Science, Policy, and Conservation Management for a Critically Endangered Primate in the Atlantic Forest of Brazil

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Long-standing concerns about the status of the world's endangered primates have stimulated significant international efforts, such as the primate action plans published by the Primate Specialist Group of the International Union for Conservation of Nature's Species Survival Commission. However, national-level action plans that bring together diverse scientific experts, non-governmental organizations, and governmental agencies to focus on improving the status of endangered species are generally rare. Here, we highlight one such plan published a decade ago, the Brazilian National Action Plan for the Conservation of Muriquis, which promoted the integration of scientific findings about the behavioral ecology, demography, and genetics of northern muriquis with conservation measures supported by the Brazilian government. This plan provided a holistic framework for the development of an effective national strategy that has contributed to significant advances in research and management applied to the conservation of this Critically Endangered species. We hope that this model for muriquis will stimulate conservationists around the world to pursue integrative national-level sponsorship of action plans on behalf of other endangered species.

Keywords: primate activism, primate action plans, national action plans, Northern muriqui, Brachyteles hypoxanthus, threatened species, strategic conservation planning, conservation management

INTRODUCTION

Rising extinction risks for the world's wild primates have stimulated calls for greater activism and advocacy on behalf of endangered species (Mittermeier, 1977; Oates et al., 1982, 1987; Oates, 2013; Estrada et al., 2017; Garber, 2019, 2021). Primatologists and primatological societies are now increasingly being urged to take responsibility for “inspiring, organizing, and mobilizing others to join together to take designed to effect change” (Garber, 2021, p. 6; see also Oates, 2013). Primatologists are often the only people who possess the expert knowledge needed for informed conservation and management for their study species. Yet, there are rarely opportunities for integrating their knowledge with that of other researchers and managers with
diverse expertise, or for the direct transfer of this integrated knowledge to policy makers who hold the political power needed to enact effective and enforceable conservation legislation. It is also the case that engaging in conservation without fully understanding and taking into account local community interests and regional or national political contexts can have negative repercussions for the researchers and primates alike. Compounding these risks and the lack of access to, and influence over, the people and processes that must be mobilized for change, are the challenges of developing practical guidelines for the implementation of conservation, and of deriving measurable criteria for evaluating their success (Betts et al., 2020; Junker et al., 2020).

The International Union for the Conservation of Nature's Species Survival Commission (IUCN SSC) has successfully recruited participation from international stakeholders upon whose expertise their assessments of species extinction risks are based. The IUCN Red List resulting from these assessments has been influential in identifying species conservation priorities and in rallying for funding and other support (Rodrigues et al., 2006). Similarly, the biennial release of the World's 25 Most Endangered Primates, identified by IUCN SSC Primate Specialist Group (PSG) members and other experts during open sessions at the International Primatological Society meetings, has been effective in stimulating increased publications and public awareness over the short term, and could likely extend over longer periods if investment in the visibility of the “top 25” lists were sustained (Acerbi et al., 2020; Reuter et al., 2021). However, translating these assessments and agreed-upon priorities into actionable, sustainable conservation and management for threatened species and their habitats requires additional mechanisms that explicitly integrate a wide range of perspectives, and permit systematic evaluations of the effectiveness of conservation actions at the appropriate local, regional, and national scales (Betts et al., 2020).

Among the few available mechanisms employed for achieving these aims have been the action plans sponsored by the IUCN SSC PSG. A global primate action plan written by Mittermeier (1977) was followed by plans for African (Oates et al., 1982, 1987; Oates, 1986, 1996), Asian (Eudey, 1987), and Mesoamerican primates (Rodriguez-Luna et al., 1996) and for lemurs (Mittermeier et al., 1992; Schwartz et al., 2013)—all developed via correspondence, with only informal in-person gatherings. More recent action plans have been drawn up following structured workshops. Since 2003, the PSG has produced 11 action plans for all of the African great apes, the most recent being for the western chimpanzee (Pan troglodytes verus) (IUCN SSC Primate Specialist Group, 2020). The IUCN SSC Conservation Planning Specialist Group (CPSG; previously, Conservation Breeding Specialist Group, or CBSG), has used a workshop approach to develop Population and Habitat Viability Analyses (PHVAs) (Lacy, 1993/1994) which has been used for primates, including lion tamarins Leontopithecus (Seal et al., 1990; Rylands, 1993/1994; Ballou et al., 1998; Holst et al., 2006) and muriquis Brachyteles (Strier, 1993/1994; Rylands et al., 1998). The CPSG also developed the Conservation Assessment and Management Plan (CAMP) workshop methodology to provide strategic guidance for intensive management and information collection techniques for threatened taxa on a regional scale (Ellis and Seal, 1996), used for example for Indonesian (Supriatna et al., 2001) and Mexican primates (Rodríguez-Luna et al., 2009).

