católica do Paraná)
2001–2003	Carla de Borba Possamai (Bachelors from Pontifícia Universidade Católica do Paraná; currently MA student)
2001–2002	Regiane Romanini de Oliviera (Bachelors from Universidade Federal de Viçosa; currently MA student)
2000–2001	José Cassimiro da Silva Júnior (Bachelors from Universidade Federal de Minas Gerais)
1999–2001	Waldney P. Martins (Bachelors from Universidade Federal de Minas Gerais, currently MA student)
1999–2001	Vanessa O. Guimarães (Bachelors from Universidade Gama Filho, Rio de Janeiro)
1998–1999	Luiz Gustavo Dias (Bachelors and Masters from Universidade Federal de Minas Gerais)
1998–1999	Cristiane C. Coelho (Bachelors and Masters from Pontifícia Universidade Catolica de Minas Gerais)
1998–1999	Cláudio P. Nogueira (Doctorate from Universidade Federal de Minas Gerais)
1997–1998	Dennison Carvalho (Bachelors from Universidade Federal de Minas Gerais)
1997–1998	Nilcemar Bejar (Bachelors from Universidade Federal de Minas Gerais)
1996–1997	Andréia Silene de Oliveira (Bachelors from Faculdades Metodistas Integradas Izabela Hendrix, Belo Horizonte)
1996–1997	Laiena T. Dib (Masters from Universidade Federal de Minas Gerais)
1995–1996	Cláudia G. Costa (Masters from Universidade Federal de Pará)
1994–1996	William A. Teixeira (Bachelors from Pontifícia Universidade Católica de Minas Gerais)
1994–1995	Maria Amélia F. Maciel (Bachelors from Universidade Federal de Viçosa)
1994–1995	Rodrigo Cambará Printes (Bachelors from Universidade Federal de Rio Grande de Sul; Masters from Universidade Federal de Minas Gerais, currently PhD student)
1993–1994	Sebastião da Silva Ramos Neto (Bachelors from Universidade Federal de Viçosa)
1993–1994	Adriana Odália Rímoli (Doctorate from Universidade de São Paulo)
1992–1994	Lúcio P. de Oliveira (Bachelors from Universidade Federal de Juiz de Fora)
1992–1994	Cláudio P. Nogueira (Masters from Universidade de Guarulhos)
1992–1993	Ana Rosa Dias de Carvalho (Bachelors from Universidade de Taubaté)
1991–1992	Paulo Coutinho (Universidade Federal de Pará, Masters earned)
1991–1992	Fernanda Neri (Universidade Federal de Minas Gerais, Masters earned)
1990–1991	Francisco D. Mendes (Doctorate from Universidade de São Paulo)
1987–1990	José Rímoli (Masters from Universidade de São Paulo)
1989–1990	Adriana Odalia Rímoli (Masters from Universidade de São Paulo)
1986–1987	Francisco D. Mendes (Masters from Universidade de São Paulo)
1983–1984	Eduardo M. V. Veado (Bachelors from Universidade Federal de Minas Gerais)

THE CARATINGA ALLIANCE: COMMUNITY-BASED CONSERVATION EFFORTS TO INCREASE FOREST FOR THE MURIQUIS AND WATER FOR THE FARMERS

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Abstract

The northern muriqui is Critically Endangered. About 25% of the known population lives in the 1,200 ha of secondary forests of the Caratinga Biological Station (EBC) Feliciano Miguel Abdala Private Natural Heritage Reserve (RPPN-FMA) and neighboring farms. Long-term survival of the muriquis there depends on an increase in the availability of suitable habitat. Widespread deforestation has depleted soil fertility and dried up the streams in the region. Community-based conservation actions were carried out: 1) to protect and restore degraded areas to increase the availability of forests for the muriquis, and 2) to implement reforestation to improve the water balance vital for the regional recovery of rural production. Rural extension courses were provided for the local communities, which introduced modern production techniques to increase efficiency while decreasing environmental impacts. A new plant nursery was built and a pilot project to test forest restoration techniques was initiated.

Key Words – northern muriqui, *Brachyteles hypoxanthus*, community-based conservation, restoration of degraded areas, rural capacity-building, Atlantic forest

Introduction

Socio-environmental panorama

The once-continuous Atlantic Forest in the east of the state of Minas Gerais, is now extremely fragmented. Coffee drove the conversion of enormous tracts of semi-deciduous forests, with extremely high socio-environmental costs (Dean, 1995). The northern muriqui (*Brachyteles hypoxanthus*) was one of many that suffered. It is now considered one of the 25 most endangered primates in the world (Strier *et al*., 2006a). Today, more than 230 northern muriquis, or 25% of the known population, inhabit an island of about 1200 ha of secondary forest at the Estação Biológica de Caratinga / Reserva Particular de Patrimônio Natural Feliciano Miguel Abdala (EBC/RPPN-FMA) and neighboring farms. The long-term survival of this population depends on increasing the area of forest available for the muriquis (Strier, 1993–1994).

Widespread deforestation and obsolete agricultural techniques have depleted soil fertility in the region and severely reduced the availability of water in the streams that run through the neighboring farms of the EBC/RPPN-FMA. Numerous people have become aware of this; most of them practicing family-based agriculture of coffee, corn, sugar cane, rice and beans. Cattle-ranching is also a common activity in the region. With soils depleted of their nutrients, farmers turn to milk production for some income. The extensive ranching, in turn, contributes to the compacting and erosion of the remaining land that could otherwise be used for agriculture if correctly managed (IDEA, 1996).

Traditionally, the forest has been seen as an almost infinite source of timber, firewood, and game but, most importantly, as something to get rid of in order to initiate any 'real' economic activity. Deforestation was seen as the essential first step in 'developing' an area, and for centuries, the revenues provided by ecosystem services were almost entirely neglected by most of the local farmers and land owners. Today, the more aware recognize soil fertility, water maintenance and pest control as some of the most useful ecosystem services, now lost due to deforestation. Although some conservation-oriented perceptions are shared by many local people, neither muriquis nor their conservation are considered a top-priority (Bueno, 2005).

As is typical of human nature, an environmental crisis is necessary before people can perceive that, instead of an obstacle, the forest can be helpful for maintaining rural production. Understanding the socio-economic and environmental contexts that influence the local communities, their lives and perspectives is essential prior to proposing any practical solutions that could reverse this dramatic panorama. Encouraging the adoption of more

sustainable-oriented production techniques may require above all a demonstration of its practicality: "seeing is believing" (Goodwin, 1998; Twyman, 2000).

Initial conservation efforts

Karen Strier's research on the northern muriqui at the EBC/RPPN-FMA began in the early 1980's (Strier, 1999). The initial focus was centered on their ecology and behavior, but was gradually expanded to encompass a much wider perspective on the conservation needs of the muriqui population and the forest remnants (Strier, 1999; Strier and Boubli, 2006; Strier *et al.*, 2006b). In 1988, the first local environmental NGO, *Associação Pró-Estação Biológica de Caratinga* (ApEBC), was created and became involved in a number of conservation projects and initiatives. In 1994, the ApEBC initiated its first contacts with the local communities, and worked with the *Instituto de Ecodesenvolvimento Agrícola* (IDEA) to conduct the first socio-environmental diagnosis in the region surrounding the EBC/RPPN-FMA. At the same time, ApEBC built a nursery to produce seedlings of native species to be used for the recuperation of degraded areas in the EBC/RPPN-FMA. In 2001, as an honor to the late conservationist and patriarch, Feliciano Miguel Abdala, his family decided to turn the 957-ha forest of the Fazenda Montes Claros into a Private Natural Heritage Reserve (RPPN), an officially recognized category of protected area in Brazil. A three-year floristic inventory and phenology study was begun in 2002, which served to demonstrate the botanical and ecological importance of the muriqui's forest habitat (Boubli *et al.*, 2003). In 2002, the *Sociedade para a Preservação do Muriqui* (SPM) was founded to manage the EBC/RPPN-FMA and propose other conservation projects to protect the northern muriqui and restore its local habitat.

Muriqui Conservation Project

In mid-2003, we invited the then Director of the ApEBC, the late Eduardo Veado, to collaborate on a proposal for a comprehensive conservation project. Eduardo contributed with the concepts of fencing the RPPN to protect the forest from cattle invasions and of developing a new nursery to produce seedlings for the restoration of degraded areas. The proposal was approved as a PROBIO/Brazilian Ministry of the Environment/GEF project entitled Muriqui Conservation (MC). The project created a network of partnerships that included ApEBC, SPM, Conservation International's regional Brazil office (CI–Brazil), the Instituto Dríades, the Caratinga city council, and the National Rural Extension Service (*Serviço Nacional de Aprendizagem Rural – SENAR-MG*), among others. Synthesizing current information on the muriquis, and the plans and measures for their conservation in Caratinga, it resulted in a proposal for community-based, grass-roots development that should work towards the common goals of both scientists/conservationists and farmers (Pontual *et al.*, 2005).

The Muriqui Conservation project had four components: 1) a macroecological synthesis of the genus *Brachyteles*; 2) an in-depth study of muriqui ecology; 3) the development of a community-based conservation action plan; and 4) a pilot project for the recuperation of degraded areas. In this paper, we present the preliminary results and future perspectives of the socio-environmental activities initiated or expanded in February 2004.

Methods

Conceptual tripod

Although the Muriqui Conservation project was based on the experiences and knowledge gathered throughout the past two decades of conservation efforts in Caratinga, a new approach to the socio-environmental problems was proposed. This has been the adoption of three conceptual tenets upon which all our initiatives were based: 1) the need for the definition of common goals; 2) for ground-up development; and 3) for collaborative group efforts (*mutirão*). The common goals were the recuperation of degraded areas to increase the availability of habitat for the muriquis and the need improve the regional water balance to support rural production. We began with free extension courses to improve rural production efficiency. Members of the local communities volunteered their support as partners in the project. Decisions were made by consensus together with the landowners involved.

Community mobilization

We initiated community mobilization by inviting the EBC/RPPN-FMA neighbors to attend free rural extension courses (Fig. 1). The courses were conducted by the Rural Extension Service (SENAR-MG), a private, rural capacity-building institution sponsored by the state of Minas Gerais Agriculture Federation, an increasingly important partner of MC. The course instructors were skilled, retired University professors that taught theoretical and practical classes totaling 40 hours per course. All students had to achieve high standards of understanding and hands-on technical abilities to be awarded the certificate for the course. Although such courses are usually offered to farmers that live closer to urban centers, our project was able to make these courses available to the isolated communities surrounding the reserve.

The MC mobilization team consisted of two local people, Antônio Bragança and Janaína Mendonça, both communicative and already well known in all the communities. The first reactions were a little skeptical but, after the first extension course was concluded, the picture changed and many participants volunteered for the following courses. The MC team designed practical exercises during the courses to show the farmers the advantages of recuperating degraded areas in protecting springs and restoring fertility to the soils. The idea was to show how habitat recovery had a direct effect on water availability, soil fertility and pest control.

Recuperation of degraded areas

The recuperation of degraded areas involved four lines of action: 1) fencing off springs and forest remnants to prevent the entry of cattle; 2) building a new plant nursery; 3) transplanting seedlings to enrich degraded areas; and 4) conducting a pilot experiment to test recuperation techniques. Fences were built with chemically treated, autoclaved, 2.2-m eucalyptus stakes, using 250 stakes/km with four lines of galvanized, smooth wire. A circle of a minimum of 40 m diameter was fenced off around the springs to

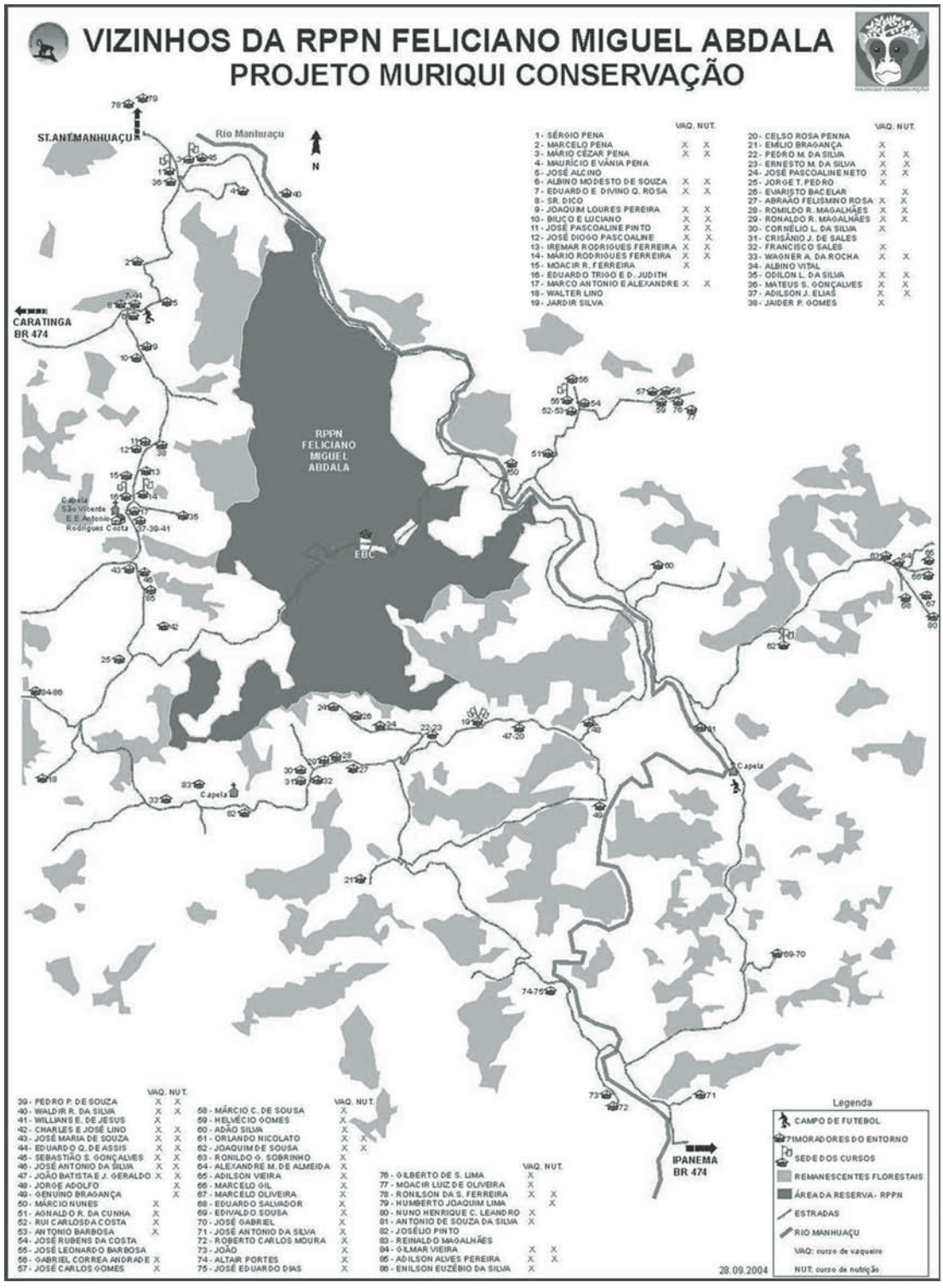

Figure 1. Map of the RPPN-FMA and its neighbors (Eduardo M. Veado, ApEBC).

protect them. The new nursery was built in an enclosure of 75 × 85 m, using gravity powered water aspersers, and natural sunlight with the appropriate shade, and fertilizer NPK 04-14-08. The estimated production was 80,000 seedlings/year. Seedlings to enrich degraded areas were planted with a 3 × 3-m spacing, using 40 × 40 × 40 cm pits prepared with 18 liters of cattle dung and 50 g of calcareous powder.

The pilot experiment was begun in an 8,400 m² fenced area to test different recuperation techniques. The area was divided into 16 plots of 21 × 25 m. The plots were arranged in four groups to test the efficiency of different recuperation techniques: 1) seedlings transplanted to high diversity islands; 2) artificial perches to encourage birds to drop forest seeds; 3) translocation of soil from the reserve, importing, as such, the forest seed bank; and 4) natural regeneration (no treatment). A fifth plot group was maintained outside the fenced area to compare the grazing and trampling effects over the other techniques of regeneration (Boubli and Strier, 2004; Pontual *et al*., 2005).

Results and Discussion

Rural capacity building

From May 2004 to July 2005, 13 SENAR-MG courses were run for the locals with the support of a number of local partners, including the Ipanema Rural Union, and the Cooperative of Producers of Ipanema (CAPIL). The courses were varied: 11 involved rural extension (five on the fundamentals of cattle-ranching, four concerning bovine nutrition and two about artificial insemination) and two taught fabric painting techniques. In total, 184 students from 12 local communities participated, and were subsequently awarded a federally-recognized certificate for the completion of the course, issued by SENAR-MG. Following our commitment to let the locals choose their options, most of the courses requested were related to livestock management. We hoped that this would help increase productivity, while decreasing environmental impacts. Cattle-ranching may be one of the least sustainable economic activities for tropical forest regions (Belsky and Blumenthal, 1997; Fortney, 2000), but we decided it would be better to improve the efficiency of the more traditional and current production activities before suggesting the introduction of exotic alternatives (Savage, 1997). This seemed especially important after the frustrating experiences that some of the farmers had suffered in attempts at organic coffee farming (Roberto Abdala, pers. comm.). The information gathered during the courses was immediately put into practice.

The traditional concept that forest should be replaced by open areas to increase rural production was challenged from the perspective of the farmer's economics. A change in attitude was based on a "less is more" concept. In other words, local people learned that it is more productive to have fewer livestock, to feed them correctly using less pasture, providing better nutrition, and to use artificial insemination techniques to breed animals of better quality. This ultimately will account for an increased milk production with a decrease on environmental impacts and unproductive work for the farmers. Artificial insemination may be the key for this socio-environmental improvement.

An insemination nitrogen bottle with 80 doses of high quality Frisian PO semen was donated by the Caratinga City Council to the São Vicente community. Supported by MC, two other communities, Boa Esperança and Pouso Alegre, received a commitment from the Ipanema City Council that a second insemination bottle would be donated. Also supported by MC was the training of a local Animal Health Agent, Albino Modesto de Souza, who has been visiting the communities, providing official vaccination and other animal health programs.

Protection and Recuperation

The Muriqui Conservation Project provided for the construction of 14 km of fences around the EBC/RPPN-FMA and five other properties, to protect springs and forests that were under pressure from cattle grazing. Funding limitations have impeded the protection of more areas. Many other landowners were willing to have their springs and forest remnants fenced because their water supply from the creeks had diminished, and the cattle were eating poisonous lianas in the forests causing numerous deaths and abortions.

The new nursery has produced 40,000 seedlings from 35 native species. Seeds were collected in the forest. Some 6,000 seedlings of 31 species were transplanted to enrich degraded areas around springs and forest edges. In six months of field work, 30 ha was protected and planted. The recuperation pilot project is still in progress. The growth of the seedlings is being measured every 90 days, but it is too early to report on any results.

Regional partners and alliances

Used to isolation and a lack of any official support, the communities around the EBC/RPPN-FMA would rely on their traditions to survive. Most local people are skeptical about change. The *mutirão* is a local concept commonly used to repair a broken bridge or refurbish an old chapel, for instance. Nonetheless, our invitation to join in a group effort to protect and restore degraded areas was a strange novelty, especially after we explained that brand new, highly quality fences would be built inside the partners' properties, in areas that both project staff and farmers would agree upon. Some people suspected that they would have to pay for the fences. Thus, the first protection and restoration measures were carried out in the EBC/RPPN-FMA, so as to demonstrate that there were no tricks, and to help the local people understand what MC was proposing.

When José Alcino, a local landowner, accepted the terms and became our first partner, his neighbors told him he was unwise to trust us. They were sure that, after fencing his spring and forested border, we would take his land

from him. However, after a couple of extension courses many farmers offered their land to be the next recipients of MC fences. Of the 47 neighboring properties of the EBC/RPPN-FMA, 45 declared themselves our partners, although only a small number actually received any fence or seedlings due to funding limitations.

On 27 August 2005, the *I Festival do Muriqui* took place in Santo Antônio, the closest town to the EBC/RPPN-FMA. The festival was organized by local people and MC staff as a celebration of the *mutirão*. During three days of festivities, there were regional music shows, horse parades, and a barbecue, with the participation of more than 8,000 people from the region. For a more select group, the highlight was the formal ceremony in which local authorities and community representatives gave the 184 course conclusion certificates to the people that attended the extension courses. All were invited to receive the diploma, issued by SENAR-MG, in front of thousands of witnesses.

The Muriqui Conservation (MC) is working on further proposals to continue the program for the protection and recuperation of degraded areas. Twenty landowners have signed legal documents attesting that they were willing partners in providing for the conservation and recovery of the Areas of Permanent Protection (forest on steep slopes and along water courses) on their properties as they should according to Brazilian environmental law. The activities of the MC brought new insights and perspectives to the local communities, and they became real partners. Isolation and lack of training has been gradually replaced by dignity and recognition. An alliance between conservationists and the EBC/RPPN-FMA neighbors has been initiated to work for a more sustainable future for the muriquis and the local communities (Pontual *et al*., 2006).

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CONSERVATION RESEARCH ON THE SOUTHERN MURIQUI (*BRACHYTELES ARACHNOIDES*) IN SÃO PAULO STATE, BRAZIL

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Abstract

In this paper we present an overview of the past and current conservation research on southern muriquis, *Brachyteles arachnoides*, in the state of São Paulo, most particularly in the forests of the Serra de Paranapiacaba, in four connected protected areas, which comprise the so-called Paranapiacaba Ecological Continuum: the state parks of Carlos Botelho, Intervales, and Alto Ribeira and the Xitué Ecological Station. These areas are the major stronghold for this species, and we discuss particularly the history of research on the muriquis of the Carlos Botelho State Park and the importance of statewide surveys and the establishment of further long term research sites to understand better its status and for the elaboration of management plans for its conservation.

