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

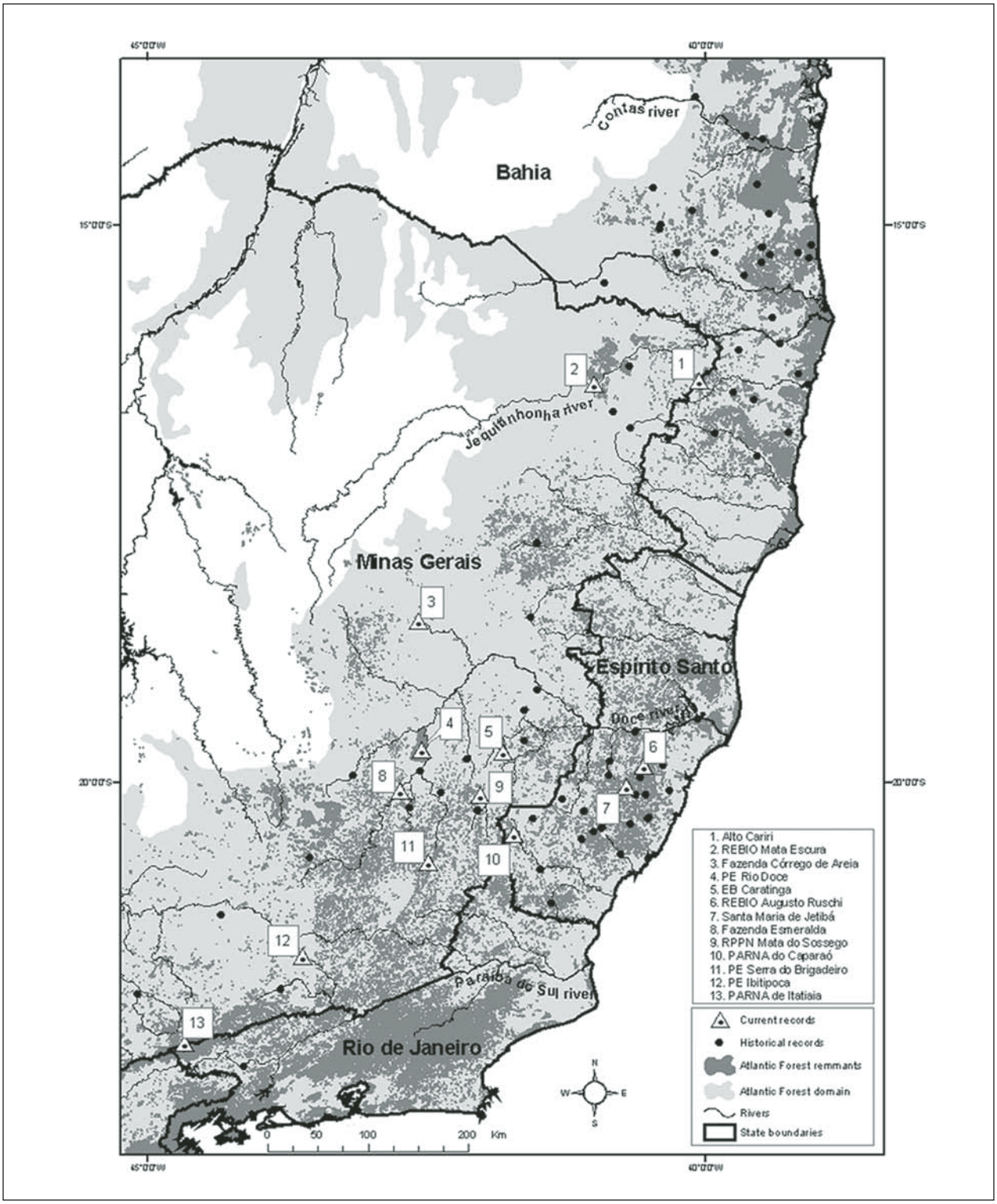

Figure 1. Historical and current records of the northern muriqui. Muriquis occur in Itatiaia National Park (#13), but the species has yet to be confirmed there.

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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