The PHVAs and CAMPs are technical working documents for informing, organizing and structuring conservation initiatives on behalf of endangered species and their habitats, focusing on particular taxa or regions. Action plans tend to be more directive in their emphasis on prioritizing conservation measures to promote action and fund-raising, typically including detailed summaries of available information about the distribution and population status of the primates at risk, as well as considerations of past and ongoing anthropogenic pressures, and recommendations for mitigating identified threats. Collating such diverse sources of information is feasible because of the participation and contributions of diverse stakeholders, ranging from researchers to non-governmental conservationists to government officials, representatives of zoos, and often local communities (IUCN/SSC, 2008; IUCN SSC Species Conservation Planning Sub-Committee, 2017).

These international initiatives have been successful in promoting conservation activities (Fuller et al., 2003) in much the same way that the IUCN Red List has proven to be an effective tool in lobbying for global conservation commitments (Betts et al., 2020). However, national-level buy-in from host country governments and engagement with local capacity is also essential for translating global priorities into local action (Collen et al., 2013; Durant, 2013). This national buy-in was consolidated in the Convention on Biological Diversity (https://www.cbd.int/) and its Strategic Plans (2002-2010; 2011-2020), with most countries committing to adopt national policies in order to prevent and reduce the loss of biodiversity. The need for national plans to save threatened species was expressed in the Aichi target 12: “By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.”

The Brazilian Environment Ministry’s Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) has sponsored the formation of advisory groups for the development of national action plans for threatened Brazilian species (Brazil, ICMBio, 2018a). Here, we review the contributions of one of these plans to our collaborative national and international actions to save the Critically Endangered northern muriqui (Brachyteles hypoxanthus). Muriquis are the largest extant nonhuman primates of the Americas and endemic to the Atlantic Forest of southeastern Brazil. It is important to note that many research and conservation efforts on behalf of the northern muriqui were already underway before the publication of the Plano de Ação Nacional para a Conservação dos Muriquis, or PAN Muriquis, a decade ago (Jerusalinsky et al., 2011). Nonetheless, many recent advances can be directly attributed to the strategic priorities, decision processes, and policy recommendations that emerged from the plan. These include targeted surveys to confirm the occurrence and numbers of remaining populations and the implementation of integrated conservation and management measures. Thus, our approach for the northern muriqui illustrates the dynamic synergism among basic scientific research and conservation actions involving
diverse public and private stakeholders (e.g., universities, NGOs, environmental agencies, and zoos) in the development of a national action plan. i.e., simultaneously informed by the best available science and aligned with Brazilian national priorities and policy. By sharing our experiences with the northern muriqui, we hope to encourage colleagues around the world to consider the merits of developing national action plans for their endangered and critically endangered primates.

**TEMPORAL AND SPATIAL SCALES OF SCIENTIFIC RESEARCH**

Concern about the future of muriquis and their Atlantic Forest habitat was raised some 50 years ago, when the first systematic survey revealed alarming declines (Aguirre, 1971). Subsequent excursions to locate and study muriquis were made during the 1970s, initiated by Brazilian and foreign researchers and conservationists (Nishimura, 1979; Valle et al., 1983; Nishimura et al., 1988). It was not until the early 1980s, however, that the first long-term studies were launched. At that time the muriqui was classified as a monotypic species, Brachyteles arachnoides, and it was not until the early 2000s that the separation of the genus into two species was widely recognized, with molecular data marking their split at c. 2 million years (reviewed by Chaves et al., 2019). The reclassification of the northern muriqui from B. arachnoides to B. hypoxanthus makes prior literature confusing to non-experts, who may not appreciate that the northern muriqui had been studied for decades before it was given its own species name (Strier, 2018).

The 1,000 or so northern muriquis estimated to survive today are distributed among 12 predominantly small, fragmented populations (Figure 1). We have information on the status of nine of these populations that have been surveyed and/or studied to varying degrees (Strier et al., 2017). At one extreme is the small population at Peçaçuha, MG (#3 on Figure 1), where the presence of at least seven muriquis was confirmed in a few hours of effort using infrared imaging and drone technology (Melo, 2021). At the other extreme is the relatively large population (currently c. 250 individuals) at the Reserva Particular de Patrimônio Natural-Feliciano Miguel Abdala (RPPN-FMA), a private natural heritage reserve in Caratinga, MG (#6 on Figure 1), where continuous, systematic studies on behavioral ecology, reproduction, life histories, and demography have been underway on one group since 1983. Northern muriquis have very distinctive facial and fur markings that make it possible to recognize individuals (Strier and Mendes, 2012).