Key Words – primates, southern muriqui, *Brachyteles*, Serra da Paranapiacaba, ecology, field studies, conservation

Introduction

Among the best-preserved and largest remnants of Brazil's Atlantic forest are found on the slopes of steep mountain ranges in São Paulo, a state which is also the most industrialized and populous in the entire country (Mittermeier *et al.*, 1987). The forests run parallel to the coastline and in the south turn inland. Most are officially protected, being part of the protected area system administered by the São Paulo State Forestry Institute (Morellato and Haddad, 2000). The single largest forest tract, known as the Paranapiacaba Ecological Continuum (PEC) (see Table 1; Fig .1), is of major biological importance and comprises 140,000 ha of continuous forest of numerous types and in all stages of ecological succession. It consists of four protected areas, and is the core of a World Heritage Site, "The Southeast Reserves of Atlantic Forest" (UNESCO, 1999).

The maintenance of large expanses of natural habitat underlies any broad biodiversity conservation strategy (Pisciotta, 2002). In the case of the Atlantic forest, the Paranapiacaba Ecological Continuum is probably the last natural area for numerous endemic species and provides, besides, the potential to harbor the largest remnant populations of the southern muriqui.

Threats

The geographical distribution and status of the southern muriqui populations in São Paulo are still poorly known. Although it would appear that they occur naturally at lower densities in large expanses of forest than in smaller, fragmented forests, these wild muriqui populations are quickly declining. The following are the current principal threats to the muriquis.

Forest loss. Less than 7% of the muriqui's forests remain, and much of what does is highly fragmented. Deforestation has occurred as a result of logging, intensive land-use for subsistence and commercial farming (for example, coffee), timber plantations (eucalyptus and pine) and cattle ranching, through urban expansion, and highway construction and general infrastructure development, both regional and national, such as dams and the leisure industry. Despite its protected status, the Paranapiacaba Ecological Continuum will always be under threat from developmental pressures such as these.

Hunting for sport. Historically, and even today in some areas, the muriqui is hunted for sport, a cultural trait that has remained from the earliest days of the colonization of São Paulo State by Europeans.

Mining in the buffer zones of protected areas. This refers particularly to bauxite, sand, clay, and granite. These activities result in deforestation, erosion, flooding, and the silting and pollution of rivers and streams.

Lack of an adequate captive breeding program. Captive breeding has been problematic due to low levels of reproduction and poor infant survival. Some zoos in São Paulo (for example, Sorocaba and Santos) receive wild-born muriqui pets every year, originating mostly from palm-harvesters and hunters who have killed the mother. Investment in a well-managed breeding program would greatly enhance our understanding of the primates and provide a backstop for population extinctions in the wild.

Illegal palm-harvesting in large areas of forest. The palm tree, *Euterpe edulis*, is endemic to the Atlantic Forest, and an economically important forest product. Palm tree

harvesters, *palmiteiros*, camp in the forest and transport and process the palm hearts in glass jars, while still in the forest. Thousands of palm trees can be felled in just a few days. Populations of *E. edulis* are declining everywhere in areas where they used to be the dominant understorey tree. *Palmiteiros* hunt game, including muriquis, during their sojourns in the forest.

In spite of little official concern, palm tree harvesting is today one of the main threats to wild muriqui populations. The presence of palmiteiros in São Paulo state's protected forests is reported by villagers, but few arrests result. We cannot afford to ignore these long-term anthropogenic pressures on the remaining populations of wild muriquis in São Paulo (Talebi, 2004). Due mainly to hunting, it is probable that wild muriqui populations are declining everywhere.

Research on the Southern Muriqui in São Paulo

Following the distribution-wide survey of Aguirre (1971), the first behavioral and ecological studies on the genus were begun in the early 1980s. Torres de Assumpção (1983a, 1983b) and Milton (1984, 1985a, 1985b, 1986) established a field site for the southern muriqui at the Fazenda Barreiro Rico in São Paulo (Fig. 3), and Strier, following the initial studies by Nishimura (Nishimura *et al*., 1988), began her research on the northern muriqui at the Fazenda Montes Claros, subsequently the Caratinga Biological Station, in Minas Gerais in 1982 (Strier, 1999). Both sites were small forest fragments in regions otherwise heavily farmed but where, perchance, the landowners had provided for the survival of the muriquis by prohibiting hunting. The terrain in both was favorable for the typically arduous work involved. Strier and Fonseca (1996–1997) listed 19 sites where muriquis were known to occur, 10 of them in the state of São Paulo. Of these, all but one (the Fazenda Barreiro Rico in east-central São Paulo) were in large expanses of remote forests in the Serra do Mar, where muriquis naturally occurred

Table 1. Protected areas of the Paranapiacaba Ecological Continuum (see Fig. 1).

	Official denomination	Area (ha)	Main Features	Reference
A	Carlos Botelho State	37,432	Largest population of muriquis in Brazil	Mittermeier *et al.* (1987)
B	Intervales State Park	45,000	Highest diversity of flora of São Paulo State	Petroni (2000)
C	Alto Ribeira State Park	55,000	Large caves, ecotourism infrastructure	UNESCO (1999)
D	Xitué Ecological Station	3,095	High levels of disturbance, regenerating forest	Gonzalez-Solis *et al.* (2001)

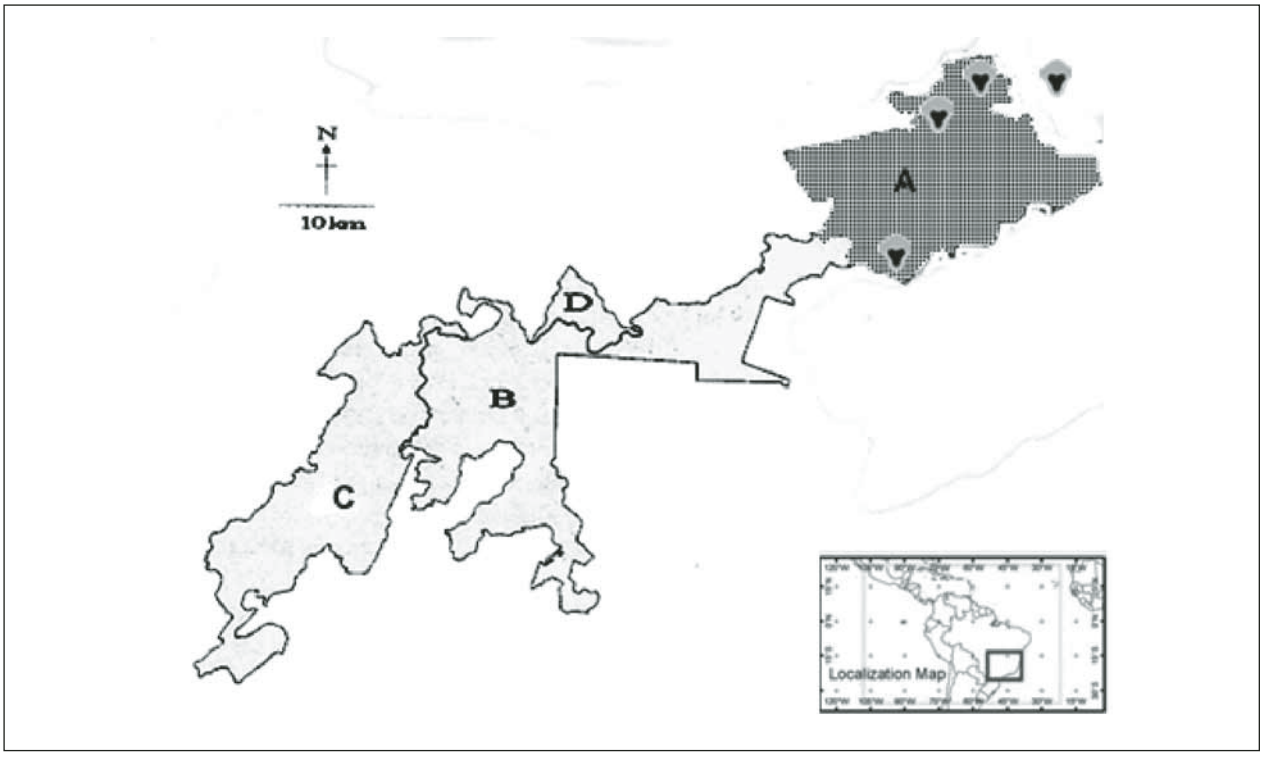

Figure 1. Map showing the protected areas of the "Paranapiacaba Ecological Continuum" and the study areas (▼) of wild southern muriquis in the Carlos Botelho State Park. A = Carlos Botelho State Park, B = Intervales State Park, C = Alto Ribeira State Park, and D = Xitué State Ecological Station (see Table 1).

at very low densities. Surveys and field studies of muriquis in these montane habitats, however, were, and still are, severely hampered by the rugged topography (Pinto *et al*., 1993; see Fig. 2), and attempts to establish field sites in the Serra do Mar in both Rio de Janeiro and São Paulo have severely tested the endurance of many (see, for example, the difficulties in even finding the muriquis as related by Garcia, 2005).

Following initial surveys by Paccagnella (1991), the Carlos Botelho State Park in São Paulo began to emerge as the best option for field studies in these montane habitats. Strier (1999) set up a field base there in 1986 (see below), establishing the only long-term site for muriquis in less-disturbed and continuous rather than fragmented forest — providing information which is vital for comparative studies and a full understanding of their demography and ecological needs (Rylands *et al*., 1998).

Southern Muriqui Research Field Sites in São Paulo

There are five important field sites in the state of São Paulo where research has been carried out on the behavior and ecology of *B. arachnoides* (Fig. 3). We have characterized them according to 1) *Forest condition* – forest fragments (FF) or more extensive (continuous) forest (CF), 2) *Duration of studies* – Short-term (2–3 years at most) (ST), or Long-term (LT), and 3) *Current status of field research* – Discontinued (Dis) or Ongoing (On).

Fazenda Barreiro Rico (FF, ST, Dis) (22°41'S, 48°06'W)
While the other muriqui field study sites are all in mountainous areas of the Serra do Mar, the Fazenda Barreiro Rico is a cattle ranch in the central plateau at the juncture of the Rios Piracicaba and Tietê, in the municipalities of Anhembi and Santa Maria da Serra. Altitude ranges from 450 to 586 m above sea level. Milton and de Lucca (1984) described five fragments of semideciduous forest there, covering 3,259 ha, and surrounded by pasture and agriculture. Today the forest is reduced to three fragments totalling 2,325 ha. Muriqui research started at this location with the work of Torres de Assumpção in 1979–1980 (Torres de Assumpção *et al.* 1982, Torres de Assumpção 1983a, 1983b) followed by Milton from 1980 to 1989 (see references) and, after a hiatus, Martins who investigated population parameters of the primates there (Martins, 2005a), along with feeding strategies and seed dispersal by *Alouatta guariba* and *B. arachnoides* (Martins, 2003a, 2003b, 2005b, 2006). The future of this important area is undetermined, as logging continues and the ranch-owners are unwilling to discuss its future in terms of conservation research. Access is currently restricted even to conservationists.

Figure 2. Aerial view of Parque Estadual Carlos Botelho (37,644 ha), part of the "The Southeast Reserves of Atlantic Forest" UNESCO World Heritage Site, the largest and most extensive single tract of Atlantic forest in Brazil (UNESCO, 1999).

Region of São Francisco Xavier (FF, ST, Dis) (23°12'S, 45°52'W)
In the east of São Paulo, municipality of São José dos Campos, in the Rio Paraíba valley, near the state boundary with Rio de Janeiro, this is a region of steep forested hills of the Atlantic escarpment of the Serra da Mantiqueira. Altitudes range from 800 to 2,000 m. Antonietto and Mendes (1994) reported the presence of muriquis in this region, estimating a population of at least 15 animals. The Instituto de Pesquisas Ecológicas (IPÊ), initiated a research program there (1997–2001), resulting in a study by Silva (1999) on their habitat and population structure. Silva (1999) estimated 70–90 individuals. At the present time, a program is underway, with the participation of local communities, universities and private foundations, to promote increased awareness and continued research activities in the region, with an overall focus on muriquis as the flagship species (Vale Verde Associação do Meio Ambiente, 2006).

Fazenda São Sebastião do Ribeirão Grande (FF, ST, On) (22°45'S, 45°28'W)
This is a private reserve in eastern São Paulo, municipality of Pindamonhangaba, in the Rio Paraíba valley, near the state boundary with Minas Gerais, and neighbouring the Campos de Jordão State Park in the Serra da Mantiqueira. It is administered by VCP Florestal. Oliveira and Manzatti (1995) reported on the presence of at least 22 muriquis there, and a research program began in early 2006. The initial aims were to establish the size of the population of southern muriquis there and to habituate them. Currently, the minimum number of southern muriquis there is 32.

Intervales State Park (CF, LT, Dis) (24°12'–24°25'S, 48°03'–48°13'W)
Created in 1995, the Intervales State Park (49,000 ha) is narrowly connected to the Carlos Botelho State Park (Figs. 1 and 3). It is administered by the Fundação Florestal of São Paulo State (http://www.fflorestal.sp.gov.br). This area has hosted southern muriqui research for about a decade through the work of Petroni (1993, 2000). In addition to the seasonal data on habitat use, muriqui research in Intervales has provided the most thorough and detailed study of the vegetation composition and structure of their habitat for these continuous forests. Intervales has the highest diversity of plant species recorded for the Atlantic forest

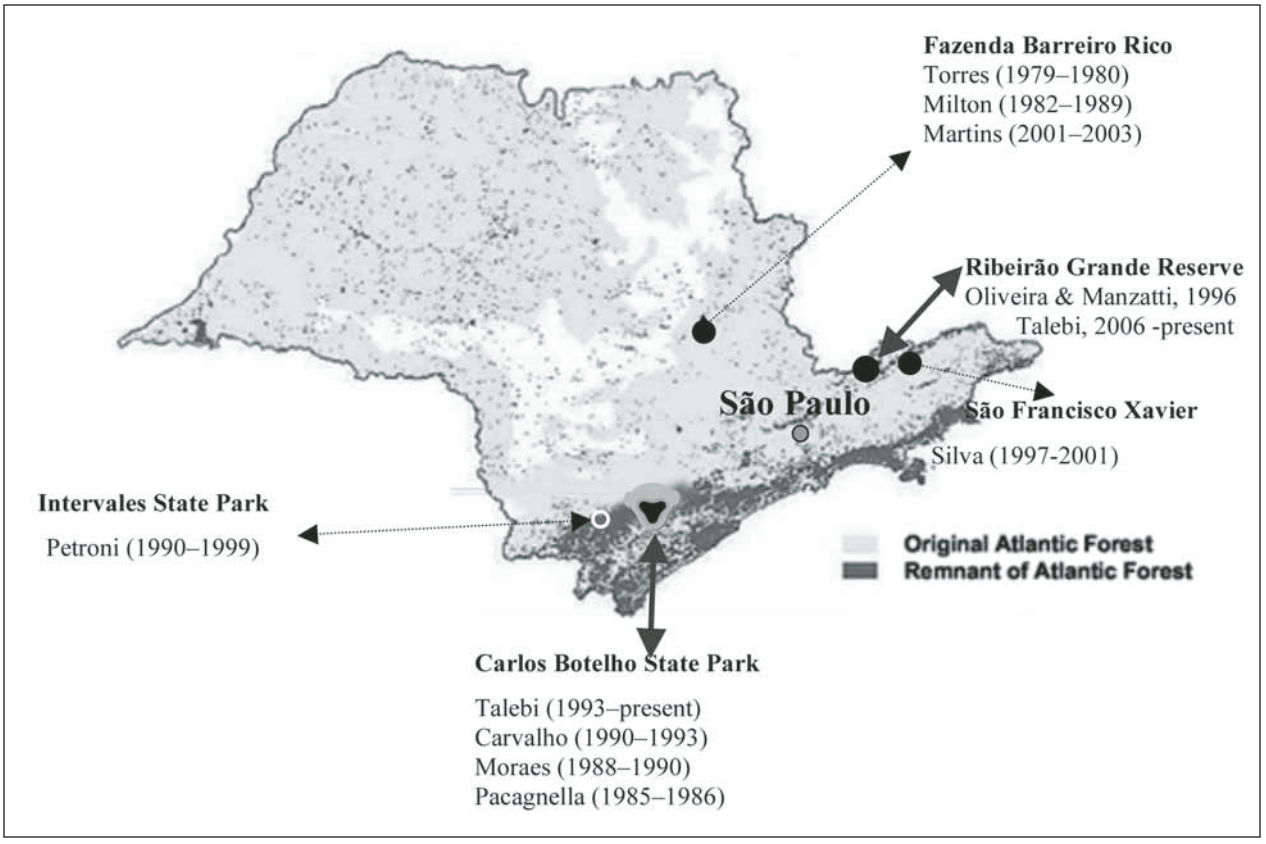

Figure 3. Field sites for research on the southern muriqui in the state of São Paulo. Solid arrows represent ongoing studies.

in São Paulo: 55 families, 114 genera and 190 species, with a predominance of Myrtaceae, Lauraceae, and Leguminosae (Petroni, 2000).

Carlos Botelho State Park (CF, LT, On) (24°15'–24°44'S, 47°46'–48°10'W)
The Carlos Botelho State Park (37,644 ha) was created in 1982 in the municipalities of São Miguel Arcanjo, Sete Barras, Capão Bonito and Tapiraí, and, like Intervales is administered by the Instituto Florestal of São Paulo (http://www.iflorestal.sp.gov.br/). The mountains and steep valleys are covered by dense montane forests; altitudes range from 500 to 1,000 m above sea level (Custódio-Filho *et al.*, 1992; Talebi, 1996). Capuchin monkeys (*Cebus nigritus*) and howler monkeys (*Alouatta guariba*) also occur there (Talebi, 2005). For additional information on this field site and the muriqui groups under study, see Pacagnella (1991), Moraes (1992a, 1992b), Talebi (1996), Carvalho *et al.* (2004), and Talebi *et al.* (2005).

Research on the Southern Muriqui at the Carlos Botelho State Park

Strier (1999) set up the long-term project on the ecology and behavior of the muriquis at the Carlos Botelho State Park in 1986 with the proposition of obtaining comparative data for her findings at the Caratinga Biological Station, as well as promoting the development and training of Brazilian conservationists. A number of researchers worked at Carlos Botelho from that time (see Talebi, 1996; and Fig. 3). By 1996, two groups had been fully habituated, and three years later an NGO, the Associação Pró-Muriqui, was founded to provide for the continuity of the research on the muriqui and its habitats in the park, as well in other locations in the Southeast Reserves of Atlantic Forest World Heritage Site. The last 18 years of research at this site have resulted in the habituation of four muriqui groups in all, with 15 individuals now identified and named. An extensive trail system of 210 km has been established and mapped. The box presents a brief summary of southern muriqui research at the Carlos Botelho State Park.

Of concern is that, although research has been carried out at other sites in the past (Fig. 3), the systematic study in the Carlos Botelho State Park is the only one still active, apart from one that concentrates on environmental education in the private reserve at the Fazenda São Sebastião do Ribeirão (Fig. 3). Our field team receives frequent requests to help farm owners and researchers interested in developing the logistics needed for starting muriqui research in other sites. As a result, over the last four years the Associação Pró-Muriqui has established a volunteer field-training program for young conservationists and newly-graduated students. More than 30 Brazilian and international students have participated, for periods ranging from two to six months.

Additional activities with southern muriquis in São Paulo include a three-year survey (in progress) of remnant

Research on the southern muriqui at the Carlos Botelho State Park (PECB), São Paulo (see Talebi [1996] for further details).

1985 – Sandra G. Paccagnella carried out the first population survey of the muriquis at the PECB (Paccagnella, 1991).

1986 – Karen B. Strier began a research program at PECB to compare northern and southern muriquis, their behavior and ecology in fragmented and large forests, and the possibledifferences related to forest habitats in different stages of succession.

1996 – Maurício Talebi took over the field research at PECB (had been field-coordinator since 1993).

2000 – The Associação Pró-Muriqui was created to ensure the maintenance and growth of research activities at PECB. The NGO counts on the participation of scientists, and students, working within the administrative structure of the Carlos Botelho State Park and the Forestry Institute of the state of São Paulo.

2002 onwards – Internship program was initiated and logistical/research capacity within the Associação Pró-Muriqui was increased. To date we have had about 30 national and international students complete the field internship program (minimum six months), with a number staying on to continue work in the project.

2005 – A survey of southern muriquis in the park was begun. Although still underway, initial findings indicate that there are fewer muriquis than had been estimated by Pacagnella in 1985 (1991).

2006 – One more group of muriquis was fully habituated for systematic observations.

southern populations. The survey was begun in 2005, and is investigating the most important areas in the state where muriquis are expected to occur. The Associação Pró-Muriqui is working to carry out long-term monitoring along an altitudinal gradient from southern to northern São Paulo, to update their geographical distribution and understand better their conservation status. To date, we have set up three field sites in different habitats so as to provide comparative data on demography, feeding ecology, reproduction, health, and behavioral plasticity. Target populations have been identified, and preliminary arrangements for long-term fieldwork have already been made at a location in the Serra do Mar (Parque das Neblinas, Instituto Ecofuturo). Systematic field work has been underway since 2006 in the Serra da Mantiqueira, at the Fazenda São Sebastião Ribeirão Grande (VCP Florestal), and there exists an agreement with VCP Florestal for a long-term study of muriquis there.

The Associação Pró-Muriqui has established links with governmental and non-governmental agencies in both Brazil and abroad in order to expand the operational logistical basis at the field site in Carlos Botelho. A Muriqui Conservation Research Plan for São Paulo State has been designed and proposed within the Action Plan of Muriqui Conservation endorsed by the International Committee for the Conservation and Management of the Atlantic Forest Atelids of the Brazilian Institute for the Environment (IBAMA). Initial discussions are in progress for designing a Muriqui Management Plan for São Paulo, to optimize the use of the academic, logistical, and financial resources available in the state.

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THE SOUTHERN MURIQUI, *BRACHYTELES ARACHNOIDES*: ECOLOGY OF A POPULATION IN A SEMIDECIDUOUS FOREST FRAGMENT

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Abstract

Southern muriquis (*Brachyteles arachnoides*) inhabit evergreen and semideciduous forest fragments in southeastern Brazil. Contrary to the broadleaf evergreen forests, the seasonal mesophytic forests experience a relatively severe dry season, which affects the muriquis' diet. Through behavioral sampling of feeding activity, I determined the diet of a group of muriquis in a semideciduous forest fragment. Leaves represented 55.3% of feeding records, flowers 16.1%, fruits 12.1%, and seeds 16.5%. Muriquis included 47 plant species in their diet. Leaf consumption was significantly higher in the dry season, but there was no evident difference between seasons in their feeding on either flowers, fruits, or seeds. Muriquis in this study shared only 11 taxa with groups in evergreen forests. The study group made consistent use of immature seeds. Dietary flexibility and the consumption of alternative resources may likely be advantageous where there are repeated lean periods and anthropogenic interference.