Research on the behavioral ecology of northern muriquis, including the long-term Muriquí Project of Caratinga, has been based on non-invasive, observational studies of wild, unprovisioned animals, and has focused on evaluating hypotheses derived from comparative theories of primate behavioral ecology and social evolution (Strier, 2019). Indeed, the early discovery that northern muriquis live in unusually peaceful, egalitarian societies in which males are philopatric and females typically disperse from their natal groups prior to the onset of puberty, contributed to a greater appreciation for primate behavioral diversity in general (Strier, 1994, 2003). Moreover, as these behavioral patterns of female dispersal in the Caratinga muriquis were confirmed in comparative studies of other northern muriquis, they took on even greater significance because of their direct implications for the success of potential translocation, reintroduction, and captive breeding programs (Tabacow et al., 2021; Oliveira et al., in press). Indeed, the strong affiliative relationships that persist among related, patrilocal males (Strier et al., 2002) implied that management efforts would be more effective and less destructive if they focused on moving females of dispersal age instead of philopatric males, consistent with their natural dispersal patterns.

The long-term data from Caratinga and comparative data from eight other populations have been equally valuable in assessing how northern muriquis respond under different ecological and demographic conditions (e.g., Lemos de Sá and Strier, 1992; Silva-Júnior et al., 2011; Strier and Mendes, 2012). For example, tree species evenness and structural traits driven by succession were found to be important factors in determining muriqui abundance patterns across different forests (Silva-Júnior et al., 2009, 2010), with higher densities generally occurring in the more disturbed forests (e.g., Pinto et al., 1993). Similarly, the long-term and comparative data on northern muriquis also show their great behavioral flexibility in response to demographic fluctuations, with high population density associated with fission-fusion grouping patterns and an expansion of their vertical niche to include an increased use of terrestrial substrates. Nonetheless, other behavioral traits, including the muriquis’ peaceful intragroup social dynamics and female dispersal with male philopatry, appear to be more conservative and persistent, even under variable ecological and demographic conditions (Strier, 2017).

**PROCESS AND POLICY OF THE MURIQUI NATIONAL ACTION PLAN**

The muriqui has been present in every official national list of threatened species in Brazil. It was listed as B. arachnoides in 1968, 1973 and 1989, and then split into B. arachnoides and B. hypoxanthus in 2003 and 2014. The IUCN Red List categories and criteria were applied in these last two editions, with the northern muriqui being assessed as Critically Endangered (Mendes et al., 2008; Melo et al., 2018). The first conservation planning for the species was a PHVA (Rylands et al., 1998). Following the recommendations of this PHVA, and the pioneering committee model developed for the conservation of lion tamarins (Kleiman and Mallinson, 1998; Rambaldi et al., 2002), in 2003 the Brazilian federal government created an international committee for conservation and management of the muriquis, linked to IBAMA (Brazil, IBAMA, 2003). This Committee initiated the elaboration of a national action plan for muriquis in 2005. Two other workshops, held in 2008 and 2010, concluded the plan, which ultimately defined the structure that was broadly followed by dozens of subsequent such plans to reverse the extinction risk of other threatened species (Brazil, ICMBio, 2018b), including those...
FIGURE 1 | Historical distribution and extant populations of the northern muriqui, *Brachyteles hypoxanthus*. The historical distribution was adapted from Aguirre (1971), Ingberman et al. (2016), and Melo et al. (2018). For context of the translocated female indicated by the star, see Table 1; for other cases of translocated northern muriqui females, see Tabacow et al. (2021).

Currently covering all of the Brazilian imperiled primates (e.g., Escarlate-Tavares et al., 2016; Jerusalinsky et al., 2017).

The overarching goal of the PAN Muriquis was to downlist both muriqui species by at least one risk category. Ten objectives with 58 actions were set to reach this goal, with responsibilities, timeframes, products, and cost estimates assigned to each action. Compiling a collective knowledge about the muriqui and incorporating this understanding into conservation and management actions was a collaborative effort that involved more than 30 participants, including 14 members of the federally recognized Technical Advisory Group, or GAT (Brazil, ICMBio, 2014). As such, the PAN Muriquis was broadly participatory, and...
hadly translocation of isolated muriquis. With these protocols, all northern muriqui populations and their habitats would never have been developed without these exchanges (Valença-Montenegro et al., in press). Among them are criteria for classifying the viability of muriqui populations (Lanna et al., in press), a “Decision Key” for objectively identifying inviable populations and the subsequent steps of assessing the most appropriate forms of management for them (Strier et al., in press), and a procedure for evaluating the compatibility of populations identified as inviable for management purposes (Moreira et al., in press). With these protocols, all northern muriqui populations can now be evaluated as potential sources of females for in situ or ex situ management purposes, or as receptors of females, depending on their status.