Key Words – southern muriqui, *Brachyteles arachnoides,* feeding ecology, São Paulo, Atlantic forest, Brazil

Introduction

The original range of the southern muriqui (*Brachyteles arachnoides*) extended through two forest types in the Atlantic forest: the broadleaf evergreen forests on the eastern slopes of the Serra do Mar in the states of Rio de Janeiro and São Paulo, and the mesophytic, semideciduous forests on the central plateau, in the interior of the states of São Paulo and Paraná. These seasonal forests were largely devastated because the flat terrain favored the development of farming and cattle-ranching. The ongoing process of habitat fragmentation drastically reduced the populations of southern muriquis, that now survive in only a few forest fragments.

The pattern of rainfall determines differences in the flora and climate of the two types of Atlantic forest. In the evergreen forests, annual rainfall is quite evenly distributed through the year, but in the semideciduous forests there is a relatively severe drought during part of the year (Morellato and Haddad, 2000). The occurrence of two distinct seasons leads to changes in food availability for the forest's folivores. As such, it is possible to suppose that muriquis in semideciduous forests face greater restrictions in relation to the availability of fleshy fruits, most especially at times of reduced rainfall, when fewer trees are fruiting. By contrast, the diet of muriquis in evergreen forests remains relatively unchanged through the year (Carvalho *et al*., 2004). In her long-term study of southern muriquis in a semideciduous forest fragment, Milton (1984a) found a high proportion of leaves in their diet, which also included flowers, and fleshy and dry fruits. However, Milton did not investigate whether the muriquis' diet changed between seasons.

The aim of this study was to determine the dietary composition of a group of *B. arachnoides* in a semideciduous forest fragment, examining particularly differences in food preference compared to groups in more humid forests, and the feeding strategies adopted during the dry season. The study area was in the Fazenda Barreiro Rico, in a forest fragment adjacent to that where Milton (1984a) carried out her study.

Methods

Study area

Most of the area of the Fazenda Barreiro Rico (22°41'S, 48°06'W; 450–586 m above sea level) is now split into several properties located in Anhembi and Santa Maria da Serra, in the eastern side of the central plateau of the state of São Paulo. Sandy quartzic soils of low fertility predominate in the region (Magalhães, 1999). Although the landscape is dominated by a mosaic of urban centers, farmland and pasture, the Fazenda Barreiro Rico maintains fragments of semideciduous submontane forest: 1,450 ha, 501 ha and 374 ha in size. All these forest fragments have been subjected to selective logging. As a result, they have broken canopies, clearings, and dense tangles of lianas in some parts. The predominant climate is mesothermic, with a dry season from April to September when monthly rainfall is below 70 mm. Sixty-year mean annual rainfall (1940–1999, data from a local weather station) is 1,284.5 ± 285.5 mm.

Further information on the area can be found in Martins (2005).

Study group

The study was carried out in the 1,450-ha forest fragment between June 2001 and May 2002. The muriqui group was completely habituated to the presence of observers. The lack of natural marks and unique attributes made it impossible to precisely identify all of the group members. It was easier to identify females with dependent infants than the males of any age category because the size and sex of the infants allowed me recognize them from one observation session to the next. The muriquis traveled alone or in subgroups with a mean size of 3.25 ± 1.65 individuals. A group size of 25–30 was estimated by counting the number of adult females with their young, summed with the largest grouping of males that I saw (11 at one time) (Martins, 2003).

Data collection

The observation and recording method used was instantaneous scan sampling (Altmann, 1974). I scanned the group every five minutes and registered the behavior of each individual I could see. The behavior categories I recorded were: moving, resting, ingesting food, and interacting socially. The foods were classified as leaves, flowers, fruits and seeds. Although separating fruits from seeds is not usual in studies of muriqui feeding ecology, I had to include it as a category due to the frequency with which I saw them eating the seeds of dry (non-succulent) fruits. As such, when I saw them eating fruits I noted especially the treatment they gave to the seeds, which I classified in one of three categories: seeds ingested (passive), seeds discarded, or seeds eaten (predated). When I saw them ingesting seeds passively while eating the entire fruit or parts of it, or discarding the seeds, I scored the individual as eating fruit, but when the muriqui was evidently targeting the seeds, chewing on them, I scored seed predation. I collected fecal samples from the adults to check whether the seeds were intact or chewed up and fragmented. The plants used in the muriqui's diet were marked, and herbarium samples were collected subsequently for identification. The muriquis were accompanied for three to four days each month, totaling 534 hours of observation, including 38 complete days. I made 5,984 scans which resulted in 2,532 feeding records.

Statistical analysis

The time spent eating different food items and species was calculated as a proportion of the total feeding records for each of the complete days of observation in each month, and expressed as monthly means (number of days varying from three to four). Proportions of different food items and species were also calculated as a proportion of the overall total feeding records. The seasons were determined according to the mean monthly rainfall for the area. Months when precipitation was below 100 mm were classified as dry season months (June to September 2001 and April to May 2002). Months with rainfall above 100 mm were considered to be rainy season months (October to December 2001 and January to March 2002). Seasonal differences in the amount of time spent eating leaves, flowers, fruits and seeds each day were tested with ANOVA. Homogeneity among variances was examined using the Levene test, the proportions being transformed to the arcsine of the square root when the variances were not homogeneous. I used the program STATISTICA 5.0 to carry out the test. Significance levels were pre-assigned to 0.05.

Results

Leaves took up 55.3% of the feeding records of the group, flowers 16.1%, fruits 12.1% and seeds 16.5%. The muriquis included 47 species of plants in their diet during the study (Table 1). Records for five of the species were incidental (seen outside of the formal observation sessions, or recorded through the presence of seeds in the fecal samples). Intact seeds of 18 species of plants were found in 117 fecal samples. Of the total of 31 food species recorded during observation sessions, *Aspidosperma polyneuron* (Apocynaceae) was most frequently registered, followed by *Duguetia lanceolata* (Annonaceae), *Hymenaea courbaril* (Caesalpinoideae) and *Esenbeckia leiocarpa* (Rutaceae) (Table 1). *Aspidosperma polyneuron* and *H. courbaril* supplied mainly leaves, while *D. lanceolata* and *E. leiocarpa* were important sources of immature seeds.

The consumption of leaves differed significantly between the seasons, but this was not so for flowers, fruits or seeds. The muriquis spent more time eating leaves in the dry season than in the wet ($F = 7.33$; $p = 0.01$). Variation in the daily contribution of flowers ($F = 0.31$; $p = 0.57$), fruits ($F = 1.11$; $p = 0.29$) and seeds ($F = 3.12$; $p = 0.08$) was higher between the months of each season than between seasons (Fig. 1). The muriquis made use of temporarily available resources. For example, flowers and nectar were eaten when *Mabea fistulifera* (Euphorbiaceae) was flowering in April (Fig. 1). Only four succulent fruits were included in the diet for the four months of the dry season; the liana *Pereskia aculeata* (Cactaceae), which fruited in June and July, was eaten most. Immature seeds were eaten in all months except October. There was an increase in seed consumption between January and March (Fig. 1) when *E. leiocarpa* was fruiting.

Discussion

The diet of the muriquis in this study showed some considerable differences to those recorded for groups in more humid forests. Of the 47 species of plants the muriquis ate, only 11 were also recorded in the studies of muriquis in the montane evergreen forests of the Carlos Botelho and Intervales state parks (Table 1). Ten of the species, members of the families Apocynaceae, Euphorbiaceae and Rutaceae, were eaten only by the muriquis at Barreiro Rico. In terms of their relative frequency, these three families are well represented in the area (Cesar and Leitão-

Table 1. Percentage of feeding records on each species (N = 2,532) by *Brachyteles arachnoides* in the Fazenda Barreiro Rico, and coincidence with records from two other study sites—Carlos Botelho State Park (PECB) and Intervales State Park (PEI), both of dense evergreen forest.

Species	Family	Percentage of records	PECB[1]	PEI[2]
Arrabidea sp.	Bignoniaceae	1.72		
Aspidosperma nemorale	Apocynaceae	2.47		
Aspidosperma polyneuron	Apocynaceae	12.47		
Astronium graveolens	Anacardiaceae	0.07		
Campomanesia sp.	Myrtaceae	0.11		
Cariniana estrellensis	Lecythidaceae	0.51	x	
Celtis spinosa	Ulmaceae	0.71		
Copaifera langsdorffii	Caesalpinoideae	0.51	x	
Cordia sellowiana	Boraginaceae	0.19		x
Croton floribundus	Euphorbiaceae	2.63		
Cryptocaria moschata	Lauraceae	IO	x	x
Diclidanthera sp.	Polygalaceae	1.81		
Dolichandra unguis-cati	Bignoniaceae	1.42		
Duguetia lanceolata	Annonaceae	6.5	x	
Esenbeckia leiocarpa	Rutaceae	5.84		
Eugenia ligustrina	Myrtaceae	2.48		
Eugenia pyriformis	Myrtaceae	0.77		
Eugenia sp.	Myrtaceae	0.27	x	x
Ficus sp.	Moraceae	SF	x	x
Fridericia samydoides	Bignoniaceae	0.11		
Gonatogyne brasiliensis	Euphorbiaceae	0.19		
Hymenaea courbaril	Caesalpinoideae	6.15		x
Inga striata	Mimosoideae	0.74		
Jacaratia spinosa	Caricaceae	0.46		
Lundia obliqua	Bignoniaceae	0.15		
Mabea fistulifera	Euphorbiaceae	1.3		
Metrodorea nigra	Rutaceae	0.7		
Mouriri glaziowiana	Melastomataceae	SF		
Myrciaria sp.[a]	Myrtaceae	—		
Neomithrantes obscura	Myrtaceae	0.55		
Ocotea catharinensis	Lauraceae	0.27	x	
Ocotea corymbosa	Lauraceae	0.81	x	
Ocotea velutina	Lauraceae	1.42		
Pachystroma ilicifolium	Euphorbiaceae	0.23		
Pereskia aculeata	Cactaceae	4.62		
Pithecoctenium sp.	Bignoniaceae	0.55		
Philodendron sp.	Araceae	0.42	x	
Psidium sp.	Myrtaceae	SF		
Qualea jundiahy	Vochysiaceae	4.69		
Rudgea sp.	Rubiaceae	1.45		
Savia dictyocarpa	Euphorbiaceae	2.84		
Sloanea monosperma	Elaeocarpaceae	0.07		
Styzophyllum riparium	Bignoniaceae	0.98		
Syagrus romanzoffiana	Arecaceae	SF		
Tanaecium seloi	Bignoniaceae	0.98		
Xylopia brasiliensis	Annonaceae	4.54		
Zanthoxylum rhoifolium	Rutaceae	0.19		

[a] = Recorded by Milton only (1984a). PECB = Carlos Botelho State Park, PEI = Intervales State Park. References: [1]Moraes (1992), Carvalho *et al.* (2004), Talebi *et al.* (2005); [2]Vieira and Izar (1999), Petroni (2000). IO = Incidental observation; SF = seeds in a fecal sample.

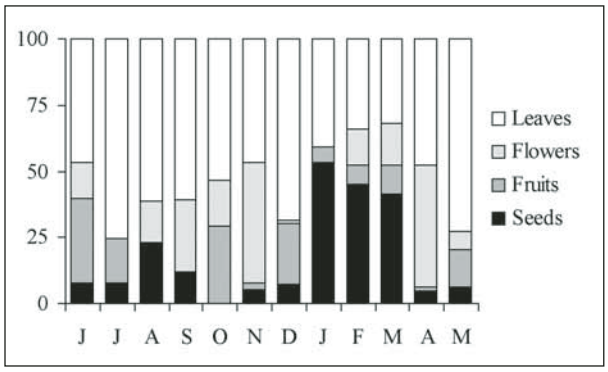

Figure 1. Monthly percentages of feeding records for four food items (leaves, flowers, fruits, and seeds) for *Brachyteles arachnoides* between June 2001 and May 2002 in the Fazenda Barreiro Rico, São Paulo.

Filho, 1990). The floristic composition of broadleaf evergreen and semideciduous forests in southeastern Brazil are distinct (Oliveira-Filho and Fontes, 2000), explaining the low overlap of food species between Barreiro Rico on the one hand and the Carlos Botelho and Intervales state parks on the other.

The consumption of immature seeds was seen frequently, and yet this food resource would appear to be rare or even absent from the diets of the muriquis in the broadleaf evergreen forests to the south (Moraes, 1992; Carvalho *et al.*, 2004; Talebi *et al.*, 2005). Milton (1984a) also recorded seed predation in the group she studied in the neighboring forest patch in Barreiro Rico. Milton (1984a) did not record the frequency of this behavior, however, which may indicate that it was less frequent. There are differences (to be expected) in the diets we recorded. For example, leaves of *Xylopia brasiliensis* accounted for 11% of the diet of Milton's (1984a) group, but only 4.5% of the records for the group I studied. Seeds ingested by primates contain non-structural carbohydrates and lipids (Maisels *et al.*, 1994; Norconk, 1996; Heiduck, 1997), but also nitrogen (Ayres, 1986). However, what it is that is attracting the Barreiro Rico muriquis to eat seeds is unclear. Acquisition of special skills to fracture or scrape the hard pericarps of, for example, *E. leiocarpa*, *D. lanceolata*, and *P. ilicifolium*, and the metabolic attributes to deal with the secondary compounds are interesting questions for further investigation.

The annual proportion of leaves in the diet recorded by Milton (1984a) for her study group and that which I found in my study group were similar (both more than 50%), and much higher than that recorded by Carvalho *et al.* (2004) (33%) and Talebi *et al.* (2005) (24%). The group at Barreiro Rico lives in a forest which, for a fragment, is quite large (1,450 ha), and it is relatively well conserved, despite the occasional logging. I would believe that the higher consumption of seeds and leaves may well be typical of muriquis occupying the more seasonal, semideciduous forests of the central plateau when compared to those in the less seasonal montane evergreen forests of the Serra da Paranapiacaba, for example. The behavioral strategy of *Brachyteles* is considered to be one of efficiency in exploiting dispersed and isolated patches of food resources such as fruits (Rosenberger and Strier, 1989), but the consumption of leaves, distributed more homogeneously, is still significant in the larger expanses of forest such as that at the Carlos Botelho State Park. Cecal fermentation (Milton, 1984b) and broad post-canine teeth (Rosenberger and Strier, 1989) allow these primates to process these low energy foods. Talebi *et al.* (2005) suggested an association between the higher contribution of leaves in the diet and the fact that animals are living in forest fragments. However, independent of and prior to any fragmentation, the muriquis would be selected to adapt to the lower diversity of zoochoric fruits and the greater seasonality in fruit availability that characterizes these semideciduous forests. A comparison of groups in fragmented and extensive semideciduous forests would be ideal, but unfortunately none of the latter remain in the range of the southern muriquis.

Muriquis at Barreiro Rico eat more leaves in the dry season, but although very variable between months, eat similar proportions of the other plant foods across seasons. The adaptive abilities of the muriqui are demonstrated by their increased consumption of leaves when succulent fruits are scarce. This pattern is not evident for the groups in the broadleaf evergreen forest, probably because of the larger number of species producing succulent fruits and a more uniform fruit abundance over the year. At Carlos Botelho, Carvalho *et al.* (2004) failed to detect any significant differences in the composition of the diet during the year.

The results suggest a greater variability in the diet of *Brachyteles arachnoides* than had been previously recognized. I have identified differences in the diet of the group in Barreiro Rico from those recorded for the groups in humid broadleaf forests, not only in the plant species eaten, but in the regular and considerable contribution of immature seeds. The predator-plant interaction deserves further research considering its effects on the recruitment of the plant species involved, and the influence of *Brachyteles* as a seed predator on the floristic communities of the forests where they live. Reliance on seeds and dietary flexibility were probably crucial aspects enhancing the southern muriqui's capacity to occupy seasonal semideciduous forests. This plasticity may well be allowing them to adapt to structural and floristic changes in the forests over recent decades. For example, the muriquis may well have developed or increased their capacity to eat ruderal invasives such as *Croton floribundus* (Euphorbiaceae) and *Inga striata* (Mimosoideae) or species which respond positively to fragmentation and disturbance such as lianas. It is possible that these feeding strategies provide an advantage for muriquis to tolerate not only repeated dry season conditions, but also anthropogenic effects over the remaining forests where they live.

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THE SOUTHERN MURIQUI, *BRACHYTELES ARACHNOIDES*, IN THE STATE OF PARANÁ: CURRENT DISTRIBUTION, ECOLOGY, AND THE BASIS FOR A CONSERVATION STRATEGY

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Abstract

Primatologists have suspected the existence of remnant populations of the southern muriqui, *Brachyteles arachnoides* (É. Geoffroy, 1806), in the state of Paraná since the early 1970s. Only in 2002, however, was this confirmed, with the discovery of a group in the upper Rio Ribeira valley. Here we report on some observations of this group, which totals 23 individuals living in a tiny remnant of the primary dense broadleaf forest that formerly extended in a continuous belt into Paraná's first planalto along the valleys of the rios Ribeira and Açungui. We also discuss possibilities for the occurrence of muriquis elsewhere, and our ongoing efforts for the conservation of this threatened species in the state of Paraná.

Key Words – southern muriqui, *Brachyteles arachnoides*, Atlantic forest, conservation, state of Paraná, Brazil

Introduction

The possibility of the continued presence of the southern muriqui, *Brachyteles arachnoides* (É. Geoffroy, 1806), in the state of Paraná was reported by Aguirre (1971). He believed that they might still occur in the region of Guaraqueçaba, because there could be found the largest expanses of well-conserved forest in the state. This idea was subsequently reinforced by Lange and Jablonski (1986) and confirmed by Martuscelli *et al.* (1994).

Koehler *et al*. (2002) reported on a new locality for the occurrence of *B. arachnoides* in the municipality of Castro, Paraná; a region with very few remaining patches of intact forest. This unexpected discovery gave rise to renewed research and conservation measures for the protection of the southern muriqui in the state of Paraná. It established a new southern limit to the present-day range of the species and drew the attention of primatologists and conservationists to the middle valley of the Rio Ribeira where it had been found. Besides initiating research on the group discovered by Koehler *et al*. (2002), efforts were made to find other groups surviving in the area, and two more were discovered. Here we summarize our research and findings since the discovery of the first group, and provide some suggestions for a conservation strategy for a region that unfortunately has a long history of environmental abuse.

Current range of *Brachyteles arachnoides* in the State of Paraná

According to Aguirre (1971), *Brachyteles arachnoides* was to be found in climax montane forests at altitudes of 600 to 1,800 m above sea level, in well-preserved remnants of seasonal and evergreen forests in the states of Bahia, Espírito Santo, São Paulo, Minas Gerais and Rio de Janeiro. Based on a reference of Krieg, cited by Hill (1962, pp.252–356), Aguirre (1971) considered the southern limit of the range of the species to be about 25°S, in the region of the Rio Ribeira in Paraná. He concluded that the distribution center of the species was the Serra do Paranapiacaba in São Paulo, well known for its richness of plants in the Lauraceae family. The Serra do Paranapiacaba today has the largest remaining southern populations of *Brachyteles* in a continuous stretch of forest covering some 100,000 ha, including the Intervales and Carlos Botelho state parks, Xitué Ecological Station and the Alto Ribeira State Tourism Park, together now known as the "Paranapiacaba Ecological Continuum" (Talebi and Soares, 2005).

The integrity of the "continuum" in the state of Paraná was broken several decades ago. Wachowicz (2002) recorded that the valley of the Rio Ribeira, the headwater springs of which are on Paraná's Second Planalto, draining into the Atlantic on the coast of São Paulo, was one of the principal routes for miners and prospectors entering the Planalto in the middle of 17th century.

Maack (1950) mapped the vegetation of the state and classified the forests in the Rio Ribeira valley as secondary along

the initial one-third and middle sections of the river. The section known as the Rio Ribeirinha and, to the east, the section in the Serra do Paranapiacaba, known regionally as the Serra da Canha, are within the domain of tropical and subtropical coastal rain forests. The primary forests have been gradually destroyed, the only fragments remaining being in the remotest and most inaccessible areas.

According to Roderjan *et al.* (2002), the dense evergreen forest (*Floresta Ombrófila Densa*) extends into the Paraná planalto, a region otherwise characterized as "Campos Gerais" (grasslands), accompanying the courses of the rios Ribeira and Açungui, and being increasingly delimited by the *Araucaria* pine forest at altitudes of 700 m above sea level. This penetration of the Atlantic forest, following the courses of the principal rivers of the region, and invading, so to speak, the open vegetation of the Planalto, is referred to in Brazil as an Area of Ecological Tension (*Área de Tensão Ecológica*). This floristic mixture continues until it reaches elevations where *Araucaria* begins to appear and eventually predominate; a characteristic of mixed evergreen forest (*Floresta Ombrófila Mista*) (see Fig. 1).

The muriqui group found in the Fazenda Lagoa Alegre, municipality of Castro, Paraná (Koehler *et al.*, 2002) was in a tiny remnant of dense evergreen forest, within the domain of the mixed forest along the courses of the rios Ribeira and Açungui. The other two groups discovered later (L. M. Pereira *et al.*, unpublished) were in similar vegetation on the banks of the Rio Turvo (Fig. 1).

Martuscelli *et al.* (1994) informed of two localities where they found muriquis in Paraná. One was in the municipality of Jaguariaíva, the other in the Guaraqueçaba Environmental Protection Area (APA), near to 25°S, and corroborating the southern limit of Aguirre (1971). According to the coordinates provided by the authors, the first locality is in the municipality of Sengés, on the banks of the Rio Jaguaricatu, and the second is in the south of the state of São Paulo. The mixed forest types we have described as being typical of the valleys of the Rios Ribeira, Açungui and Turvo disappear at this point, and the species which occur with *Araucaria*, and *Araucaria* itself, are lost in the dense evergreen forest typical of the coastal Atlantic forest, even at altitudes above 600 m. It is possible that *B. arachnoides* could still be found in small remant forests in the valleys of the rios Jaguaricatu (Martuscelli *et al.*, 1994) and Itararé to the north, in the region of Jaguariaíva and Sengés, where landscapes today are dominated by extensive pine plantations, *estepes* (wooded grasslands), and a small area of open savanna, besides secondary forests with *Araucaria*.