A third contribution from the PAN Muriquis and its associated protocols has been the sequence of steps taken to insures the persistence of the muriqui population in Ibitipoca, Minas Gerais (#11 on Figure 1). There, episodic censusing demonstrated a small and declining population (Nogueira et al., 2010) and by August 2014 only two adult males remained. At the same time, reports of solitary females from two locales elsewhere in the state had been confirmed, and the decision was made to bring both males and the females into an outdoor enclosure, with access to a 2-ha patch of forest. At present writing, one of the males has already sired an infant with one of the translocated females (Tabacow et al., 2021).

Throughout this process, expertise from researchers of both captive (Coimbra-Filho et al., 1993) and wild muriquis has been integrated, distinguishing it from previous female translocations and other management initiatives. In January 2020, ICMBio staff met with a subset of the PAN Muriquis’ contributors to determine the key decisions about the management of any northern muriqui individual, not only considering emergency situations (Strier et al., in press) but also cases where the translocation of isolated animals, or even groups of muriquis might be warranted. The PAN Muriquis provided both the motivation for the meeting and the tools to achieve what is now a comprehensive approach for the conservation and management of this species.

A fourth contribution from PAN Muriquis to the conservation of the northern muruqi has been the coordination of efforts to create new protected areas (Objective 3 in Table 1) and an expanding network of forest corridors to increase connectivity among prioritized populations. A first step in these efforts has been the official designation of the Sossego-Caratinga Ecological Corridor (SCEC), recognized by the Minas Gerais State Decree No. 397 on August 1, 2014 (Brazil, Minas Gerais, IEF, 2014). Designation of this important corridor was motivated by the need to protect the northern muriqui populations present in the two fragmented, private reserves 45 km apart (#5 and #6 on Figure 1),
TABLE 1 | Advances following the adoption of the PAN Muriquis concerning ongoing conservation initiatives for the northern muriqui, Brachyteles hypoxanthus. Adapted from Brazil, ICMBio/CPB (2017).