The Muriqui Group at the Fazenda Lagoa Alegre

Group size

This group was found by chance, during a forest inventory along power transmission lines. They were first seen on 29 June 2002. After three further sightings in the same area (Fazenda Lagoa Alegre), we were able to count only eight individuals in the group (Koehler *et al.*, 2002). By the beginning of our systematic study in March 2003, however, we had registered 15 individuals, and after intensive efforts to habituate the muriquis, in September 2003 we registered 18, due to three dependant infants we had not seen earlier, two of them still riding dorsally and the third ventrally. In September the older two would occasionally leave the mother to explore, and the third could sometimes be seen on the mother's back. A new count in November 2003, recorded 22 muriquis; three adult females, four adult males, three subadults, four infants and eight other individuals we were unable to classify by sex or age. At the end of 2004, another infant was born, and in April 2005 there were 23 muriquis in the group.

Home range

We studied the home range of the group from January 2004 to September 2005. The points of observation and travel paths were plotted using a Geographic Positioning System (GPS). The data obtained from 246 hours of *ad libitum* observation lead us to conclude that the group used a core area of 38.14 ha, in four forest fragments of 24.69 ha, 3.44 ha, 5.96 ha, and 4.05 ha. The area covered by the muriquis was estimated at 128.65 ha. The maximum travel distance observed was 1,862 m (September 2004; 20.3 hours of observation), and the minimum was 146 m (March 2005; 18.5 hours of observation) (Pereira, 2006).

Milton (1984) and Dias and Strier (2003) concluded that the home range of muriqui groups varies according to differences in forest structure and floristic composition, the availability and abundance of food, and the presence or otherwise of other groups. The home range of a group of 23–26 northern muriquis *Brachyteles hypoxanthus* at the Caratinga Biological Station, Minas Gerais, increased from 168 ha to 309 ha due simply to an increase in the amount of habitat available (regeneration at the forest borders) (Dias and Strier, 2003).

Diet

The muriqui diet is very diverse, including fruits, leaves, flowers, lianas and epiphytes (Milton, 1984; Nishimura *et al.*, 1988; Petroni, 2000); the contribution of each varying according to their availability and the time of year (Dias and Strier. 2003). We examined the diet of the muriqui group at the Fazenda Lagoa Alegre by collecting feces and by direct observation. Between January 2004 and July 2005 we registered 27 species of plants of 20 families in their diet, including Myrtaceae, Annonaceae, Aquifoliaceae, Rubiaceae, Euphorbiaceae, and, most especially, Lauraceae (six species). They also eat fruits and leaves of epiphytes, especially cactuses and bromeliads. The most commonly eaten items were leaves, fruits and flowers. Once we saw an individual pulling an orchid off a branch and eating its bulbs (P. A. Nicola, unpublished data).

Our observations on the diet of the Fazenda Lagoa Alegre group indicate that they are using the same plant families and many of the same genera and species recorded in the diets of muriquis elsewhere, in forests with similar physiognomies, structure, and floristic composition (see, for example, Moraes, 1992) (remembering, however, the ecotonal nature of the forest arising from the gradual transition to mixed evergreen forest [P. A. Nicola, unpublished data]).

Habitat quality

The forest cover in the home range of the muriquis is not uniform. The forests there are reduced to fragments

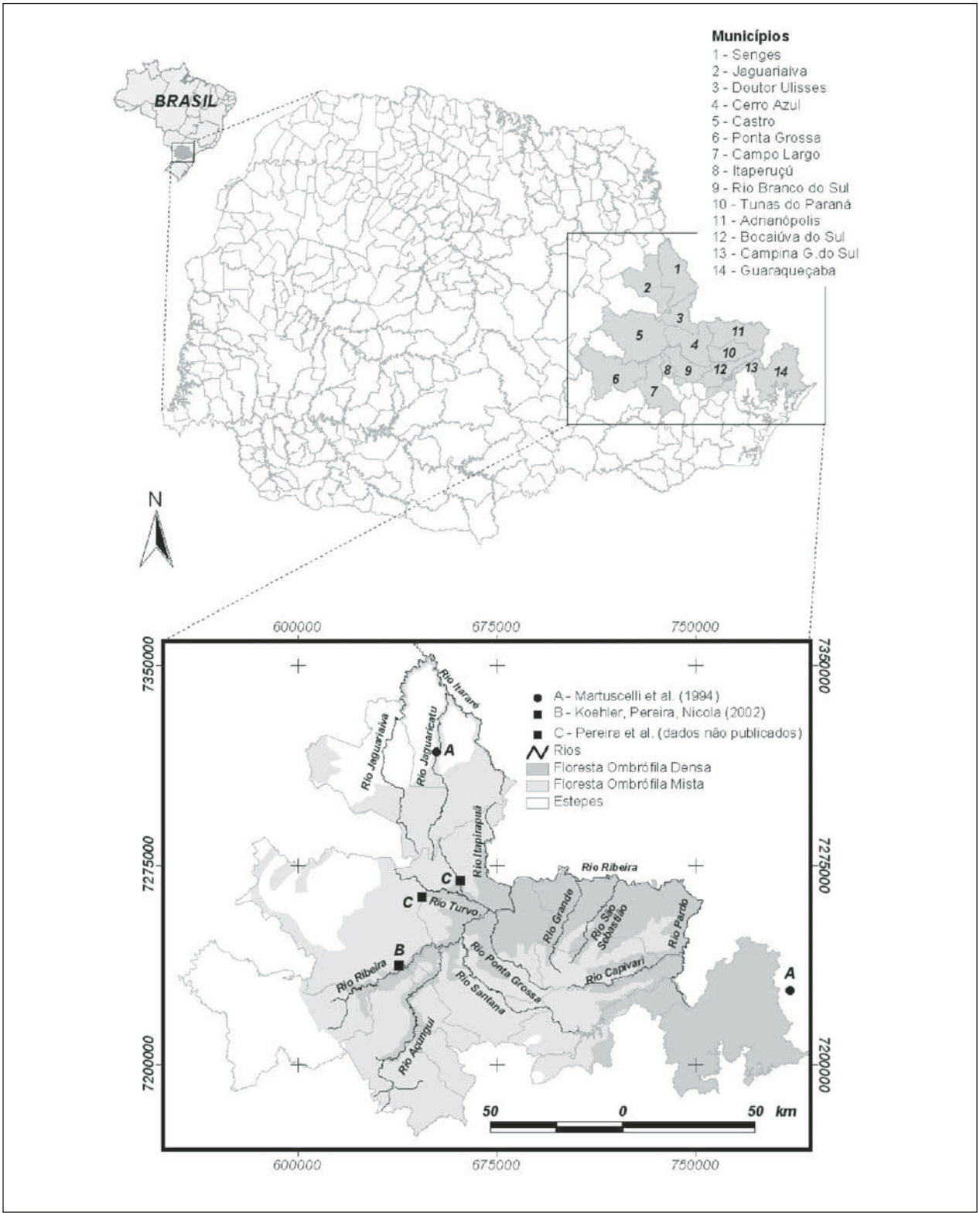

Figure 1. Geographic distribution of *Brachyteles arachnoides* in the state of Paraná.

surrounded by pasture, tree plantations (*Pinus*), and crops. The fragment where the muriquis live, although intact structurally, shows signs of past logging in some places. Although only 50 ha, it is one of the best-preserved forests of the region. Most of the forest in the valley is secondary, resulting from abandoned farming plots and pasture, with small patches of degraded primary forest in the valley bottoms and steeper slopes, and, rarely, in areas even of easier access.

The proximity of some of the better-conserved secondary forest patches to the 50-ha forest of the muriquis allows them to use them for shelter, passage and food. Alone we believe they would be inadequate to support muriquis; nowhere in the literature have we been able to find evidence that muriquis could live in secondary forest only. The advance in succession and growth of these forests, however, are no doubt vital for the long-term survival and growth of the muriqui population there.

The secondary formations differ considerably from the primary forest, most markedly in the understorey, which is very dense, and of course in the floristic composition. Bromeliads, orchids, epiphytic cacti, and Araceae are all rare. On the other hand, *Araucaria angustifolia* is more abundant, with mature trees in the first stratum of the forest. There are floristic differences in the lower strata too, from the lower canopy to the understorey. In both the primary and secondary forests, gaps in the canopy favor the proliferation of native bamboos (*taquara*) along trails and in tree falls. The control of these *taquaras* is key to managing these forests to favor the dissemination and growth of trees. The edges of both primary and secondary forests are dominated by bracken, *Pteridium aquilinum*, locally called *samambaia das taperas*, which is prejudicial to regeneration, complicating the germination and survival of saplings which could otherwise gradually advance the forest into the abandoned fields and pasture. The control of bracken is very difficult, not only because of the often steep terrain, but also because it is an aggressive disperser, an invasive species with a strong regenerative capacity. As such, fire is the means most used, which is invariably destructive too for all other saplings and seeds that could contribute to the regrowth of the forest. Fire is also used to clear bracken for pasture, which is frequently unsuccessful because of the speed with which bracken recovers and takes over once again.

These aspects restrict the regenerative capacity of the forest patches. Many areas, farmed in the past and abandoned could well have returned to forest if it were not for the farming practices in neighboring areas. Increasingly predominant in the landscape are pine plantations, *Pinus taeda* and *Pinus elliottii*, which limit the native forests to few trees left standing and able to coexist. More and more land is being given over to these pine plantations, so the possibilities of forest regeneration are severely limited or nil. All existing native forest patches, primary and secondary, must, therefore, be protected.

Selective logging in the area also has serious impacts. The felling of some trees in small primary forest in a farm next to the Fazenda Lagoa Alegre completely altered the micro-environment, and after four years the proliferation of bracken in the understorey is still impeding any natural regeneration. Unfortunately, the landowners are quite unwilling to mitigate this process, even though it would so obviously be of advantage for them to facilitate the regeneration of the forest patches they find so useful as a provider of timber, especially for fences. The cost they find unjustified. Despite the patent degradation of these forests, lacking a continuous canopy of any sort, the muriquis are still able to travel through them, but predictably not for much longer.

The owner of the Fazenda Lagoa Alegre, the laborers and staff, and some of the neighboring families have supported our research in the region. All agree that the muriquis should be protected, and they are strong allies in our attempts to do this. There is a local cement company with a large property in the region that has a forest of 200 ha. Most is secondary, in the middle to advanced stages of succession, and allowing this forest to expand, promoting the establishment of a connection with the Fazenda Lagoa Alegre forest, would be enormously beneficial to the muriquis. Some other property owners have small forest patches which are accessible to, and used occasionally by, the muriquis, but their understanding of how important this is for the muriquis conflicts with their dependence on these forest patches as sources of timber and firewood. These marginal forest patches, potential habitat for muriquis, are gradually diminishing as a result.

Another important element is the management of the pine plantations. The plantation companies need to fulfill legal requirements in terms of the so-called "Legal Reserve" (protection of a fixed portion of native forest on their land), and the Areas of Permanent Preservation (areas that must be left as forest, and natural vegetation along watercourses and on steep slopes, according to the Forest Code). These legal instruments could well be brought to bear as a means of designing a forested landscape, which, with the collaboration of the companies, could be more favorable to muriquis (and the accommodation and dispersal of wildlife in general).

Although the muriquis enter the degraded and secondary forest patches, moving through them, resting there and even sometimes feeding, in the majority of our studies we have been watching them in the primary forest, which is evidently the habitat vital for their continued existence in the region.

Future Research and Conservation Strategies

University teaching staff and students of the postgraduate course in Forestry of the Universidade Federal do Paraná (UFPR), and also the Pontifícia Universidade Católica do Paraná, have been carrying out the research on the muriquis

of the Fazenda Lagoa Alegre. The Department of Zoology of the UFPR should also be involved, as should the Museu de História Natural do Capão da Imbuia (MHNCI) in Curitiba. We hope that other universities and research institutions may also be inspired to collaborate, besides the relevant non-governmental conservation organizations. The future of muriquis in the state of Paraná will undoubtedly depend on their participation. The creation of a protected area, or areas, is vital, but not a simple prospect considering the expense and the fragmentation of the remaining forest. The means would be through, perhaps, a series of Private Natural Heritage Reserves (RPPNs), combined with institutional programs for the socio-environmental development of the region, working to preserve and connect the forest patches and improving soil management and farming practices to promote their regeneration, would the best plan for the short- to mid-term.

The search for more groups continues, with our expectations centered on the courses of the rios Açungui, Ribeira, Turvo, Santana and Ponta Grossa and, farther east, on the rios Grande and São Sebastião; all affluents of the Rio Ribeira marking the state limits of Paraná with São Paulo. Throughout the region, the only remnant forest of any considerable size is that of the Lauráceas State Park of 23,000 ha, in a montane region of the municipalities of Adrianópolis and Tunas do Paraná. It is quite probable that muriquis will be found there.

We believe that the establishment of a state committee for the conservation of the muriqui in Paraná and its integration with the national committee would be an important step, providing as it would the principal forum for guiding research on the animal, as well as promoting integration with other institutions working on the southern muriqui, most especially in São Paulo. The committee would be the point of contact and articulation among non-governmental organizations, universities and state and federal governments, besides dealing directly with landowners concerning the creation of private reserves.

Improved policing for environmental crimes and abuses and inappropriate land use and management in the Rio Ribeira valley in Paraná is urgent. If current practices do not change, the tiny remaining forests in any reasonable state of conservation will be lost, and with them the chances for survival of the muriqui there. Government measures to improve the livelihoods, education, and well-being of the local communities in the region are also urgently needed. Development in the region has been slow, but the introduction of activities oriented towards reforestation and the conservation of the forests there would undoubtedly be a viable option. A reforestation project of Bracatinga has already begun in the northern Paraná section of the Ribeira valley, an initiative of the Development Agency for the Middle Ribeira Valley (*Agência de Desenvolvimento Mesorregião Vale do Ribeira*), in partnership with the Brazilian Agricultural and Cattle-Breeding Research Company (*Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA*) and the State Company for Technical Assistence and Rural Extension (*Empresa Estadual de Assistência Técnica e Extensão Rural – EMATER*), financed by the Ministry of National Integration (*Ministério de Integração Nacional*), in the municipilaties of Bocaiúva do Sul and Campina Grande do Sul.

In conclusion, this is the moment to think of the strategic re-establishment of wildlife corridors extending to the Paranapiacaba Ecological Continuum, using these isolated forest fragments of the Ribeira valley as stepping stones and bridges. Diversified agrosilvicultural projects could well be an excellent solution in the short- to medium term, besides the implementation of agricultural policies to improve farming practices, to end the predominant and pernicious traditional systems, which include itinerant farming (slash-and-burn) that has for years been degrading the soils and ruining the landscapes of the region.

Acknowledgment

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STATUS OF THE MURIQUI (*BRACHYTELES*) POPULATIONS REMAINING IN THE STATE OF RIO DE JANEIRO, BRAZIL: PROJETO MURIQUI-RIO

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Abstract

In his study of the status and geographic distribution of the muriqui, *Brachyteles arachnoides*, of the Atlantic forest, Aguirre (*O mono* Brachyteles arachnoides *(É. Geoffroy). Situação atual da Espécie no Brasil*, Acad. Brasil. Ciênc., Rio de Janeiro. 1971) documented its widespread disappearance from the state of Rio de Janeiro, identifying only six localities where it could still be found, and estimating a population of only 650 to 840 individuals. In this paper, I report on 25 survey expeditions carried out from 1999 to 2003 to verify the continued presence of muriquis in six localities in the state of Rio de Janeiro: the Serra dos Órgãos National Park, Desengano State Park, Paraíso Ecological Station, the Cairuçú Environmental Protection Area (adjoining the Serra da Bocaina National Park), the region of Macaé de Cima and the Itatiaia National Park. A total of 55 muriquis were seen in Serra dos Órgãos, Cairuçú, and Desengano. Local inhabitants reported that muriquis were now very rare in the region of Macaé de Cima and the Paraíso Ecological Station. No muriquis were seen in the Itatiaia National Park, but three specimens on show in the museum indicate that it is the northern muriqui (*B. hypoxanthus*) which occurs there, rather than the southern muriqui (*B. arachnoides*) known from the rest of the state.

Key Words – muriquis, *Brachyteles*, conservation, distribution, Atlantic forest, Rio de Janeiro

Introduction

In his study of the status and geographic distribution of the muriqui, *Brachyteles arachnoides* (É. Geoffroy, 1806), of the Atlantic forest, Álvaro Coutinho Aguirre (1971) documented its widespread disappearance from the state of Rio de Janeiro, identifying only six localities where it could still be found, and estimating a population of only 650 to 840 individuals. Over the last 35 years, we have witnessed an accelerated destruction of the Atlantic forest, not just in the state of Rio de Janeiro, but in all of eastern and southern Brazil. Forest covered 97% of the state in 1500, but with the various economic cycles, based largely on the exploitation of natural resources, today the forest is entirely fragmented, and has been reduced to 7,346.29 km², about 17% of its original extent (42,940 km²) (Fundação S.O.S. Mata Atlântica / INPE, 2001).

Hunting has also been a major factor in the disappearance of muriquis from the state and, although today minimal in terms of its volume compared to the past (Lane, 1900), is no less significant in its depredation of the tiny and isolated populations remaining. According to Silva (1987), more than 10 muriquis were shot in 1980 in the Serra do Subaio, in the municipality of Guapimirim, and Martuscelli (1994) recorded that five muriquis were killed by local hunters in the vicinity of the Pico do Cairuçú, municipality of Paraty, in 1990.

Very little is known about the numbers or the location of the remaining populations of muriquis in the state of Rio de Janeiro. Morphological, genetic and social differences have led a number of researchers to argue for the existence of two subspecies of muriqui, one southern and the other northern, divided by the Serra da Mantiqueira (Lemos de Sá *et al*. 1990). Populations in Minas Gerais and Espírito Santo (*B. hypoxanthus* [Kuhl, 1820]), have spotty, partially depigmented faces and genitalia, and a vestigial thumb, but those in São Paulo (*B. arachnoides*) have darkly pigmented faces and genitals, and lack the vestigial thumb (Lemos de Sá and Glander, 1993). Coimbra-Filho *et al*. (1993), Rylands *et al*. (1995, 2000) and Groves (2001) consider them to be distinct species.

As Rio de Janeiro marks the supposed range limits of the two species, there are doubts even as to the taxonomic identity of the muriquis there. The "Projeto Muriqui-Rio" was created in 1999 to obtain information regarding the whereabouts, identity, and population sizes of muriquis in the state of Rio de Janeiro as well as to assess the threats they are facing. This paper reports on the findings from a series of surveys, including numerous interviews of local people, carried out by a team led by the author from 1999 to 2003 specifically to address these questions.

Methods

From January 1999 to December 2003, we visited six protected areas in the potential range of the muriqui in Rio de Janeiro. Each field trip lasted from 7 to 30 days and our survey methodology included: 1) interviews with the staff of the protected areas and people in nearby villages; 2) consultation of topographic maps at different scales to locate and demarcate sites to be surveyed; 3) the hiring of local guides in each locality; 4) daily walks along trails in search of muriquis; 5) use of 'play-back' — playing a recording of muriqui vocalizations ('long-calls') using a speaker, walkman tape-recorder, a 200W amplifier and battery; and 6) use of a Geographic Positioning System (GPS) Garmin 12XL) to map the trails we walked and to pinpoint the locations of primate sightings. When seeing muriquis, we recorded the time and duration of the encounter, GPS coordinates and altitude, group size, sex and age of the individuals seen (adults, juveniles and infants), the vegetation type and height in the forest, and made descriptions of their appearance and behavior (for example, their reactions to us). We always accompanied the muriquis for as long as we could. In general, we used already existing trails, but in some cases it was necessary to open up new ones.

Results

We carried out 25 expeditions from 1999 to 2003. We were able to verify the presence of muriquis in three of the six protected areas we visited: the Serra dos Órgãos National Park, Desengano State Park, and the Cairuçú Environmental Protection Area (adjoining the Serra da Bocaina National Park).

Serra dos Órgãos National Park
The Serra dos Órgãos National Park of 11,800 ha (elevations ranging from 300 to 2,263 m above sea level) is marked by precipitous terrain, with steep cliffs rising above the dense submontane forest typical of the Serra do Mar. We identified four vegetation types in the park: dense evergreen submontane forest (*floresta ombrófila densa submontana*), montane evergreen forest (*floresta ombrófila montana*), high altitude evergreen forest (*floresta ombrófila alto montana*), and high altitude grassland (*campos de altitude*).

The first expedition to the park in 1999 involved 30 days of fieldwork. No muriquis were seen then, but we succeeded in finding them during intense fieldwork there over 10 months in 2002 (see Garcia and Andrade Filho, 2002; Garcia, 2005). Groups were seen in four locations: forest near to the Dedo de Deus ("Finger of God", a notable rock formation), and in the vicinity of the headwater springs of three rivers: the Rio Paquequer, Rio Soberbo (Garrafão), and Rio Santo Aleixo. The first three locations are close to each other, and were quite possibly sightings of the same group. The maximum number of individuals seen in the three areas was 22. At Santo Aleixo we saw another group of at least 15 animals. As such, the minimum number of muriquis seen was 37, we believe in two separate groups.

The muriquis in the Serra dos Órgãos National Park had the appearance of *B. arachnoides*; all with dark faces. They were very shy, and intolerant of our presence. On seeing us, one of the adults would face us, apparently trying to intimidate us, grimacing, shaking branches, and vocalizing loudly while the other muriquis would slip away silently.

Three other primates were seen in the park: the horned capuchin (*Cebus nigritus*), the brown howler monkey (*Alouatta guariba*), and the black-tufted-ear marmoset (*Callithrix penicillata*) (introduced). Cunha (2003) has also registered the black-fronted masked titi (*Callicebus nigrifrons*) in the region, but we never saw it in the park.

A number of hunter's hideouts (*ranchos*) were found in the park, one of them (found by the team in 1999) near the home range of the muriquis, with many shotgun traps (*trabucos*) and rifles. At Santo Aleixo we found a capuchin monkey in a trap for large animals. There are two other threats to the muriquis in the park besides hunting: loss of forest due to occasional wildfires, especially in the dry season, and, as argued by Cunha (2004), adventure tourism.

Paraíso Ecological Station
The Paraíso Ecological Station of 5,000 ha is in the municipalities of Guapimirim and Cachoeiras de Macacú (22°26'–22°32'S and 42°50'–42°56'W). Altitudes range from 60 m to 1,350 m (Serra do Subaio) above sea level. The vegetation there is typical submontane and montane forest. We worked for seven days in the area, but no muriquis were located. The people there informed us that they were very difficult to see, having been, for too long, a favored target of hunters. Silva (1987) reported that more than 10 muriquis were killed in the Serra do Subaio in 1980.

Region of Macaé de Cima
Part of the 46,350 ha of forests that today make up the Três Picos State Park, this region (22°21'–22°28'S and 42°27'–42°35'W) is covered by typical montane evergreen forest at altitudes ranging from 880 m to 1,720 m (Lima and Guedes-Bruni, 1997a). It is one of the most important areas of montane forest remaining in the state of Rio de Janeiro. Botanically rich, the flora includes representatives of 122 families, and 1,103 species of vascular plants have been recorded there. Predominant are Lauraceae, Myrtaceae, Melastomataceae and Leguminosae (Lima and Guedes-Bruni, 1997b). We spent 15 days in the area but no muriquis were seen. Local inhabitants told us they were there, but very rare. The primates we did see were the buffy-tufted-ear marmoset (*Callithrix aurita*), horned capuchin monkey (*C. nigritus*) and the brown howler monkey (*A. guariba*). The forest was well preserved, and the rarity of the muriquis could only be due to hunting. Four hunter's hideouts

were found with shotgun traps (*trabucos*) and traps for medium-sized animals.

Desengano State Park
In the municipalities of Santa Maria Madalena, São Fidélis, and Campos, this park of 22,400 ha protects the last remnant of the Atlantic forest in the northern part of the state. The vegetation there is dense evergreen submontane (up to 500 m) and montane (between 500 and 1,500 m) forest and high altitude grasslands (above 1.600m).

We carried out four expeditions to the park. The first was for 20 days in June and July of 1999, when we surveyed the forests of Morumbeca (*Matas da Morumbeca*) cited by Aguirre (1971). We found a group of 17 muriquis (15 adults and 2 infants) on 12 July 1999 at 13:00 h, at a place called "Boqueirão da Mata na Serra Grande" (21°52'90"S, 41°52'93"W), about three hours walking from Morumbeca (base camp). Other locations in the park were visited between November 2002 and March 2003. In January 2003, again at Morumbeca, our team found two muriquis crossing a trail going up to the Pedra do Desengano, 200 m away. It was not possible to be sure of the identity of the muriquis as either *B. hypoxanthus* or *B. arachnoides*. Howler monkeys (*A. guariba*) and capuchin monkeys (*C. nigritus*) were also seen within the park boundaries. There are people living, illegally, within the park. They have some livestock and cultivate small garden plots, and hunt. According to informants there, muriqui meat is much appreciated.

Cairuçú Environmetal Protection Area (APA)
The APA Cairuçú (33,800 ha) is in the far south of the municipality of Paraty (23°10'–23°23'S and 44°30'–44°51'W). The continental portion begins at the Rio Mateus Nunes and ends at the state border with São Paulo, and the island portion (63 islands) extends from the Ilha do Algodão in Mambucaba (see Vaz, 1998) to the Ilha da Trindade in Trindade. It adjoins the Serra da Bocaina National Park in São Paulo. The relief is mountainous with altitudes ranging from sea level to 1,320 m (Pico Cairuçú). Marques (1997) reported the following vegetation types there (in order of importance): Dense evergreen forest; secondary forest, rocky outcrops and rocky shorelines; mangroves and *restinga* (coastal scrub and forest on sand soil). There are cultivated areas, beaches and urban areas such as the town of Paraty itself and the Condomínio Laranjeiras (a housing estate).

The word 'cairuçú' translates in Tupi-Guarani to "cai" = monkey and "ruçu" = big, which makes us believe that muriquis were common in the region at least in the past. We spent 33 days in the area in August and September 1999, and later in February and December 2000. We visited the following locations: Toca do Ouro (adjoining the Serra da Bocaina National Park), Pico do Cairuçú (Vargem Grande and the coastal area of the beach of Martin de Sá, Juatinga Ecological Reserve) and Saco do Mamanguá. Only one muriqui was seen; at the Toca do Ouro, identifed as *B. arachnoides*.

Protected by local legislation, the local people, called caiçaras, are fisher communities but also hunt, even though local informants told us that there was little wildlife left. With regard to habitat loss and degradation, the impact of the caiçara communities is not yet serious, but is increasing markedly. Specimens of muriquis in the mammal collection of the Museu Nacional of the Federal University of Rio de Janeiro (UFRJ) were collected in Pedra Branca (Paraty) in 1941 and 1943 and Mambucaba, Angra dos Reis in 1942 (Vaz, 1998).

Itatiaia National Park
The Itatiaia National Park is in the southwest of the state of Rio de Janeiro (22°19'–22°45'S and 44°45'–44°50'W), in the municipalities of Resende and Itatiaia, extending into southern Minas Gerais, in the municipalities of Alagoa, Bocaina de Minas and Itamonte. With an area of 28,267 ha, the park takes in the highest elevations of the Serra da Mantiqueira, and is characterized by mountains and rocky outcrops at altitudes of 650 m to 2,787 m (Pico das Agulhas Negras). According to the phytoecological classification of Veloso *et al.* (1991), the vegetation of the Itatiaia National Park includes: Dense evergreen montane forest at altitudes ranging from 650 m to 1,500 m; high altitude evergreen forest, above 1,500 m; mixed montane evergreen forest with *Araucaria angustifolia* at altitudes around 1,200 m; seasonal semideciduous montane forest along the leeward slopes at 500 m; and high altitude grasslands in rocky and precipitous regions above 1,600 m (IBDF, 1982).

We visited the park twice — in October 1999 and in December 2002. We did not see any muriquis on either occasion. Câmara (1995) and Marriog and Sant'Anna (2001) however, have registered their presence there. We examined three taxidermized muriquis on show in the museum of the park; an adult male, adult female and infant collected by Elio Gouveia in 1950 at a location called Maromba that is within the park boundaries. All three had the vestigial pollex, which would characterize it as the northern muriqui, *B. hypoxanthus* (Lemos de Sá and Glander, 1993). We saw the black-fronted masked titi (*Callicebus nigrifrons*) and the horned capuchin monkey (*C. nigritus*) during our field surveys there.

It would appear that there is little hunting in the area, even though there are some private properties within the park (Rocha *et al.*, 2003). There is some adventure tourism which could be affecting the use of the forest by the muriquis, as was observed by Cunha (2005) in the Serra dos Órgãos National Park.

Discussion

Distribution and abundance of muriquis in the state of Rio de Janeiro

Montane forests at elevations above 500 m in Rio de Janeiro and other regions of southeast Brazil are evidently good habitat for the muriqui (Aguirre, 1971). The largest areas of forest remaining in the state of Rio de Janeiro are in these mountainous regions, and many are in protected areas (Rocha *et al.*, 2003). Of the six surveyed by the Projeto Muriqui-Rio, we were able to confirm muriquis in three (Serra dos Órgãos National Park, APA Cairuçú, and Desengano State Park); observing a total of 55 individuals. Although this is a small number, much lower than was estimated for the state by Aguirre (1971) in the 60s (between 650 and 840), it is patent that much more research and field work are needed. Their long history of being hunted means that muriquis are not just scarce but also extremely wary and shy, and they now reside in areas of extremely difficult access. Further work needs to be done in the areas we have visited, as well in the four protected areas we have yet to survey, all of which are reported to contain muriquis: Tinguá Biological Reserve (26,000 ha), APA Mangaratiba (22,936 ha), Três Picos State Park (46,350 ha), and the Serra da Bocaina National Park (110,000 ha). The region around Pedra Branca (Paraty) is also a priority for further surveys, considering the historical (1941 and 1943) records of muriquis occurring there.

In Rio de Janeiro, the muriquis are confined to montane forests at high elevations, difficult to reach and difficult to survey, which also means that we are undoubtedly underestimating their numbers. In the Serra dos Órgãos National Park, for example, they were found at altitudes ranging from 800 m to 1,500 m (Garcia, 2005). Muriquis may also occur in naturally lower densities in the larger forest tracts, as has been noted for the southern muriqui in São Paulo by Strier (2000). In spite of these difficulties, it is vital that we obtain better and more precise information on the number and extent of muriquis remaining in the state if we are ever to draw up a realistic conservation plan for the species.

Based on the absence of the vestigial pollex and the presence of dark pigmentation in the bare skin of the face and genitals of the muriquis that we observed in Serra dos Órgãos National Park, and on the presence of the thumb and the freckled pigmentation of the three stuffed specimens on show in the museum in the Itatiaia National Park, it is evident that both species occur in the state—*B. arachnoides* in the Serra do Órgãos and *B. hypoxanthus* in Itatiaia. The southern muriqui (*B. arachnoides*) evidently occurs along the Serra do Mar, from northern Paraná, through São Paulo into Rio de Janeiro, passing as such through the southern (APA Cairuçu and Serra da Bocaina National Park) and central (Serra dos Órgãos National Park) regions and probably extending into the north of the state (Desengano State Park). The northern muriqui (*B. hypoxanthus*) then would be in the southwest (Itatiaia National Park), following the Serra da Mantiqueira. These roughly delineated distributions require further research.

Threats to the muriqui in Rio de Janeiro

Although occurring in a number of protected areas, we found that muriquis were under pressure from hunting, habitat loss and degradation, and disturbance from human activities of all sorts everywhere we went. In the Serra dos Órgãos National Park, for example, both adventure tourism (perhaps restricting the area that the muriquis will use) and hunting were evidently serious enough to be prejudicial to the small number of muriquis surviving there (Cunha, 2005). We found evidence of hunting throughout the park. In the APA Cairuçú, the Paraíso Ecological Station, and in the region of Macaé de Cima hunting is also the key factor, both from the evidence we found and the reports of Silva (1987) and Martuscelli (1994). Both hunting and deforestation by squatters are threats in the Desengano State Park. The Itatiaia National Park would seem to be comparatively free of hunting, and habitat loss is probably the key issue with the constant presence of people living in the park, of tourists, the threat of fires, and the illegal exploitation of plants such as palms for palm hearts (Rocha *et al.*, 2003).

Muriquis are large, they travel in large groups, and are quite noisy, which makes them easy prey to the patient hunter. We were informed in the APA Cairuçú and the Desengano State Park that muriqui meat is considered a delicacy. As they have a slow reproductive rate (one infant every three years: Strier, 1993–1994) and possibly naturally low densities in the larger areas of forest (Strier, 2000), killing just a few individuals each year can have serious consequences in determining a gradual decline in numbers. Besides increasing vigilance, it is important that environmental education programs be put in place in the vicinity of these parks.

Future research

There are long-term programs in conservation and research in most of the states where muriquis occur. Rio de Janeiro is one, however, where activities of this sort are unfortunately still incipient. We still lack basic information on the numbers and location of the surviving populations of muriquis, besides many other threatened species. In 2005, André A. Cunha and Jean P. Boubli launched the Projeto Muriqui-Rio Fase II, with the specific objective of determining how many muriqui populations are remaining in the state and their size. This project has received financial support from Conservation International, The International Newcomers Club of Rio de Janeiro, the Zoological Society of San Diego, the Serra dos Órgãos National Park and the Brazilian Institute for the Environment (IBAMA), and the Instituto Terra de Preservação Ambiental. The Projeto Muriqui II will visit further sites and also collect fecal samples of muriquis in order to begin genetic studies examining the genetic diversity and structure of the remaining populations. Two sites will be selected to set up long-term ecological, behavioral and demographic studies, including

phenological and floristic monitoring of the vegetation, to examine the ecological diversity of the muriquis.

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SURVEY AND STATUS OF THE MURIQUIS (*BRACHYTELES ARACHNOIDES*) IN THE SERRA DOS ÓRGÃOS NATIONAL PARK, RIO DE JANEIRO

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Abstract

The Serra dos Órgãos National Park protects 11,800 ha of Atlantic forest in the state of Rio de Janeiro (22°30'S, 43°06'W; 300 to 2,263 m above sea level). Vegetation types include montane dense evergreeen forest up to altitudes of 1,800 m; cloud forest from 1,800 to 2,000 m; and high altitude grassland above 2,000 m. This paper reports on surveys carried out in 10 localities in the park specifically to obtain a minimum estimate of the population of northern muriquis (*Brachyteles arachnoides*). Muriquis were sighted 26 times at altitudes ranging from 800 to 1,500 m. It is possible that they belonged to four groups in which case the minimum number of individuals recorded would be 56. If in fact the sightings were of just two groups, the minimum number of individuals would be 32. Black-horned capuchin (*Cebus nigritus*) and brown howler monkeys (*Alouatta guariba*) were also recorded for the park. The buffy-tufted-ear marmoset (*Callithrix aurita*) was not seen.

Key Words – primates, muriqui, *Brachyteles*, Serra dos Órgãos, Atlantic forest, Brazil

Introduction

There is now some quite substantial information on the populations of the northern muriqui in Minas Gerais (*Brachyteles hypoxanthus*) in the states of Minas Gerais and Espírito Santo, as well as on the occurrence of the southern muriqui (*B. arachnoides*) in São Paulo (Mittermeier *et al*., 1987; Paccagnella, 1991; Pinto *et al*., 1993; Martuscelli *et al*., 1994; Strier and Fonseca, 1996/1997). The same cannot be said of the state of Rio de Janeiro, where the remaining populations have yet to be located and counted — it is still unclear exactly which of the species occur there.

In his survey more than 30 years ago, Aguirre (1971) found that they had disappeared from most of their range in Rio de Janeiro, and estimated a total population of only about 770. From 1999 to 2003, Garcia (2005) surveyed a number of localities in the state (Projeto Muriqui – Rio) in order to identify their continued occurrence there and the status of the populations. Hunting and forest loss continue to be major threats. The "Projeto Muriqui" was created in 2002 in the Serra dos Órgãos National Park as a focus for studies on the conservation of muriquis in Rio de Janeiro. Here I report on the results of one of the projects of this program; a study of the remnant population of muriquis in the park itself.

Methods

Study area

The Serra dos Órgãos National Park, of 11,800 ha, was created in 1939. It covers parts of the municipalities of Petrópolis, Teresópolis, Magé and Guapimirin, in Rio de Janeiro (22°30'S, 43°06'W) (Fig. 1). A number of rivers supplying water to urban centers in the lowlands have their sources in these mountains, including the rios Paquequer, Soberbo, Jacó, Bananal, Bonfim and Santo Aleixo. The terrain is one of steep slopes and rugged mountains, with elevations ranging from 300 to 2,263 m (the Pico da Pedra do Sino). The climate is tropical superhumid, with temperatures during the year averaging 19°C.

The park is largely forested, within the domain of the Atlantic Forest (Rizzini, 1997): lower montane, montane and upper montane dense evergreeen forest (*Floresta Ombrófila Densa*), following the classification of Veloso *et al.* (1991). Following the altitudinal gradient it is possible to identify three phytophysiognomies in the park: montane forest — the majority of the park, with very large trees and a high canopy, at altitudes up to 1,800 m; cloud forest (*Mata Nebular*) — with smaller trees, lower canopy, abundant in epiphytes, from 1,800 a 2,000 m; and high altitude grassland (*Campos de Altitude*) — with shallow soils, bushy and herbaceous plants, many of them of endemic, at altitudes above 2,000 m. Although the forest would appear to be primary — with immense trees, and rich in palms, lianas, and epiphytes — the long history of exploitation of these forests means that they are in fact secondary, but in late stages of succession. Only some parts of the park maintain their original forest cover.

Data collection

In a reconnaissance expedition in January 2002, we visited the park and neighboring areas to determine where muriquis had been seen. Ten areas were selected. Field work was from February to October 2002. To reach the

Figure 1. Location of the Serra dos Órgãos National Park in the state of Rio de Janeiro.

locations where muriquis had been reported, it was necessary to provide training in rock climbing techniques (Fig. 3). The field team included a coordinator in field research, two assistants, three mountain climbers from Teresópolis, two guides from Santo Aleixo (the village near the park), and four porters.

The areas surveyed were some distance from the park headquarters and difficult to reach. We camped in each location for up to 10 days. The porters were dispensed with once camp had been set up. Locations and sightings were mapped using a Geographic Positioning System, although satellite reception was rather intermittent. We also mapped our survey routes and made notes on sightings of other primates and large mammals and birds, as well as all signs of hunting (including traps and hideouts) and encounters with the hunters themselves and their dogs.

To locate the muriquis we would watch for them from vantage points, such as rocks or trees that afforded broad views of a valley and the surrounding forest. All day watches were set up at these lookouts while other team members would walk the trails (Fig. 4). We used existing trails mostly, but in some areas it was necessary to cut new ones. Radios "Talk" were used to maintain contact between team members and an HT radio to maintain contact with the park headquarters.

We used "play-backs"—a recording of muriqui vocalizations to increase the chance of locating them. We did four to six play-back sessions a day, each one lasting 15 minutes

Figure 2. View of Serra dos Órgãos National Park, showing some of the rock. Peaks from left to right: Escalavrado, Dedo de Nossa Senhora, Dedo de Deus and Cabeça de Peixe. Photo by José Caldas.

Figure 3. An obstacle met when surveying the muriquis in the Serra dos Órgãos National Park.

Figure 4. One of the of the observation points for muriquis in the Serra dos Órgãos National Park.

(Fig. 5). For each muriqui sighting we noted the following: date, time, number of individuals, age-category and sex when possible, vegetation type, activity when first seen, and the location. We accompanied each muriqui group for as long as possible. We surveyed ten areas, totaling 86 days of field work, averaging 65 hours per expedition. "Playback" recordings of their vocalizations were broadcast for a total of six hours and 55 minutes.

Results

We saw muriquis 26 times, and found indications of hunting on 24 occasions (Table 1). The areas where we found most signs of hunting were Santo Aleixo and Rio Bananal. The majority of them were their hideouts and camps, but we also found nets and various types of traps including shotgun traps (armed), and wooden platforms, and ceven came across the hunters' dogs and the hunters themselves. A black-horned capuchin (*Cebus nigritus*) was in one of the traps (it was photographed and released). Nearly all the camps we found were evidently recent, with the remains of food, a cooking fire, and cooking utensils — ready as such to be used at any time. In most cases we were able plot the location of these camps with the GPS.

Despite the considerable use of the "play-back" recordings, they resulted in replies from the muriquis only twice. On the first occasion the team, watching from a lookout had already seen a group, which was living in the area of

Table 1. Expeditions dates, their duration and hours in the field, time spent in playback sessions, number signs of hunters, sightings of muriquis, and numbers of fecal sample obtained. Serra dos Órgãos National Park, Rio de Janeiro.

Expedition (months) 2002	No. of days	Field work (hours)	Time spent in 'playback'(mins.)	Signs of hunting[1]	Sightings	Number of feces collected
Rio Beija Flor (February)	4	40	0	2	0	0
Dedo de Deus and Cabeça de Peixe (February–March)	5	36	0	1	1	1
Rio Paquequer or Córrego Pedra Açu (March)	7	25	0	1	2	1
Vale das Orquídeas and Basin of the Rio Paquequer or Córrego Pedra Açu (April)	8	77	230	0	1	0
Basons of the rios Jacubá and Beleira and Pedra Itaculumi (Santo Aleixo) (May)	11	66	95	4	0	0
Trilha das Torres da CERJ (Santo Aleixo/Petrópolis) (June)	10	56	0	2	0	0
Basin of the Rio Bananal (July)	10	78	135	4	0	0
Basin of the Rio Soberbo (August)	10	82	105	1	12	3
High altitude grassland and Rio Jacó	10	75	45	2	0	0
Rio Santo Aleixo	11	114	45	7	10	1
Total	**86**	**649**	**655**	**24**	**26**	**6**

[1]Hunters' camps, traps, hunters and their dogs.

the springs of the Rio Paquequer. The muriquis had not seen the observer, who decided to test the recording. The muriquis were moving away, but when they heard the recording the turned about and moved towards the calls. On the second occasion, the observer had just completed a playback session, but was leaving because it was becoming foggy, at which moment an adult female appeared out of the mist in the exact spot were the recording was being played. It would seem that she had responded to the playback even though she did not herself vocalize.

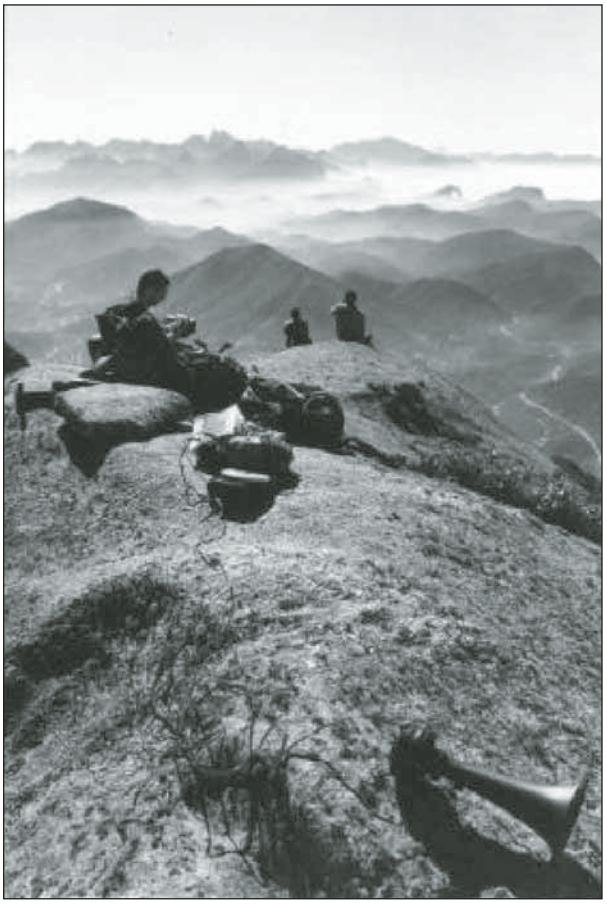

Figure 5. Testing the "playback" equipment, Serra dos Órgãos National Park, Rio de Janeiro.