| Specific objectives | Advances attributed to PAN Muriquis |
|---------------------|------------------------------------|
| 1. Quantify the remaining populations of muriquis. | • Increased information about areas of occurrence of northern muriquis and their population sizes. New information includes: o Confirmation of the presence of Brachyteles hypoxanthus in Itatiaia National Park and Serra do Papagaio State Park (#12 in Figure 1); Aximoff (2015) and Carvalho et al. (2015). o Confirmation of the decline in Ibitipoca population (#11 on Figure 1) to only two adult males as of 2015 (and targeted as priority for management with translocated females). o Confirmation of an isolated female in a forest near the area of Esmeralda de Ferros, Ferros, Minas Gerais (star on Figure 1—see Objective 10). o Confirmation of the occurrence of a small group in Peçanha, Minas Gerais (#3 in Figure 1). o Population estimates obtained for 9 of the 12 areas (75%) where northern muriquis occur, with the total confirmed number being 1,213 individuals. o Completion of the protocol for quantifying muriqui populations [Tabacow et al. (in press, a)]. o Increased monitoring of hunting in various locations in Minas Gerais [Brazil, ICMBio/CPB (2017)]. |
| 2. Increase enforcement measures to effectively reduce hunting pressure on muriqui populations in and around protected areas. | • Creation of new private reserves (RPPNs): o Two private reserves (RPPNs) near Caparaó National Park (#9 on Figure 1): “Dois Irmãos: Cláudio Murilo Belletti Rodrigues,” 57.25 ha [Brazil, Minas Gerais, IEF (2016)] and “Dois Irmãos: Emílio Sérigo Belletti Rodrigues,” 50.31 ha [Brazil, Minas Gerais, IEF (2017)]. o Private reserve of 339.48 ha continuous with that of Sossego (#5 on Figure 1): RPPN Sossego do Muriqui, created by Curirimaba Mining Company (with help from the Muriqui Institute of Biodiversidade (MIB) and the Fundação Grupo Boticário de Proteção à Natureza) [Brazil, Minas Gerais, IEF (2018)]. |
| 3. Create or expand strictly protected areas and private reserves in all areas of occurrence of potentially viable muriqui populations. | • Although a specific fund has yet to be created, the PAN Muriquis enhanced the capture of financial resources to support projects and actions related to these objectives. For example: o The “Programa de Conservação Muriquis de Minas (PCMM)” financed for 4 years by the Fundação Grupo Boticário de Proteção à Natureza; o The “Casa do Muriqui” project funded by the Comuna da Ibitipoca, New World Primate Taxon Advisory Group of the Association of Zoos & Aquariums, and Mohamed bin Zayed Species Conservation Fund; o Thirteen grants, totaling $93,499, awarded by the Primate Action Fund of Rewild (formerly Global Wildlife Conservation) and the Margot Marsh Biodiversity Foundation (2011–2020). |
| 4. Implement mechanisms to finance muriqui research and conservation activities. | • Completion of analyses for prioritizing populations and for monitoring population demography [Strier et al. (2017)]. o The demographic monitoring of three populations ongoing (Caratinga, Santa Maria do Jetibá, and Ibitipoca; #6, 8, and 11, respectively, on Figure 1). o Initiation of monitoring of two additional populations (Mata do Sossego and Caparaó National Park; #5 and 9, respectively, on Figure 1). |
| 5. Establish an integrated program for the demographic monitoring of muriqui populations in priority areas. | • Increase in integration and variation among long-term and new research programs, specifically with relevance for conservation, e.g., o Demographic fluctuations: Strier et al. (2017, 2019); Tabacow et al. (2021). o Genetics: Chaves et al. (2019). |
| 6. Implement an integrated long-term research program applied to the conservation of muriquis | • Maps of areas of occurrence and land use, with a protocol for identifying priorities for connectivity [Tabacow et al. (in press, b)]. o Minas Gerais: The official designation of the Sossego-Caratinga Ecological Corridor [Brazil, Minas Gerais, IEF (2014)]. o Espírito Santo: Project approved to promote connectivity among forest fragments in Santa Maria de Jetibá, Santa Teresa, and Santa Leopoldina. |
| 7. Develop state projects to ensure and increase connectivity in at least 50% of the areas where potentially viable muriqui populations occur. | • Popular books for children [Moreira (2009)] and the general public, including “O Muriqui” [Mendes et al. (2014) and Lettião et al. (2017)]. o Educational videos, such as, “Entre Montanhas e Muriquis” and “Resgate de Esmeralda: Salva o Muriqui” (https://mib.org.br/videos/). |
| 8. Establish strategies for Environmental Education, scientific dissemination, communication and income generation aimed at the conservation of muriquis. | • Citizen Science for monitoring primates in the Brazilian Atlantic Forest [Nery et al. (2021)]. |
| 9. Have strategic institutions working in coordination for the conservation of muriquis. | • Annual meetings of the Technical Advisory Group of PAN Muriquis. o Post PAN Muriquis meetings, including: o 1st meeting for Research and Conservation of the Northern Muriquis, held at the Instituto Nacional para a Mata Atlântica (INMA), Vitória, ES, September 2018. o 2nd meeting for Research and Conservation of the Northern Muriquis, sponsored by the Comuna da Ibitipoca, Ibitipoca, MG, January 2020. o At least 60 participants from at least 40 institutions and organizations collaborated on research and conservation activities through 2017. |

Continued)
both of which are recognized as priority populations for this species (Strier et al., 2017). The value of ecological corridors is particularly high for the Atlantic Forest (Rezende et al., 2018), and one of the protocols resulting from the PAN Muriquis is focused on developing connectivity of areas prioritized for their muriqui populations (Tabacow et al., in press, b). Once established, the SCEC will cover an area of 66,424.56 ha in the Atlantic Forest, spanning seven municipalities in the state (Brazil, Minas Gerais, IEF, 2017). The hope is that the corridor will permit these currently isolated muriqui populations to expand into suitable habitat where gene flow can occur through female dispersal.

CONCLUSIONS

Our experience with these national level and species-specific action plans is that they are effective, especially in integrating the diverse experiences and perspectives of scientists with different areas of expertise, non-governmental organizations, and the appropriate government agencies. National Action Plans serve a vital role in channeling global biodiversity priorities into actionable conservation commitments implemented directly by the countries where the species occur. National Action Plans can also simultaneously provide a platform and a stimulus for the development of even more focused regional and state-level plans, as has occurred with the Plano Estadual de Ação para a Conservação dos Muriquis, which is being implemented in the state of Espírito Santo (Brazil, Espírito Santo, SEAMA/IEMA, 2014).