The muriquis we saw in the Serra dos Órgãos National Park looked more like the southern muriqui (*B. arachnoides*) than the northern (*B. hypoxanthus*). Their faces were very black. They were very difficult to observe. On seeing us they would make alarm calls. One individual would show intimidating behavior, calling, while the rest of the group would slip away quietly. They were seen in four areas of the park: in the forests adjacent to the Pedra do Dedo de Deus and the Pedra da Cabeça de Peixe (individuals were seen, and photographed going up and down the latter, which is entirely forested), and areas of the springs of the rios Paquequer, Soberbo and Roncador (or Santo Aleixo) (Table 2). When we saw them near the Dedo de Deus (in March) they were eating fruits of a *Myrcia* (Myrtaceae) tree, the seeds of which were consistently found in the feces we collected in the area of the Rio Soberbo in August. It would seem that the species fruits for prolonged periods or that the mountainous terrain provides for different climates in the various parts of the park that in staggered fruiting. The muriquis of the Rio Soberbo were also seen eating fruits of *Crysophyllum viride* (Mart. & Eichler), a tree of the Family Sapotaceae. We found seeds of at least six other species in their feces, but they could not be identified. The high altitudes and humid conditions year round in many parts of the park, we believe favor fruit production even in the dry season, when they would be lacking in drier forests.

If the muriquis seen in each of the four areas are different groups, we have a minimum count of 56 for the park. We saw muriquis at altitudes ranging from 800 to 1,500 m. One record, a photograph taken by a tourist of a muriqui walking on the ground was at 2,000 m in the high altitude grassland. This is the highest elevation recorded for the species, which Aguirre (1971) believed should be between 1,800 and 2,000 m. The best estimates for group composition came from observations of the Rio Soberbo and Paquequer muriquis. Solitary females, females with infants, juveniles of different sizes, and adults.

Two other primates were observed besides the muriquis: the black-horned capuchin (*Cebus nigritus*) and the brown howler monkey (*Alouatta guariba*) (Fig. 6). The buffy-tufted-ear marmoset (*Callithrix aurita*) certainly

Table 2. Sightings of muriquis in the Serra dos Órgãos National Park, Rio de Janeiro.

Location	Altitude (m)	Number of indivíduals	Age/sex composition[1]	Forest type[2]	Activity when first seen
Forest adjacent to the mountain peaks of Dedo de Deus and Cabeça de Peixe	1.300	7	3AD, 1AM, 1AF, 2JU	MF	Eating fruit
Rio Paquequer basin (Córrego Pedra Açu)	1.500	17	1AM, 6AD, 1AF+1, 9UN	MF	Traveling
Rio Soberbo basin	1.250–1.493	20	2AF+1, 5JU, 12AD	MF and HAF	Eating fruit
Rio Roncador (Santo Aleixo)	800–1.200	12	10AD, 2JU	MF	Vocalizing
Total		**56**			

[1]AM = adult male; AF+1 = adult female with infant; JU = juveniles; UN = sex and age unknown; AD = adults
[2]MF = montane rain forest; HAF = high altitude rain forest.

occurred in the region in the past (specimens in the Museu Nacional of Rio de Janeiro), but it was never seen. An introduced black-tufted-ear marmoset (*Callithrix penicillata*) was seen near the park headquarters. Muriquis were the most frequently seen of the primates, even though they were only found in four areas. Capuchins and howler monkeys were seen in most of the areas we visited, but only very infrequently.

Table 3. Population density estimates for muriquis, *Brachyteles*. For the Serra dos Órgãos National park (this study) the estimated minimum number of muriquis was divided by the area of the park (in bold).

Local	Estado	Área (km^2)	Densidade (ind/km^2)
Jacupiranga State Park	SP	300.00	0.0067
Jurupará State Park	SP	263.00	0.0190
Alto Ribera State Park	SP	350.00	0.0343
Serra do Mar State Park	SP	662.50	0.0377
Juréia State Park	SP	200.00	0.0400
Rio Doce State Park	MG	360.00	0.0583
Caparão National Park	ES	260.00	0.0731
Ibitipoca State Park	MG	14.88	0.1344
Fazenda São Sebastião do Rio Grande	SP	107.00	0.2056
Serra do Brigadeiro State Park	MG	200.00	0.2500
Augusto Ruschi Biological Reserve	ES	40.00	0.2750
São Francisco Xavier	SP	40.00	0.3750
Parque Nacional da Serra dos Órgãos	**RJ**	**118.00**	**0.474**
Intervales State Park	SP	380.00	0.6316
Carlos Botelho State Park	SP	376.44	1.3282
Mata do Sossego Biological Station	MG	8.00	2.6250
Fazenda Barreiro Rico	SP	32.59	2.9150
Caratinga Biological Station	MG	8.60	10.4651
Fazenda Córrego de Areia	MG	0.60	13.3333
Fazenda Esmeralda	MG	0.44	27.2727

Source: Strier & Fonseca, 1996/1997.

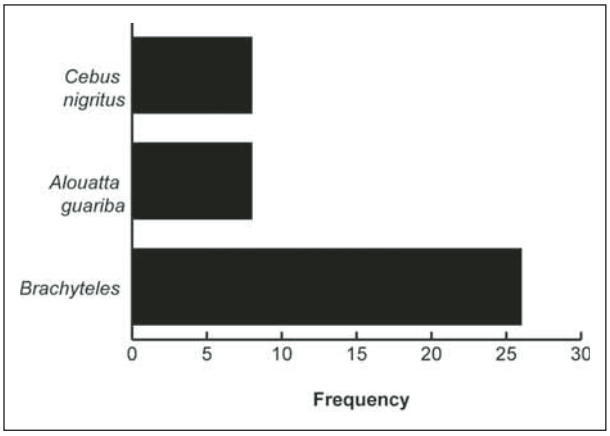

Figure 6. Numbers of sightings for three primates in the Serra dos Órgãos National Park, Rio de Janeiro.

Discussion

Dividing the estimated minimum number of muriquis (56) by the area of the park gives a density of a little less than 0.5 muriquis per km^2 (Table 3). Although not very different from estimates of populations elsewhere, it would still seem very low, and is certainly lower than any population which would be considered viable in the long-term (Lande, 1988). It is quite possible that the overall density is low because not all parts of the Serra dos Órgãos National Park provide suitable habitat in terms of the abundance and dispersion of food resources. Equally it may be that in these montane habitats home ranges are naturally larger for the same reason. Prolonged field research would be required to test this and, considering the difficulties of working in such terrain, the chances of such studies being carried out would seem to be slim.

While hunting is obviously taking its toll, the muriquis are extremely shy and the terrain so difficult for any realistic estimate. The growth of the population at the Caratinga Biological Station in Minas Gerais, would, however, be reason for hope that, with due protection and time, the population would increase considerably (Strier, 2000). Under any circumstances there are no doubts this is a most significant population, both genetically and in terms of numbers.

We presume that the observations of muriquis in the four areas were of different groups. Strier (1987) in her study of *B. hypoxanthus* in the Caratinga Biological Station recorded that muriquis can travel up to 3,400 in a single day, and it is possible in this case that the Rio Soberbo, Dedo de Deus and Rio Paquequer were of the same group or just two groups, rather than three. We have no doubts that the Santo Aleixo group at least was not confused with any of the others because of the distance separating them. If there were in fact only two groups, the minimum number would be 32 (20 for Soberbo and 12 at Santo Aleixo). If three groups, the number would perhaps be 49 (Soberbo with 20, Paquequer with 17, and Santo Aleixo with 12). Further studies, including the use of radio-collars perhaps, would be needed to understand better the ranges of these muriqui groups and provide more accurate counts.

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CONSERVATION GENETICS OF THE MURIQUI: PAST, PRESENT AND FUTURE

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Abstract

Our understanding of the genetics of the muriqui have increased in recent decades. In the mid 1980's the first data was obtained from polymorphisms of allozymes of 10 individuals of *B. hypoxanthus* (northern muriqui) from Minas Gerais, and two individuals of *B. arachnoides* (southern muriqui) from São Paulo. All specimens were considered to be of a single species. The DNA was extracted from blood samples, which required capture and anesthesia of animals. We can now extract mitochondrial DNA from feces samples. Analyzing more than 120 individuals of the northern muriqui from two populations, we are now able make inferences about genetic variability, population distinctiveness as well as intra- and interpopulation gene flow. DNA sampling through feces is reliable, efficient, and economic, and does not risk the physical integrity of the animals, and furnishes enough DNA that is easily reproducible for PCR amplification. Using this method it is possible to sample a greater number of individuals in nature than would be possible if live capture were necessary. A muriqui feces and DNA bank has been set up, and currently has samples of 230 individuals from seven of the twelve known populations of northern muriqui. The samples resulted from field studies, but more coordinated and systematic efforts among fieldworkers at the different muriqui sites are needed to improve representation across populations and species. Future perspectives include the use of new genetic markers (nuclear and mitochondrial DNA) to identify parents, offspring, and closely related individuals in captive and wild populations; to define units for conservation and the gene flow between them; to quantify genetic variability in the populations; to assess the rate at which genetic variation has been lost over time; to estimate the degree of inbreeding in the population; and to understand better the genetic differentiation of the two species.

Key Words – conservation genetics, muriqui, *Brachyteles*, fecal DNA, genetic variability.

General Issues of Genetic Conservation

A major goal of conservation biology is to preserve genetic diversity, based on the assumption that higher heterozygosity (the measure of the within-population component of genetic variation) increases the probability of a population's survival in the event of ecological or evolutionary changes. Under this concept, concerns about the conservation of biodiversity represent concerns about the conservation of genetic diversity.

For threatened species, hunting and reduction of habitat are associated with a reduction of population size. In extreme cases, a significant percentage of a population is killed or otherwise prevented from reproducing (bottleneck); the most frequent cause of loss of heterozygosity. When a large percentage of a population is lost, only a subset of the genes of the original gene pool will survive. Some alleles will be disproportionately represented, while other alleles may be gone forever. If one survivor has a rare allele, then that allele may come to be represented in the resulting population (a few generations later) in greater numbers than was the case prior to the population crash (a founder effect). In small populations, the effects of genetic drift on loss of genetic variation (stochastic events that alter allele frequencies among members of a population and change the diversity of the group over time) are much greater than they are in larger populations. Some examples of the effects of habitat reduction on loss of genetic variation have been reported for both the Florida panther (Roelke *et al*., 1993) and the cheetah (O'Brien, 1994).

A critical parameter for the management and conservation of natural populations, therefore, is the effective population size, which affects the rate at which genetic diversity is lost in the population by genetic drift (Franklin, 1980). The longer the species experiences a bottleneck, the higher the effects of genetic drift (Futuyma, 1992). Delays in promoting a species' population recovery can be highly prejudicial in terms of loss of genetic diversity, and measures that can rapidly bring about an increase in population size are paramount.

Moreover, due to reduction of population size, most of the individuals will not mate randomly within the population, and the effect of inbreeding is that the alleles are prone to become homozygous and the hybrid heterozygous advantage is lost. With inbreeding, the chance of unfavorable recessive genes turning up in the offspring is greatly enhanced. Thus, the presence of recessive alleles in the population may lead to inbreeding depression, which means impaired fitness with the reduction in evolutionary potential,

and ultimately an increase in the probability of a population going extinct (Frankham *et al.*, 2002).

The viability of species that survive short-term demographic and environmental threats may depend upon the genetic variability and its spatial distribution prior to the population crash. The spatial pattern of the population crash also has important consequences for the resulting genetic variability (or lack of it). Thus, small and isolated populations are at a higher risk of extinction than large and well-connected populations (Frankham, 1995; Meffe and Carroll, 1997; Ebert *et al.*, 2002; Frankham *et al.*, 2002).

Over the short term, most endangered species are threatened by extrinsic, environmental factors, but effective long-term conservation planning must also incorporate genetic factors. Conservation planning operates at many levels, from whole ecosystems and communities to individual organisms. At each of these levels, molecular genetic techniques may provide appropriate tools to evaluate processes and to develop management strategies. However, it is necessary to understand how molecular analyses can address questions about levels of threats and extinction.

First, threats must be identified clearly, and effective steps taken to alleviate them (Caughley, 1994). Next, it is necessary to identify priorities for conservation action — an understanding of where measures are needed most urgently to avoid the situation deteriorating rapidly and irrevocably. In both cases, molecular genetic analyses can play an important role.

Management of genetic heterozygosity is the challenge of conservation genetics. In captive populations, controlling inbreeding to maintain minimal population sizes and adequate levels of heterozygosity is crucial (Queiroz *et al.*, 2000). In natural populations, measures must be taken not only to guarantee the maintenance of the habitat, but also to facilitate gene flow among individuals of local populations in order to avoid inbreeding and loss of heterozygosity.

The general importance of genetic factors can be summarized in two points. First, knowledge of genetic variation allows an understanding of the current status and the historical evolutionary processes that generated biodiversity patterns. Second, future persistence of populations may depend upon the preservation of important remnant components of genetic diversity.

In the pre-molecular era, most of the studies involved phenotypic data amenable to observation (morphology, physiology, behavior) to estimate kinship and phylogeny (Avise, 2004). However, rapid advances in the development of molecular markers over the last two decades have facilitated gaining a better knowledge of the genetic structure of natural populations. Molecular genetic approaches have been used to identify parents, offspring, and closely related individuals in captive and wild populations; to define units for conservation, and the gene flow between such units; to quantify genetic variability of historical populations; to assess the rate at which genetic variation has been lost over time in fragmented landscapes; to estimate the degree of inbreeding in the population; to determine limits that distinguish a species, and so on. All of these areas are important in the conservation genetics of endangered species.

Conservation Genetics of the Muriqui

Interspecific differentiation

The genus *Brachyteles*, the muriqui or mono-carvoeiro, belongs to the Family Atelidae. In the past, only one species was recognized, *Brachyteles arachnoides*, distributed from southern Bahia to northern Paraná, along the Brazilian Atlantic rainforest. In 1971, Aguirre (1971) estimated that the total number of individuals had been about 400,000 individuals.

Vieira (1944) it was who recognized two subspecies of *Brachyteles*. Some morphological differences such as facial skin pigmentation and the presence or absence of vestigial thumbs suggested that this monotypic genus should be separated into *arachnoides* É. Geoffroy, 1806 (in the states of Rio de Janeiro, São Paulo and Paraná along the Serra do Mar) and *hypoxanthus* Kuhl, 1820, occurring in southern Bahia, Minas Gerais, and Espírito Santo south to the Serra da Mantiqueira. Lemos de Sá *et al.* (1990, 1993), Fonseca *et al.* (1991) and Lemos de Sá and Glander (1993) indicated that Vieira's (1944) standing was valid, but that differentiation is even more extreme and justifies the classification of the two forms as separate species (Coimbra-Filho *et al.*, 1993; Groves, 2001), the northern muriqui, *B. hypoxanthus* (Kuhl, 1820), and the southern muriqui, *B. arachnoides* (É. Geoffroy, 1806). Whether the presence or absence of vestigial thumbs is a good morphological marker to separate the species remains questionable, however (S. L. Mendes, pers. comm.).

The first question, therefore, about muriqui genetics involves whether the southern specimens, *B. arachnoides*, possess enough genetic diversification from northern specimens, *B. hypoxanthus*, to be designated as a separate species under phylogenetic approaches, and whether, in an *a priori*, non-discriminated analysis, specimens from the south group together separately from the ones from northern areas.

In general, mitochondrial DNA allows for analysis of phylogenetic relationships reflecting the history of maternal lineages within a population, requiring only one-fourth of the effective population size when compared to autosomal nuclear genes. The use of mtDNA is inappropriate for detecting paternal gene flow between populations. On the other hand, mtDNA is only a single genetic locus, lacking recombination, which reduces its power to detect the structure and the genetic history of the population at spatial and temporal levels. DNA sequence data allow both a

phylogenetic and an allele-frequency approach to the analysis of population structure and patterns of population variation. Because effective population size calculated under mitochondrial loci in a given population is one-fourth of nuclear loci, genetic drift is more powerful at mitochondrial loci; populations separated recently can show mitochondrial divergence unlike nuclear loci (Neigel and Avise, 1986). Thus, the mtDNA analyses involving samples from several localities of northern and southern muriqui would seem to be sufficient to address this question.

Genetic structure of populations

The historical deforestation of the Brazilian Atlantic forest since the 1500s has reduced it to small fragments with little or no connection between them. This has resulted in few, small and widely separated muriqui populations which represent genetic bottlenecks, and has eliminated opportunities for gene flow through the migration of individuals between these populations.

Currently, about 1,000 southern muriquis occur in relatively large and well protected areas. The situation of the northern muriquis is, however, more dramatic with fewer than 900 individuals in 12 separate populations, a large number restricted to unprotected forest fragments (Rylands *et al*. 2003; Mendes *et al*., 2005a). *Brachyteles hypoxanthus* is considered one of the world's 25 most endangered primates (Strier *et al*., 2006a).

The ecology, behavior, reproduction, and demography of a population of northern muriquis have been investigated by Karen B. Strier and her students since 1982 at the Caratinga Biological Station (EBC), also called the RPPN Feliciano Miguel Abdala (EBC/RPPN-FMA), in Minas Gerais (Strier, 1999). The population at the EBC has been growing steadily since long-term monitoring began, increasing from about 50–70 individuals in the 1980's to about 226 individuals as of January 2005 (Strier *et al*., 2006b). Since 2001, some new populations have been studied by Sérgio Mendes in the municipality of Santa Maria de Jetibá, in the state of Espírito Santo (Mendes *et al*., 2005b). Since 2003, Luis G. Dias has also initiated studies of muriqui populations in other areas of the state of Minas Gerais (Rio Doce and Serra do Brigadeiro state parks, and the Mata do Sossego private reserve).

In large populations with multiple groups, female muriquis leave their natal groups and move into others before reaching reproductive maturity, reducing the risks of close inbreeding (Printes and Strier, 1999; Strier and Ziegler, 2000). However, in smaller populations living in highly fragmented and disconnected areas, dispersal is restricted, and females with nowhere to go have been observed at the periphery of their natal groups (S. L. Mendes, pers. comm.). Research into the genetic variation and gene flow among muriqui populations and the relationship of population size to within-population genetic variability is critically needed for the formulation and implementation of a management plan to ensure the long-term persistence of remaining muriqui populations.

The first study involving muriqui genetics was conducted by Pope (1998), based on polymorphisms of allozymes of 10 individuals of *B. hypoxanthus* from Fazenda Esmeralda, Minas Gerais, and two individuals of *B. arachnoides* from Fazenda Barreiro Rico, São Paulo. The DNA for these genetic analyses was extracted from blood, with an invasive method that depended on the capture of live specimens (Lemos de Sá and Glander, 1993). At that time, Pope analyzed all individuals as the same species, *B. arachnoides* (the possibility of two species was not generally recognized). Pope observed a high level of genetic divergence using allozyme investigations, despite the small size and isolation of the populations. The variability observed was probably large due to between-species rather than within-population genetic diversity.

The first study using 126 individuals from two northern muriqui populations (Estação Biológica de Caratinga – EBC, Minas Gerais, and Santa Maria do Jetibá – SMJ, Espírito Santo) investigated the polymorphisms of restriction fragments (PCR-RFLP) of 480 base pairs (bp) of a hypervariable region of mtDNA or D-loop (Paes, 2005; Fagundes *et al*., in press). DNA was obtained from feces samples, a noninvasive method useful for endangered species (Chaves *et al*., 2006). The overall level of genetic differentiation between these muriqui populations was high. The test of genetic differentiation (F_{ST}), which characterizes genetic differentiation among populations, indicated that there was extensive genetic differentiation (F_{ST} = 0.635, *P*-value = 0.000) between the EBC and SMJ populations (Fagundes *et al*., in press). Values of *Nm* [$Nm = (1/F_{ST}-1)/4$] indicated less than 1 migrant per generation between SMJ and EBC, and related F_{ST} data revealed an absence of gene flow and high genetic distinction between these two populations.

Also, Chaves (2005) studied the sequence of 280 bp from the hypervariable internal segment of D-loop of 84 individuals from EBC and SMJ, and also observed high genetic diversity among these populations (F_{ST} = 0.56). Despite the distinction in mtDNA, the alleles did not cluster by geographic origin. Alleles from EBC and SMJ are interspersed in both clades, which mean that these populations are not completely distinct at this locus. Chaves (2005) also observed that values of nucleotide diversity of *B. hypoxanthus* are considerably lower when compared to other endangered species of mammals, including the gorilla (Garner and Ryder, 1996), chimpanzee (Deinard and Kidd, 2000), and the giant panda (Lu *et al*., 2001).

Our previous studies have shown that the loss and fragmentation of once contiguous habitat has caused the loss of genetic variation in the muriqui, and that genetic variation in the populations is among the lowest reported for any species of primate. This substantial loss of genetic variation

has contributed to extensive genetic differentiation among populations.

The next steps to measure genetic variability among populations of northern muriquis will require field efforts to sample new populations and individuals. Currently, our collection of feces is from individuals of seven of the twelve populations (Table 1). Some populations are still poorly sampled, however, and not yet representative of the total population. Just a few genetic samples for southern muriquis are available from blood, which makes it difficult to conduct comparative analysis of genetic variability between *B. arachnoides* and *B. hypoxanthus*. New approaches to evaluate genetic variability, including nuclear loci, are needed to better understand the consequences of fragmentation, reduction of population size and genetic drift in muriquis, and to assess the degree of genetic variation between the northern and southern populations.