With many of the conservation and management actions identified in the PAN Muriquis already underway for B. hypoxanthus, there is now a solid, resilient network that makes us optimistic about the potential to increase the viability of northern muriqui populations that have been badly affected by anthropogenic activities in the past and will experience increasing pressures from climate change and ongoing human impact in the future. We urge everyone with a commitment to the conservation of endangered species to work with local stakeholders representing diverse organizations to explore existing mechanisms or establish new ones for developing national action plans. We also recommend that these national action plans be established as public policies, as is the case in Brazil, so that their chances for success are enhanced.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

KS, FM, SM, MV-M, AR, RM, and LJ contributed to the conception and design of the study. MV-M and LJ organized the results presented in Table 1. LJ and FM organized the data shown in Figure 1. KS wrote the first draft of the manuscript. FM, AR, and LJ wrote sections of the manuscript. All authors contributed to the article, and approved the submitted version.

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REFERENCES

Acerbi, A., Kerhoas, D., Webber, A. D., McCabe, G., Mittemeier, R. A., and Schwartz, C. (2020). The impact of the “World’s 25 Most Endangered Primates” list on scientific publications and media. *J. Nat. Conserv.* 34:125794. doi: 10.1016/j.jnc.2020.125794

Aguirre, A. C. (1971). O *Mono, Brachyteles arachnoides* (E. Geoffroy) – Situação atual da espécie no Brasil. *Rio de Janeiro, RJ: Academia Brasileira de Ciências*

Aximoff, I. (2015). Confirmação da ocorrência do muriqui-do-norte (Primates: *Brachyteles hypoxanthus*) no Espírito Santo – PAE Muriqui. *Vitória: Governo do Estado do Espírito Santo, Secretaria do Meio Ambiente e Recursos Hídricos (SEAMA), Instituto Estadual do Meio Ambiente e Recursos Hídricos (IEMA)*

Brazil, ICMBio (2014). *Portaria N.° 119, de 11 de março de 2014* – Diário Oficial da União – N.° 119, Seção 2, 51.

Brazil, ICMBio (2018a). *Guia para Gestão de Planos de Ação Nacional para a Conservação das Espécies Ameaçadas de Extinção: PAN – Elaborar e Monitor*, 1. Brasília: Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio)

Brazil, ICMBio (2018b). *Portaria N.° 702, de 7 de agosto de 2018 – Aprova o Plano de Ação Nacional para a Conservação dos Primatas da Mata Atlântica e da Preguiça-de-Coqueira – PAN PPMA*, Brasília: Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio). Diário Oficial da União – N.° 153, Seção 1, 57.

Brazil, ICMBio/CPB (2017). *Plano de Ação Nacional para a Conservação dos Muriquis: Relatório de Avaliação Final*, Centro Nacional de Pesquisas e Conservação de Primatas Brasileiros (CPB), Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), João Pessoa, Brazil.

Brazil, Minas Gerais, IEF (2016). *Decreto Estadual N.° 305, de 2 de setembro de 2016 – Reconhece como Reserva Particular do Patrimônio Natural, a RPPN "Dois Irmãos: Claudio Murilo Belletti Rodrigues"*, Belo Horizonte: Instituto Estadual de Florestas (IEF).

Brazil, Minas Gerais, IEF (2017). *Portaria N.° 71, de 18 de julho de 2017 – Reconhece como Reserva Particular do Patrimônio Natural, a RPPN "Dois Irmãos: Emilio Sérgio Belletti Rodrigues"*, Belo Horizonte: Instituto Estadual de Florestas (IEF).

Brazil, Minas Gerais, IEF (2018). *Portaria N.° 63, de 13 de setembro de 2018 – Reconhece como Reserva Particular do Patrimônio Natural, a RPPN "Sossego do Muriqui"*, Belo Horizonte: Instituto Estadual de Florestas (IEF).

Carvalho, W. D., Xavier, B. S., and Estéberard, C. E. L. (2015). *Primitas do Parque Estadual da Serra do Papagaiog e RPPNs adjacentes, estado de Minas Gerais*. *Belo Horizonte: Instituto Estadual de Florestas (IEF)*

Chaves, P. B., Magnus, T., Jerusalinsky, L., Talebi, M., Strier, K. B., Breves, P., et al. (2019). *Phylogeographic evidence for two species of muriqui (genus Brachyteles)*. *Am. J. Primatol.* 81:e23066. doi: 10.1002/ajp.23066

Coimbra-Filho, A. F., Pissinatti, A., and Rylands, A. B. (1993). *Breeding muriquis (Brachyteles arachnoides) in captivity: the experience of the Rio de Janeiro Primate Centre (CPRI/FEEMA)*

Collen, B. P., Pettorelli, N., Baillie, J. E. M., and Durant, S. M. (2013). *“Biodiversity monitoring and conservation: bridging the gaps between global commitment and local action,” in Biodiversity Monitoring and Conservation: Bridging the Gap between Global Commitment and Local Action*, eds B. Collen, N. Pettorelli, J. E. M. Baillie, and S. M. Durant (New York, NY: John Wiley & Sons), 1–16. doi: 10.1002/9781118490747.ch1

Durant, S. M. (2013). *“Building sustainable national monitoring networks,” in Biodiversity Monitoring and Conservation: Bridging the Gap between Global Commitment and Local Action*, eds B. Collen, N. Pettorelli, J. E. M. Baillie, and S. M. Durant (New York, NY: John Wiley & Sons), 313–334. doi: 10.1002/9781118490747.ch14

Ellis, S., and Seal, U. S. (eds.). (1996). *Conservation Assessment and Management Plan (CAMP) Process Reference Manual*. Apple Valley, MN: IUCN/SSC Conservation Breeding Specialist Group (CBSG).

Escalante-Tavares, F., Valença-Montenegro, M. M., and Jerusalinsky, L. (eds.). (2016). *Plano de Ação Nacional para Conservação dos Mamíferos da Mata Atlântica Central*, Brasília: Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio), Série Espécies Ameaçadas, 23.

Eudey, A. A. (1987). *Lion Tamarin Population and Habitat Viability Assessment*, 81:e23052. doi: 10.1002/ajp.23052

Euclides, A. (2006). *Lion Tamarin Population and Habitat Viability Assessment Workshop 2005, Final Report*. Apple Valley, MN: IUCN/SSC Conservation Breeding Specialist Group (CBSG).

Fuller, R. A., McGowan, P. J. K., Carroll, J. P., Dekker, R. W. R., and Garson, P. J. (2003). What does IUCN species action planning contribute to the conservation process? *Biol. Conserv.* 112, 343–349. doi: 10.1016/S0006-3207(02)00331-2

Garber, P. A. (2019). *Moving from activism to advocacy: changing views of primate field research and conservation over the past 40 years*. *Am. J. Primatol.* 81:e23052. doi: 10.1002/ajp.23052

Garber, P. A. (2021). *Advocacy and activism as essential tools in primate conservation*. *Int. J. Primatol.* 1–17. doi: 10.1177/01636825-2100311-x

Holst, B., Medici, E. P., Marinho-Filho, O. J., Kleinman, D. G., Leus, K., Pissinatti, A., et al. (2006). *Lion Tamarin Population and Habitat Viability Assessment Workshop 2005, Final Report*. Apple Valley, MN: IUCN/SSC Conservation Breeding Specialist Group (CBSG).

Holt, B., Medici, E. P., Marinho-Filho, O. J., Kleinman, D. G., Leus, K., Pissinatti, A., et al. (2006). *Lion Tamarin Population and Habitat Viability Assessment Workshop 2005, Final Report*. Apple Valley, MN: IUCN/SSC Conservation Breeding Specialist Group (CBSG).

Ingram, B., Fusco-Costa, R., and Monteiro-Filho, E. L. A. (2016). A current perspective on the historical geographic distribution of the endangered muriquis (*Brachyteles spp.)*: Implications for conservation. *PLoS ONE* 11:e0136906. doi: 10.1371/journal.pone.0136906

IUCN SSC Primate Specialist Group (2020). *Regional Action Plan for the Conservation of Western Chimpanzees* (Pan troglodytes verus) 2020-2030. Gland: IUCN SSC Primate Specialist Group. Available online at: http://www.
Nishimura, A. (1979). In Search of Woolly Spider Monkey. Reports of New World Monkeys. Inuyama: Kyoto University, Primate Research Institute, 1, 21–37.

Nishimura, A., Fonseca, G. A. B., Young, A. L., Stier, K. B., Mittermeier, R. A., and Valle, C. (1988). “The muriqui, genus Brachyteles,” in Ecology and Behavior of Neotropical Primates, Vol. 2, eds R. A. Mittermeier, A. B. Rylands, A. F. Coimbra-Filho, and G. A. B. da Fonseca (Washington, DC: World Wildlife Fund-US), 577–610.