The genetic markers used in the last two decades have changed, and there is an improved understanding of their potential to answer the most important questions in conservation genetics. They include either mitochondrial (mtDNA) or nuclear loci analyses, each with their advantages and disadvantages (Avise 2004). Analyses of nuclear DNA microsatellite loci have become an important approach for the conservation geneticist. This class of highly variable repeated sequences, polymorphic and single locus markers is routinely used to assess levels of genetic variability in small, endangered populations using non-invasive samples, with important implications in conservation biology. Because of their high mutation rates, microsatellites can be excellent markers for studying genetically depauperate populations, which show little or no variation at allozyme loci or mitochondrial DNA. Moreover, because of their short sequences, microsatellite loci can be amplified from degraded DNA, as often occurs when DNA is obtained non-invasively from hair and scat samples.

Table 1. Samples of feces collected from individuals of northern muriqui populations.

Population	Minimum population size	Total of sampled individuals	Percentage of sampled population
Espírito Santo			
Santa Maria do Jetibá	115	43	37.4
Caparaó National Park	82	2	2.4
Minas Gerais			
Caratinga Biological Station	226	130	57.5
Serra do Brigadeiro State Park	285	20	7.0
Rio Doce State Park	132	22	16.7
Serra do Ibitipoca	5	3	60.0
RPPN Mata do Sossego	42	10	23.8

Which methodology and DNA segments are more appropriate to study is always subject to doubt. To answer this question, it is necessary to look at the evolutionary properties of each class of DNA segment (mitochondrial or nuclear, single or multiple copy, coding or non-coding sequence, functional or non-functional) to evaluate the mutation rate and forces that drive the evolutionary patch of each segment. In general, most molecular data have proved to support rather than contradict previous statements based on other molecular markers. Nonetheless, the use of multiple molecular markers allows for more accurate conclusions.

Genetic approaches to the study of reproductive and social behavior

Developments in techniques of molecular genetics have been widely used to address important issues in the biology and behavioral ecology of mammal species (Woods *et al.*, 1999; Aitken *et al.*, 2004). In particular, knowledge of the current level of genetic variability and differentiation, relatedness between individuals, extent of inbreeding, and pedigree reconstructions are required to develop effective strategies for the conservation of endangered populations.

Many of the demographic features of *Brachyteles*, such as small and isolated populations, long inter-birth intervals, slow maturation rates, and long and overlapping generations, make them vulnerable to the effects of genetic drift and inbreeding, with the risks of lowering genetic variability and viability (Strier, 2000; Strier *et al.*, 2002). Nonetheless, demographic data on the muriquis have not yet revealed any evidence of deleterious signs of close inbreeding. Reproductive rates have remained stable, and infant mortality has been low in one group (Matão group) that has been monitored since 1982 (Strier, 2000). Females typically disperse from their natal groups prior to the onset of puberty or sexual activity, thereby reducing the risks of close inbreeding between siblings or father-daughter pairs (Strier, 1996; Printes and Strier, 1999; Strier and Ziegler, 2000).

The mating patterns of northern muriquis at the EBC are based on a system in which each female copulates with several males during their peri-ovulatory periods (Strier, 1997). Although females generally mate with multiple partners, copulations between mothers and their adult sons are very rarely observed (Strier, 1997). Also, behavioral observations have revealed a high tolerance of adult males to all infants (Guimarães and Strier, 2001). It is possible that behavioral mechanisms for inbreeding avoidance have contributed to the growth of the EBC muriqui population, which has more than quadrupled in the past 24 years (Strier *et al.*, 2006b).

Because of the muriquis' promiscuous mating system, it is impossible to determine the paternity of infants without

direct genetic data. Results from paternity studies can provide new insights into understanding muriqui mating behavior, and the relationship between adult male tolerance toward infants and male-infant genetic relatedness.

Known as Short Tandem Repeats (STR) sequences, microsatellites have the potential to evaluate inter-individual genetic variability. Microsatellite loci have been extensively used to genotype samples of primates. Many of them, isolated from the closely-related spider monkey (*Ateles*), can also be used to genotype the northern muriqui (Di Fiore and Fletcher, 2004). The use of heterologous primers is a good strategy to initiate new investigations on endangered species because the development of new primers of microsatellite DNA demands training, time and heavy financial investments. Heterologous primers were successful in amplifying the DNA of black and brown bears (Lorenzini *et al.*, 2004). Also, tests of several human microsatellite loci were positive and compatible in baboons (Morin *et al.*, 1998) and chimpanzees (Constable *et al.*, 2001), and may also be an option in muriqui studies.

Paternity and relatedness among members of northern muriqui populations can be obtained from analyses of genetic variability of STR sequence data. Analyses could be conducted on infants and juveniles, their mothers and possible fathers. However, this approach is only possible in a population such as that at the EBC, where data on paternity and genetic variation can be used to evaluate hypotheses derived from long-term behavioral data.

Monitoring and Management of Populations

The Management Plan for Muriquis, proposed by Mendes *et al.* (2005a), includes recommendations for monitoring unknown populations, conducting long-term studies of ecology and behavior, the reforestation of habitats in order to facilitate dispersion of females, and reductions in hunting and deforestation. Isolated groups and females in muriqui populations would seem to be more frequently observed in areas of highly fragmented forest. Translocation of reproductive individuals into potential receptor groups is a difficult challenge, but it is necessary in order to rescue the genetic variation represented by these individuals, which would otherwise die without leaving descendants. Due to the relatively recent history of translocations in muriqui (S. L. Mendes, pers. comm.), it is unknown what effects they can have on the genetic structure of the populations.

The problem of preserving the remaining wild populations is pertinent to concerns about the most appropriate conservation and management units, such as Evolutionary Significant Units (ESUs) and Management Units (MUs) as defined by Waples (1991) and Moritz (1994). Distinct MUs can be defined as populations connected by little or no contemporary gene flow, but not separated historically for very long periods of time (Waples, 1991).

The population viability of endangered species can be estimated based on demographic data (such as birth rates, death rates, longevity, reproductive rates, effective population size). Nonetheless, genetic studies of small populations can provide fundamental evidence of how observed patterns of mating and dispersion affect the loss of rare alleles within and between groups. In addition, comparative genetic studies can help to identify populations that are at such high risk of extinction due to the loss of heterozygosity that interventions (such as translocations) might be necessary.

The Muriqui Feces Bank

Most of the molecular genetic analyses of primates have been restricted to DNA extracted from blood or tissue samples (Surridge *et al.*, 2002), limiting the number of samples and risking the individuals due to anesthesia, capture and handling. The quantity of material required for DNA analyses may be infinitesimal using noninvasive methods, which are essential to studies of endangered species. Hairs, archeological or museum samples of pelts and bones, or feces from wild subjects, for example, can be obtained noninvasively. The first successful effort in isolating human shed epithelial cells mixed with feces was performed by Iyengar *et al.* (1991), and since then, studies in conservation genetics using DNA from faecal samples have been carried out on many threatened species.

The non-invasive technique of obtaining DNA from feces to investigate the genetic variability of northern muriquis has been applied in the past few years. DNA sampling through feces is a reliable, efficient, and economic method, which does not risk the physical integrity of the animals, and furnishes enough DNA that is easily reproducible for PCR amplification of fragments up to 800 bp in length (Chaves *et al.*, 2006). Also, it is a way of sampling a greater number of individuals in nature than would be possible if live captures to obtain blood were necessary.

At the same time, intensive fieldwork is needed to be able to obtain reliable fecal samples from individuals in nature. This may require long-term investment to habituate wild animals to human presence. An extensive study involving monitoring populations is the limiting factor in enabling the collection of feces from individually-known animals.

Currently, the feces bank comprises samples of 230 individuals from seven out of twelve populations of northern muriqui, all the result of extensive field studies (Table 1). The bank represents still a minor percentage of the northern populations, and a more coordinated and systematic effort among fieldworkers at the different muriqui sites is needed to achieve better representation across populations and species. Although the present studies are not as complete as would be desirable, they represent a landmark in the conservation genetics of free-living populations of muriqui, since the lack of completeness of the data is

a situation that confronts all population geneticists and behavioral ecologists studying endangered species.

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MANAGEMENT OF MURIQUIS (*BRACHYTELES*, PRIMATES) IN CAPTIVITY

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Abstract

Muriquis are the largest of the Neotropical primates. Two forms are recognized today — *Brachyteles arachnoides* (É. Geoffroy, 1806), the southern muriqui with a black face, and *Brachyteles hypoxanthus* (Kuhl, 1820), the northern muriqui with face and genitalia mottled pink and black. They occur in eastern Brazil from the south of the state of Bahia to northern Paraná. The destruction, degradation and fragmentation of the Atlantic forest, along with hunting, are the reasons for their severely threatened status today. In this article, I briefly describe the history of conservation efforts and research on muriquis. Captive breeding, although still incipient as an effective conservation measure, has been successful at the Rio de Janeiro Primate Center (CPRJ/FEEMA) and the Curitiba Zoological Park, Paraná. I discuss particularly aspects of breeding success, cage design, colony formation, feeding and nutrition, diseases and the prevention and treatment of illnesses.

Key Words – primates, muriqui, *Brachyteles*, Atelidae, captive breeding, Atlantic forest

Introduction

Muriquis are the largest of the Neotropical primates. They occur in southeastern Brazil, with recent discoveries of a population in the state of Paraná in the south (Koehler *et al.*, 2002, 2005), and reports of their existence in the state of Bahia, to the far north. Their name comes from the word "Myraqui," of the Tupi language. Its approximate meaning is "people that swing as they come and go" and it refers particularly to the large, pale brown monkeys that inhabit forests along Brazil's Atlantic coast, initially assigned the scientific name of *Ateles hypoxanthus* by Wied-Neuwied (1958).

Two forms are recognized today — *Brachyteles arachnoides* (É. Geoffroy, 1806), the southern muriqui with a black face, and *Brachyteles hypoxanthus* (Kuhl, 1820), the northern muriqui with face and genitalia mottled pink and black. The first author to consider the two forms distinct was Vieira (1944), although he subsequently referred to *Brachyteles* as a single species (Vieira, 1955). More recent studies by Lemos de Sá and Glander (1993) confirmed Vieira's initial suggestion, which had also been considered by Torres de Assumpção (1983) and Coimbra-Filho (1990, 1992a, 1992b).

Coimbra-Filho and Magnanini (1968) and Coimbra-Filho (1972) noted the increasing scarcity of muriquis. However, only in 1982 was there international recognition of the plight of *Brachyteles*, during a symposium on the conservation of primates in tropical forests held in Houston, Texas, USA (Mittermeier *et al.*, 1983). The most detailed evaluation of the population and habitat status of *Brachyteles* was conducted by Aguirre (1971), but studies on this taxon resumed only in the 1980s, with work by Fonseca *et al*. (1983), Mittermeier *et al.* (1987), Nishimura *et al*. (1988), Oliver and Santos (1991) and Strier (1992), whose long-term research, begun in 1983, focused on the northern form of *Brachyteles*, at the Fazenda Montes Claros, Caratinga, in Minas Gerais. Torres de Assumpção (1983) and Milton (1984) carried out some early studies of the southern muriqui at the Fazenda Barreiro Rico, São Paulo, but a long-term field research program was established (in the Carlos Botelho State Park) only in the mid 1990s (Talebi and Soares, 2005).

In the early 1980s, Russell A. Mittermeier, Chair of the IUCN/Species Survival Commission (SSC) Primate Specialist Group (PSG), and then Director of Primate Programs at the World Wildlife Fund–US, began working in close collaboration with researchers at the Rio de Janeiro Primate Center (*Centro de Primatologia do Rio de Janeiro – CPRJ/FEEMA*), the Zoology Department of the Federal University of Minas Gerais (UFMG), the Brazilian Forestry Institute (*Instituto Brasileiro de Desenvolvimento Florestal – IBDF*), and a non-governmental organization (NGO), the Brazilian Foundation for Nature Conservation (*Fundação Brasileira para Conservação da Natureza – FBCN*) in Rio de Janeiro, to identify the most important federal and state reserves protecting remnants of the Atlantic forest and its rich endemic fauna (Mittermeier *et al.*, 1982). The WWF–US project included three areas of investigation. One concerned the nonhuman primates and

other large mammals, another the avifauna, and the third the vegetation and flora.

The Endemic Primates of the Atlantic Forest

The status of the primate species in the region was studied in great detail, with the aim of assessing their populations and habitats. In the first phase, emphasis was given to the most threatened — the muriquis (*Brachyteles*), and the lion tamarins (*Leontopithecus rosalia*, *L. chrysomelas*, and *L. chrysopygus*) (*L. caissara* was only discovered in 1990). Hunting and the widespread destruction and degradation of their forests are the principal causes of threat.

Twenty-four species and subspecies of nonhuman primates occur in the Atlantic forest. Twenty of them are endemic, and 17 are found in the southeast — the states of São Paulo, Rio de Janeiro, Espírito Santo, the eastern portion of Minas Gerais and the southern part of the state of Bahia, below the Rio de Contas. We consider this area critical because it is where most of the remaining forests still exist, and because it is where the Pleistocene forest refugia are thought to have been concentrated (Kinzey, 1982; Rylands *et al*., 1996). Of the 17 species and subspecies of nonhuman primates in southeastern Brasil, 14 are endemic and only encountered in this region. As indicated by the field investigations conducted by the Primate Program organized by WWF–US/CPRJ-FEEMA, at least 13 of these forms are seriously endangered and two are vulnerable. Some of the endangered primates were even considered on the verge of extinction.

Muriquis (*Brachyteles*) are one of the most endangered nonhuman primates in southeastern Brazil, and are also considered to be amongst the most threatened primates in the world (Strier *et al*., 2006). Altogether, the total population of *B. hypoxanthus* is estimated at 864 individuals, and for *B. arachnoides* the estimate is 1300 individuals (Melo and Dias, 2005) which, for both species, live precariously in few remaining forests, mostly degraded and isolated.

The original habitat of *B. arachnoides* and *B. hypoxanthus* is primary forest, or late successional and mature forest to be more precise. Few forests remain that provide adequate habitat for the muriquis. They are always a target for hunters that further reduces their populations, even in state and federal protected areas. Improving the management and policing of these reserves and parks, would be a very positive measure for their long-term protection.

Unlike the three species of *Leontopithecus* that benefit from highly organized and effective captive breeding programs, there are very few muriquis in captivity. There are small colonies in the Centro de Primatologia do Rio de Janeiro (CPRJ/FEEMA) and the Parque Zoológico de Curitiba, where they have been bred successfully.

The Captive Breeding Program

The existence of a Primate Center in the region where *Brachyteles* occurs made it possible to establish an *ex situ* breeding project to support an integration of field and captive management, following the example established and functioning for *Leontopithecus.* Despite the critical status of the two species, only a few individuals were maintained in public or private institutions in the past, and without any pretensions to a structured breeding program. It fell to the Centro de Primatologia the historic task of reproducing this rare species in captivity (Coimbra-Filho *et al*., 1993). Animals kept by a Swiss Animal dealer, Marco Schwarz, were transferred to the Parque Zoológico de Curitiba, which has also had success with their reproduction. The Fundação Parque Zoológico de São Paulo, Orquidário de Santos, Parque Zoológico Quinzinho Barros, Museu de Biologia Mello Leitão (Ruschi, 1964) have all maintained this primate, but without establishing a breeding nucleus. Perhaps, as Crandall (1964) and Aguirre (1971) thought, and even today for many others, the maintenance and reproduction of these primates *ex situ* represents a difficult and uncertain challenge.

Conditions in captivity

Captive management is one of the alternatives for the preservation of species threatened with extinction. In these man-made environments, it is necessary to utilize specific knowledge to develop plans for the areas and people, as well as the animals involved. These plans must take into consideration the principals of functionality, hygiene, and security. Enclosures must be sufficiently large, and contain high quality space suitable for the species. Other specific considerations that must be taken into account in the construction of enclosures include:

- Protection against predators
- Exposure to the sun's rays, preferably in the morning
- Avoidance of large fluctuations in temperature and humidity
- Access to shade
- Minimization of contact with feces, urine, and food remains
- Sheltered areas, as necessary.

In addition to the preparation of areas for the temporary isolation of individuals when needed, there must also be:

- Storage areas for both non-perishable and perishable foods (controlled refrigeration)
- Storage areas for equipment and materials used in the colony
- Storage for any hazardous materials and food wastes
- Medical-veterinary supplies and storage
- An area to maintain and store data
- A hygienic area for the workers and other people involved in the management of the colony

- An area for washing and disinfecting equipment, cages, etc.

Colony formation

Ex situ reproduction should begin with a founding population that is of high quality in every aspect. This unfortunately was not the case with the colony at the CPRJ-FEEMA, as shown by Coimbra-Filho *et al.* (1993), and in Table 1. Nonetheless, we have had notable breeding success in a period of only five years. Ideally, captive breeding initiatives would have a colony of healthy animals of the appropriate sexes and ages, and the behavior of which has not been influenced by humans and, most especially, negative social experiences. These factors, along with dietary management and sanitary medicine, could result in successful reproduction. However, the Centro de Primatologia has received confiscated animals many of which were in terrible condition on their arrival (Coimbra-Filho *et al.*, 1993). Some even died soon after arriving (Table 1), while others presented health risks to the rest of the colony. Some of the individuals that developed an aversion to the food they were presented ultimately recovered over time (CP 891, CP 924, CP 2049, CP 2097). Others died quickly (CP 2047 e CP 2050) (Table 1), despite every effort and care.

Feeding and nutrition

Special care in the choice of food and in the preparation of the diets for these monkeys is necessary. Knowing the fondness that muriquis have for Garapa (*Apuleia leiocarpa*) and for Jacarandá-branco (*Platypodium elegans*) leaves, we

Table 1. Breeding and Management of captive muriquis, *Brachyteles*, at the Centro de Primatologia do Rio de Janeiro (CPRJ-FEEMA).

Species	Sex	Origin	Local number	Date of arrival (A) or birth (B)	Locale	Father	Mother	Date of death	Tatoo	Experience	Cause of death
B. hypoxanthus	F	W	850	A 11 Sep 87	CPRJ	WB	WB	25 Jun 90	A 1	NOX	Multiple lesions; peritonitis associated with *Strongyloides*
B. hypoxanthus	F	W	891	A 12 Jan 88	CPRJ	WB	WB	11 Oct 96	A 2	IE 2(2) B 2(2)	Serious internal hemorrhage
B. hypoxanthus	F	W	924	A 18 Jul 88	CPRJ	WB	WB	25 Jul 97	A 3	IE 2(2) B 3(3)	Enteritis and anorexia
B. arachnoides	M	W	1012	A 24 May 89	CPRJ	WB	WB	Transfer to Rio Zoo (12 Mar 99)	A 4	IE 4(4) B 1(1)	Hepatitis B
B. arachnoides	M	W	1091	A 5 Jan 90	CPRJ	WB	WB		A 5	B 4(4)	
Hybrid	F	C	1245	B 10 Sep 91	CPRJ	1091 MS	924 FS	12 Sep 91	-	NOX	Birth difficulties; ruptured lung vessel
Hybrid	F	C	1286	B 30 Oct 91	CPRJ	1091 MS	891 FS		Chip 2558	IE 1(1)	
Hybrid	F	C	1335	B 3 Jun 92	CPRJ	1091 MS	924 FS	4 Jun 98	-	IE 2(2)	Festering abscess of abdominal wall; peritonitis
B. arachnoides	M	W	1407	A 21 May 93	CPRJ	WB	WB	4 Dec 96	-	NOX	Hepatitis B
Hybrid	-	C	1430	B 12 Oct 93	CPRJ	1091 MS	924 FS	12 Oct 93	-	NOX	Dead at birth
Hybrid	M	C	1475	B 25 Apr 94	CPRJ	1091 MS	891 FS		CHIP 9539	IE 3(3)	
Hybrid	M	C	1488	B 24 Jun 94	CPRJ	1091 MS	924 FS	Transfer to Rio Zoo (12 Mar 99)	1488	IE 2(2)	Hemorrhagic enteritis
B. arachnoides	F	W	1528	A 20 Dec 94	CPRJ	WB	WB	13 Jul 95	-	NOX	Anorexia, general infection
Hybrid	M	C	1671	B 8 Jun 96	CPRJ	1012 MS	924 FS	11 Oct 98		IE 1(1)	Enteritis
Hybrid	M	C	1689	B 7 Sep 96	CPRJ	1012 MS	891 FS	25 Sep 96		NOX	Exhaustion due to mother's illness
B. hypoxanthus	F	W	2047	A 22 Jan 02	CPRJ	WB	WB	21 Jun 02		NOX	Anorexia, enteritis
B. arachnoides	F	W	2049	A 6 Feb.02	CPRJ	WB	WB	-		NOX	
B. arachnoides	M	W	2050	A 14 Mar 02	CPRJ	WB	WB	22 Mar 02		NOX	Serious intestinal lesions and *Strongyloides*
B. hypoxanthus	F	W	2097	A 13 Nov 02	CPRJ	WB	WB			NOX	

Legend: WB = Wild born, W = Wild, C = Captivity, NOX = None, IE = Infant experience, B = Breeder

planted them nearby. This was enormously beneficial for the recovery of these animals when brought to us in poor health (Coimbra-Filho *et al.*, 1993). Those that were rescued were generally reluctant to accept artificial food, or even wild foods that were not part of their accustomed diet. New foods must be introduced carefully, with variety, to break the monotony of the diet and to stimulate their digestive tracts. Milton (1984), Strier (1991), and Moraes (1992) made important observations on the diet of *Brachyteles* in the wild that indicate appropriate recipes in captivity.

In general, primates with strongly folivorous diets are more difficult to maintain in captivity, mainly because of the difficulty of obtaining a diversity of appropriate foods to offer them. Owing to the enviable location of the CPRJ-FEEMA, we were able to overcome these difficulties, a factor certainly contributing to our success in breeding them. Animals that had been kept as pets had, in general, been accustomed to very bizarre diets (the case of the individuals CP 1528 and CP 2047, for example), which made the process of adapting them to a diet more typical of their natural needs more difficult. To illustrate the complications of adjusting their feeding regime, we relate the story of one individual (CP 1528) that had been maintained on entirely inadequate foods.

To stimulate this individual to eat a new diet, she was housed in an enclosure that was adjacent to that of the resident muriqui group. There, she could observe, vocalize and interact with the other muriquis, and become familiar with their diets. Over time, with little or nothing to eat, we decided to release her with the others, where she was well-received. Under these conditions, she ate few of the new food items, and in very small quantities, which probably lowered her physical resistance. She contracted a respiratory illness, and later had gastrointestinal problems. Although experiencing a long period of improvement, during which she received various medications, she eventually died.