Nogueira, D. F., Ferraz, D. S., Oliveira, A. F., Tabacow, F. P., Souza Amâncio, S. M., and Melo, F. R. (2010). Ocorrência de primatas no Parque Estadual do Ibitipoca e entorno, estado de Minas Gerais, Brasil. Neotrop. Primates 17, 67–70. doi: 10.1896/044.017.0204

Oates, J. F. (1986). Action Plan for African Primate Conservation 1986–1990. Gland: IUCN/SSC Primate Specialist Group.

Oates, J. F. (1996). African Primates: Status Survey and Conservation Action Plan. Gland, Switzerland: IUCN/SSC Primate Specialist Group. doi:10.22035/IUCN.CH.1996.SSC-AP.A.en

Oates, J. F. (2013). Primate conservation: unmet challenges and the role of the International primatological society. Int. J. Primatol. 34, 235–245. doi:10.1007/s10764-013-9664-1

Oates, J. F., Garlán, S. J., and Struhsaker, T. T. (1982). A framework for planning rain-forest conservation. Int. Primatol. Soc. News 4–9.

Oates, J. F., Garlán, S. J., and Struhsaker, T. T. (1987). “A framework for African rain forest primate conservation,” in Primate Conservation in the Tropical Rain Forest, eds C. W. Marsh and R. A. Mittermeier (New York, NY: Alan R. Liss), 321–327.

Oliveira, P. C., Tabacow, F. P., Gasparotto, V. P. O., Teixeira, E. P., Testa, M. F., Teixeira, D. S., et al. (in press). Relato de caso envolvendo a translocação de uma fêmea de Brachyteles hypoxanthus (Primates, Atelidae) para um recinto semi-natural, como estratégia de conservação da espécie em Minas Gerais, Brasil. Neotrop. Primates

Pinto, L. P. S., Costa, C. M. R., Stier, K. B., and Fonseca, G. A. B. (1993). Habitats, density, and group size of primates in the Reserva Biológica Augusto Ruschi (Nova Lombardia, Santa Teresa, Brazil). Folia Primatol. 61, 135–143. doi:10.1159/000156760

Rambaldi, D. M., Kleinman, D. G., Mallinson, J. C. J., Dietz, L. A., and Padua, S. M. (2002). “The role of nongovernmental organizations and the international committee for the conservation and management of Leontopithecus in lion tamarin conservation”, in Lion Tamarins: Biology and Conservation, eds D. G. Kleinman and A. B. Rylands (Washington, DC: Smithsonian Institution Press), 71–94.

Reuter, K. E., Mittermeier, R. A., Schwitzer, C., McCabe, G., Rylands, A. B., Jerusalinsky, L., et al. (2021). “The 25 most endangered primates list: impact on conservation fundraising and policy,” in Communicating Endangered Species: Extinction, News and Public Policy, eds E. Freedman, S. Shipley Hiles, and D. B. Sachsman (London: Routledge), 101–115. doi:10.4324/9781003004195-9

Rezende, C. L., Scarano, F. R., Assad, E. D., Joly, C. A., Metzger, J. P., Strassburg, B. B. N., et al. (2018). From hotspot to hopespot: an opportunity for the Brazilian Atlantic Forest. Perspect. Ecol. Conserv., 16, 208–214. doi: 10.1016/j.poc.2018.10.002

Rodrigues, A. S., Pilgrim, J. D., Lamoreux, J. F., Hoffmann, M., and Brooks, T. M. (2006). The value of the IUCN Red List for conservation. Trends Ecol. Evol. 21, 71–76. doi:10.1016/j.tree.2005.10.010

Rodriguez-Luna, E., Cortés-Ortiz, L., Mittermeier, R. A., Rylands, A. B., Wong-Reyes, G., et al. (1996). Hacia un Plan de Acción para los Primates Mesoamericanos. Neotrop. Primates 4, 9–23.

Rodriguez-Luna, E., Solórzano-García, B., Sheddun, A., Rangel-Negrín, A., Dias, P. A. D., Cristóbal-Azkárate, J., et al. (2009). “Taller de Conservación, Análisis y Manejo Planificado para los Primates Mexicanos.” (Veracruz; Apple Valley, MN: Universidad Veracruzana and Conservation Breeding Specialist Group [CBSG]).

Rylands, A. B. (1993/1994). Population viability analyses and the conservation of the lion tamarins, Leontopithecus, of south-east Brazil. Primate Conserv. 14–15, 34–42.

Rylands, A. B., Stier, K. B., Mittermeier, R. A., Borovansky, J., and Seal, U. S. (eds.). (1998). Conserving Brazil’s Muriquis: Population and Habitat Viability Assessment (PHVA) for Brachyteles arachnoides. Apple Valley, MN: IUCN/SSC Conservation Breeding Specialist Group (CBSG).