The acceptance of food can be improved by adopting an appropriate feeding strategy. The muriquis fight over vegetation if we offer it to them in small quantities, but when offered as a large branch with numerous leaves, the muriquis feed together peacefully, as has been observed in the wild. They remain peaceful while feeding and vocalizing, as if they were satisfied with the food. Offering natural vegetation instead of supermarket foods is a more adequate diet for these primates in captivity.

Breeding—evolution of the colony

The breeding colony at the Centro de Primatologia do Rio de Janeiro originated with two females (CP 891 and CP 924), both *B. hypoxanthus*, and two males (CP 1012 and CP 1091), both *B. arachnoides*. The two males arrived very young, but were in better condition than the females. The contributions of male CP 1091 and of female CP 924 were greater than those of male CP 1012 and female CP 891. Births were problematic in 50% of the cases, as shown in Table 2, emphasizing the precarious history of these females as "pets," which had resulted in developmental problems with their pelvic bones and subsequent complications during parturition (Table 2). Under these conditions, there are always concerns with the female and the offspring. The possibility of success is uncertain.

Table 2. Contribution of males (*Brachyteles arachnoides*) and females (*Brachyteles hypoxanthus*) in the reproduction of muriquis in captivity at the CPRJ/FEEMA.

Males *B. arachnoides*	Females *B. hypoxanthus*	Offspring	Sex	Birth conditions
1091 ×	924	1245	F	D
		1335	F	T
		1430	?	D
		1488	M	D
	891	1286	F	T
		1475	M	T
1012 ×	924	1671	M	T
	891	1689	M	D

Legend: D = Difficult birth; surgery necessary, T = Full-term (normal)

Prevention and treatment of illnesses

Various studies provide detailed coverage of pathologies associated with primates, with those by Ruch (1959), Appleby *et al.* (1963), Fiennes (1967, 1972), Martin (1986), and Brack (1987) being of particular relevance. Preventive medicine is fundamental for the good health of the colony. It is also necessary to protect researchers from illness and death due to direct or indirect contact with pathogens transmitted by primates (Whitney Jr., 1976; Brack, 1987; Dalgard, 1991; Adams *et al.*, 1995; Butler *et al.*, 1995).

Many illnesses can attack primates in the wild and in captivity, the latter exacerbated through direct contact with humans. When different species are put together, there is also the possibility that one will pass serious diseases to the others. For example, *Herpesvirus tamarinus* is latent in *Saimiri*, but fatal in *Aotus* and *Saguinus* (Holmes *et al.*, 1964; Melendez *et al.*, 1966; Hunt *et al.*, 1973) as well as in other species. Conversely, *Herpesvirus hominis* is latent in humans, but fatal for *Aotus* and *Hylobates* (Smith *et al.*, 1969).

Very little has been written about the pathologies of muriquis. Works by Artigas (1935), Travassos (1943), Stuart *et al.* (1993), and Pissinatti *et al.* (1997) remain the best sources on their parasites. There has been a prevalence of intestinal problems associated with the deaths of muriquis in captivity, where the presence of *Strongyloides* sp. is marked, despite the sanitary medical controls employed (Pissinatti *et al.*, 1997). *Strongyloides* has been the cause of deaths among the individuals received and maintained at the Center (Table 1).

The conservation status of the muriqui continues to be critical, despite the many studies conducted to date. It was only 18 years after the first intensive field studies on muriquis that the first "Population and Habitat Viability Assessment Workshop for the Endangered Muriqui. *Brachyteles arachnoides*" was held, and where some recommendations for the conservation of the species were established (Rylands *et al.*, 1998). From this meeting until present, ongoing studies have continued at Caratinga and surrounding areas, as well as in the state of São Paulo, and at the Centro de Primatologia, where efforts to extend the captive breeding project have resulted in the approval of three enclosures (similar to the one already built) as part of the compensatory measures resulting from the *Programa de Despoluição da Baia de Guanabara* (PDBG). Construction of two more enclosures has been approved as part of the project of the surrounding the Paraíso State Ecological Station. All of the approved resources for these enclosures are embargoed, however, due to unrelated administrative and political issues.

Recently, the Brazilian Institute for the Environment (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA*) and the research group working at the Serra dos Órgãos National Park initiated a census of the muriqui population. Two workshops were organized by this "Programa Muriqui", through a partnership of IBAMA/TEREVIVA. They culminated in the creation of the International Committee for the Conservation and Management of the Muriqui/Woolly Spider Monkey (*B. arachnoides* and *B. hypoxanthus*) (Edict 1.369/02 of 10 October 2002 – IBAMA) — an international committee of the government specifically to discuss the two species and provide advice and coordinated direction for research, conservation and captive management measures on their behalf (Oliveira *et al.*, 2005). We believe that the best and most important actions on behalf of this extraordinary primate can be executed now that all of the necessary legal instruments for implementing them exist.

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THE INTERNATIONAL COMMITTEE FOR THE CONSERVATION AND MANAGEMENT OF ATLANTIC FOREST ATELIDS

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Abstract

We briefly describe in this paper the objectives, structure and organization of the International Committee for the Conservation and Management of the Atlantic Forest Atelids. This is an advisory group established to assist the Brazilian Institute for the Environment (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis – IBAMA*) in the definition of effective conservation measures for the two species of muriqui (*Brachyteles hypoxanthus* and *B. arachnoides*) along with the northern brown howling monkey (*Alouatta guariba guariba*), all of which are on the Brazilian Official List of Fauna Threatened of Extinction. We also describe the participation of IBAMA's Center for the Protection of Brazilian Primates (*Centro de Proteção de Primatas Brasileiros – CPB*) and the Coordination for the Conservation of Threatened Fauna and Migratory Species (*Coordenação de Conservação das Espécies da Fauna Ameaçada de Extinção e Migratória – COFAU*). These are the sectors of IBAMA most involved with the planning and execution of conservation actions for threatened primates in Brazil.

Key Words – threatened primates, Atelidae, muriqui, *Brachyteles*, Atlantic forest, Brazil

Introduction

The efforts of one person or organization alone are rarely sufficient to save a threatened species. Numerous people, organizations, and voluntary initiatives concerned with the imminent demise of a species, and working towards to the same end, however, are also no guarantee of success in reversing the decline of a species — mitigating, neutralizing or removing the causes.

The Brazilian Institute for the Environment and Natural Renewable Resources (IBAMA) (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis*) is the principal government institution charged with executing national environmental policy. Although one of its mandates is the protection and conservation of Brazil's wildlife (Decree No. 5,718, 13 March 2006), it is obvious that no single institution can work in isolation in the resolution of the gamut of environmental issues which afflict such a large and fast-developing country as Brazil. This fact is clearly stated in the Federal Constitution, which recognizes that an ecologically-balanced environment is everybody's right and that all public instututions and the people must work towards this, to preserve a healthy natural environment for future generations. For this reason, the internal regulations of IBAMA allow for formal agreements and partnerships with other public institutions and private organizations, besides the creation of advisory councils, commissions, working groups and committees, to provide the wherewithal and expertise necessary to achieve success in promoting and carrying out the measures demanded of it (Brazil, 2002)

With regard to its efforts for the conservation of threatened species, IBAMA has taken recourse to numerous mechanisms to bring together the people and stakeholders involved, but none has been so successful as the formation of conservation and management committees. The number of committees that have now been formed — 33 in all — is proof of government policy in their favor, fully backed up by IBAMA, and endorsed by the Ministry of the Environmant over the last four years.

The Committees

The first instituted by IBAMA was the International Committee for the Conservation and Management of the Golden Lion Tamarin (*Leontopithecus rosalia*) (*Comitê Internacional para Conservação e Manejo do Mico-Leão-Dourado* [Leontopithecus rosalia]) in 1990. It included researchers and representatives of national institutions such as the Rio de Janeiro Primate Center (*Centro de Primatologia do Rio de Janeiro*), and overseas organizations such as the San Diego Zoo, California, the National Zoological Park, Washington, DC, and the University of Maryland, USA. Committees were subsequently set up for each of the four lion tamarins, *L. chrysomelas*, *L. chrysopygus* and *L. caissara* and, later, united to form a single committee for the genus (Mallinson, 1989; Kleiman and Mallinson, 1998; Rambaldi *et al.*, 2002). Although each committee

has its particularities, the lion tamarin committee and its *modus operandi* became the model for those established later by IBAMA for other threatened species.

A most important aspect of the lion tamarin committee was the fact that, over time, its role extended beyond one of assisting and advising IBAMA on specific issues. It turned into a permanent forum for discussion concerning the definition of methods, procedures and measures, *in situ* and *ex situ*, for the conservation of the lion tamarins. The responsibility for implementing conservation measures was shared among the committee members, both personally and institutionally. The committee generated a sharing of roles and responsibilities that amalgamated the work of the researchers and environmental authorities into a formal common agenda, which was reviewed and adjusted at each meeting. This dynamic was possibly one of the principal factors that contributed to the success achieved in the conservation of the golden lion tamarin, signalled by it being upgraded from Critically Endangered to Endangered on the IUCN Red List (IUCN, 2006).

The Lion Tamarin Committee even went beyond its mandate when it set up a system to raise funds for the conservation of the four species — the Lion Tamarins of Brazil Fund. Funds were raised through initiatives of the individual members of the committee, using their connections with the zoos, especially those in Europe and the USA, involved in the international captive breeding programs for *L. rosalia*, *L. chrysomelas* and *L. chrysopygus*. Funds were raised specifically for field research and conservation projects, and included the mechanism of "adopting a wild lion tamarin group" (Mallinson, 1994; Rambaldi *et al.*, 2002). A newsletter, *Tamarin Tales*, was edited by the National Zoo, Washington, DC, to inform donors of progress in lion tamarin conservation each year, and provide news on the groups that donors had "adopted."

This phenomenon of sharing roles and responsibilities was seen as a key aspect: one that should underpin each committee. While identifying and discussing key issues and measures that fall strictly within the competence of the environmental authorities, the meetings also provide an excellent forum for the various research and conservation groups to discuss their projects, progress and results, providing for complementarity and collaboration, discussions of "lessons learned", and allowing for the development of comparable protocols for their diverse initiatives.

So as to include all of Brazil's threatened primate species with permanent forums for discussion, in 2004 two new committees were formed, and the scopes of two of the previous committees were expanded. The Committee for the Atlantic forest capuchin monkeys, *Cebus xanthosternos* and *C. robustus*, created in 1992 and resuscitated in 2002 (Santos and Lernould, 1993; Baker and Kierulff, 2002), took in a Working Group created in 2003 for Barbara Brown's titi monkey (*Callicebus barbarabrownae*) and Coimbra-Filho's titi monkey (*C. coimbrai*) (both occurring in northeastern Brazil). The working group was created to outline emergency measures for the two species following their placement on Brazil's Official List of Threatened Fauna (*Lista Oficial da Fauna Brasileira Ameaçada de Extinção*) published in 2003 (Oliveira and Marini-Filho, 2003). The titi monkeys and the capuchin monkeys are all from the northern Atlantic forest and face the same threats, and the institutions and researchers interested in their conservation are, in many cases, the same. As of 2006, IBAMA has established the following advisory commitees for threatened primates:

1. International Committee for the Conservation and Management of Lion Tamarins (*Comitê Internacional para Conservação e Manejo dos Micos-leões*) – including *Leontopithecus rosalia*, *L. chrysomelas*, *L. chrysopygus*, and *L. caissara*;
2. Committee for the Conservation and Management of the Primates of the Northern Atlantic Forest and Caatinga (*Comitê para Conservação e Manejo dos Primatas do Norte da Mata Atlântica e Caatinga*) – including, *Cebus xanthosternos*, *C. robustus*, *Callicebus coimbrai*, *C. barbarabrownae*, *C. melanochir*, and *C. personatus*;
3. International Committee for the Conservation and Management of the Atlantic Forest Atelids (*Comitê Internacional para Conservação e Manejo dos Atelídeos da Mata Atlântic*a) – including *Brachyteles hypoxanthus*, *B. arachnoides*, and *Alouatta guariba guariba*;
4. Committee for the Conservation and Management of Amazonian Primates (*Comitê para Conservação e Manejo dos Primatas Amazônicos*) – including *Saguinus bicolor*, *Saimiri vanzolinii*, *Cebus olivaceus kaapori*, *Chiropotes satanas*, *C. utahickae*, *Cacajao calvus calvus*, *C. calvus novaesi*, *C. calvus rubicundus*, *Alouatta belzebul ululata*, *Ateles marginatus*, and *A. belzebuth*;
5. Committee for the Conservation and Management of Callitrichids (*Comitê para Conservação e Manejo dos Calitriquídeos*) – including *Callithrix flaviceps* and *C. aurita.*

Each committee includes researchers, either active in studying the species of interest or promoting measures for their conservation, or with a particular understanding and expertise on the genus and regions where they occur, as well as people involved in *ex situ* conservation initiatives and breeding programs, and of course government and non-governmental organizations which have the capacity and intention to participate in promoting and executing the appropriate actions on behalf of each species.

The Committee for the Atlantic Forest Atelids

The International Committee for the Conservation and Management of the Atlantic Forest Atelids was created by IBAMA through Edict No. 89/05 of 8 December 2005. This committee in fact originated from one designated solely to the muriquis, *Brachyteles*, created through Edict No. 432/03-N of May 2003; a result of the recommendations

arising from the Population and Habitat Viability Analysis (PHVA) workshop for the genus held in Belo Horizonte in 1998 (Rylands *et al.*, 1998). The committee was created by IBAMA following extensive discussions and negotiations with the institutions and researchers involved, and making use of the opportunity provided during meetings on muriqui conservation held at the Serra dos Órgãos National Park in 2002.

The composition of the committee changed little as a result of its expansion in 2005 to include the northern brown howler monkey (*Alouatta guariba*). The participation of the Associação Pró-Muriqui, the Fundação Biodiversitas, Conservação Internacional (CI–Brasil), the University of Wisconsin-Madison, the Federal University of Espírito Santo, and the Rio de Janeiro Primatology Center (CPRJ/FEEMA), along with the Center for the Protection of Brazilian Primates (CPB/IBAMA), provides the expertise necessary for the definition of research and conservation measures for the maintenance of the wild populations of all three species.

The committee is preparing conservation action plans for the muriquis, which will build on two previous documents: the PVHA workshop of 1998 (Rylands *et al.*, 1998), and the more recent action plan developed specifically for the northern muriqui, *B. hypoxanthus*, by Mendes *et al.* (2005) through the nationwide Project for the Conservation and Sustainable Use of Brazilian Biological Diversity (*Projeto de Conservação e Utilização Sustentável de Diversidade Biológica Brasileira – PROBIO*) of the Ministry of Environment (MMA). As such, the action plans will be the principal planning tool for the committee, guiding what needs to be done and how, and providing the means to evaluate progress and the effectiveness of the measures taken.

IBAMA's role in the committee

Formally, as a collegiate organ of IBAMA, the committee's role is consultative and advisory, created to help in identifying effective measures for the conservation of the two muriqui species. As is so often the case, in reality the workings of the committee go beyond its formal mandate, in that the members take on and share the responsibilities for the measures needed. Likewise, the participation of IBAMA is diversified, involving as it does the support of a number of different departments beyond the Center for the Protection of Brazilian Primates, including those concerned with threatened fauna, protected areas, and environmental fiscalization, each with the power to directly authorize and execute specific measures within, of course, their organizational mandates — highly beneficial in terms of allowing IBAMA to take action on the recommendations and decisions of the committee.

The departments most involved in the committee are the Coordination for the Protection of Fauna (*Coordenação de Proteção de Espécies da Fauna – COFAU*) and the Center for the Protection of Brazilian Primates (CPB). Both play a fundamental role in the elaboration of the action plans, and in IBAMA's implementation of the appropriate conservation measures they recommend.

The COFAU's mission is the conservation of threatened species, through 1) compiling and analyzing the information available on such as the biology, demography, geography and status of Brazilian wildlife in order to prioritize conservation measures and also to elaborate the Brazilian red list of threatened animals; and 2) developing and promoting ways to strengthen conservation measures for threatened species, often otherwise limited by lack of human and financial resources, for example. Key aspects include: 1) working with the various other sectors of IBAMA that can bring to bear such measures as the creation, implementation and management of protected areas where the species occur, and fiscalization, especially when, for example, trade and hunting are issues; and 2) establishing alliances and partnerships to implement and finance conservation programs for the threatened species. Advisory committees such as those mentioned above are a key element, not only in promoting these partnerships and alliances and providing for effective and strong conservations actions, but also in facilitating articulation among the various key sectors of IBAMA to support them and carry them out.

The Center for the Protection of Brazilian Primates (CPB) is one of IBAMA's specialized centers[1]. Created 18 October 2001, its aim is to carry out and support research and conservation measures for the Brazilian primates, especially those which are threatened, as well as coordinate the management of zoonoses and epizootics in wild and captive populations. Besides providing technical assistance to other sectors of IBAMA, it serves as the reference source for all information on Brazil's primate species and subspecies (more than 130 of them), providing information on their taxonomy, biology, distributions, conservation and management. Most of that information can be assessed on the Internet at <www.ibama.gov.br/cpb>. The CPB also guides IBAMA in its role in licensing (transport and research), in the control and management of captive colonies, and in the implementation of public policies concerning the conservation and use of primates (in research, for example).

The advisory groups and the CPB comprise, as such, the specialist technical-scientific arm of IBAMA for primate conservation and management. CPB has the institutional competence to act directly on aspects of management and research which require IBAMA's involvement. This direct involvement is especially evident with the threatened primates of Northeast Brazil (*Cebus*, *Callicebus*, and *Alouatta*) where the CPB is based.

[1] The other centers are dedicated to sea and freshwater turtles, wild cats and canids, marine mammals, birds, reptiles and amphibians, plus five regional centers for fish.

The CPB's involvement in the Committee for the Atlantic Forest Atelids, is centered mainly on the parks and reserves which are now so vital for the survival of the muriquis. They are known to occur in more than 20 private, state and federal protected areas (Rylands *et al*., 1998). This is considerably more than is generally the case for threatened primates, and is a reason for optimism. Most of the primates on the Official Brazilian List of Threatened Species are there because they are what is now referred to as "restricted-range species" in areas where there habitats have been or are being destroyed. Muriquis have a broad geographic distribution and also inhabit montane regions where the topography and remoteness have favored the survival of their forests and distanced them somewhat from the centuries of intensive hunting that has eliminated them elsewhere in the Atlantic forest. Protected areas in these regions are now key to the survival of the muriqui. The CPB supports research and conservation measures not only within the protected areas but also in the areas adjoining them, and on populations which are as yet unprotected, but must be in the near future if the populations are to survive.

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Notes to Contributors

Scope

The journal/newsletter aims to provide a basis for conservation information relating to the primates of the Neotropics. We welcome texts on any aspect of primate conservation, including articles, thesis abstracts, news items, recent events, recent publications, primatological society information and suchlike.

Submissions

Please send all English and Portuguese contributions to: John M. Aguiar, Conservation International, Center for Applied Biodiversity Science, 2011 Crystal Drive, Suite 500, Arlington, VA 22202, Tel: 703 341-2400, Fax: 703 979-0953, e-mail: <j.aguiar@conservation.org>, and all Spanish contributions to: Ernesto Rodríguez-Luna, Instituto de Neuroetología, Universidad Veracruzana, Apartado Postal 566, Xalapa 91000, Veracruz, México, Tel: 281 8-77-30, Fax: 281 8-77-30, 8-63-52, e-mail: <saraguat@speedy.coacade.uv.mx>.

Contributions

Manuscripts may be in English, Spanish or Portuguese, and should be double-spaced and accompanied by the text on diskette for PC compatible text-editors (MS-Word, WordPerfect, Excel, and Access), and/or e-mailed to <j.aguiar@conservation.org> (English, Portuguese) or <saraguat@speedy.coacade.uv.mx> (Spanish). Hard copies should be supplied for all figures (illustrations and maps) and tables. The full name and address for each author should be included. Please avoid abbreviations and acronyms without the name in full. Authors whose first language is not English should please have texts carefully reviewed by a native English speaker.

Articles. Each issue of *Neotropical Primates* will include up to three full articles, limited to the following topics: Taxonomy, Systematics, Genetics (when relevant for systematics), Biogeography, Ecology and Conservation. Texts for full articles should not exceed about 20 pages in length (1.5 spaced, and including the references). Please include an abstract in English, and (optional) one in Portuguese or Spanish. Tables and illustrations should be limited to six, excepting only the cases where they are fundamental for the text (as in species descriptions, for example). Full articles will be sent out for peer-review.

Short articles. These are usually reviewed only by the editors. A broader range of topics is encouraged, including such as behavioral research, in the interests of informing on general research activities which contribute to our understanding of platyrrhines. We encourage reports on projects and conservation and research programs (who, what, where, when, why, etc.) and most particularly information on geographical distributions, locality records, and protected areas and the primates which occur in them. Texts should not exceed 10 pages in length (1.5 spaced, including the references).

Figures and maps. Articles may include small black-and-white photographs, high-quality figures, and high-quality maps and tables. Please keep these to a minimum. We stress the importance of providing maps which are **publishable.**

News items. Please send us information on projects, field sites, courses, recent publications, awards, events, activities of Primate Societies, etc.

References. Examples of house style may be found throughout this journal. Please refer to these examples when listing references:

Journal article
Stallings, J. D. and Mittermeier, R. A. 1983. The black-tailed marmoset (*Callithrix argentata melanura*) recorded from Paraguay. *Am. J. Primatol*. 4: 159–163.

Chapter in book
Brockelman, W. Y. and Ali, R. 1987. Methods of surveying and sampling forest primate populations. In: *Primate Conservation in the Tropical Rain Forest*, C. W. Marsh and R. A. Mittermeier (eds.), pp. 23–62. Alan R. Liss, New York.

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Napier, P. H. 1976. *Catalogue of Primates in the British Museum (Natural History). Part 1: Families Callitrichidae and Cebidae*. British Museum (Natural History), London.

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Wallace, R. B. 1998. The behavioural ecology of black spider monkeys in north-eastern Bolivia. Doctoral thesis, University of Liverpool, Liverpool, UK.

Report
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