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# Restoration of *Alouatta guariba* populations: building a binational management strategy for the conservation of the endangered brown howler monkey of the Atlantic Forest

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The brown howler monkey (*Alouatta guariba*) is endemic to the Atlantic Forest of eastern Brazil and northeastern Argentina, threatened by extinction due to habitat loss and fragmentation, and hunting. Its reduced and isolated populations dramatically decreased and suffered local extinctions after recent yellow fever outbreaks, recommending the species risk uplist from Vulnerable to Endangered. In Brazil, the species occurs along eight states in sparse populations, including some large protected areas, and is being uplisted to Endangered. Following the National Action Plan for Conservation of the Atlantic Forest Primates and the Maned-sloth, and applying the Guidelines for Reintroductions and other Conservation Translocations (IUCN/CTSG), the *Ex Situ* Guidelines (IUCN/CPSG) and the One Plan Approach (IUCN/CPSG), a workshop was held on August 2021 to evaluate the need, requisites and roles of an integrated Population Management Program for *A. guariba*. Such program was developed in June 2022 defining the objectives of (i) restore *in situ* populations from *ex situ* populations, prioritizing populations in higher risk to prevent local extinctions, and (ii) establish an *ex situ* insurance population. This *in situ* – *ex situ* integrated

management program was approved by ICMBio in February 2023, with actions recommended for all states along the species distribution. In Argentina, the species is Critically Endangered, with a remaining population of 20-50 individuals. Following the National Plan for Primate Conservation in Argentina, in a process similar to that in Brazil, two workshops were held in 2022/2023 to evaluate and define management actions for the long-term recovery of *A. guariba*. The priorities indicated were (i) reintroduction in ten potential areas in Misiones – due to a lower risk when compared to reinforcement of remaining populations, and (ii) establishing an *ex situ* management program in Argentina – still non-existent. The progressive collaboration between the initiatives of both countries is promoting the exchange of experiences and the integration of strategies. Here we summarize the planning and management carried out in Brazil and Argentina, highlighting the need for integrated measures. We debate on the progress and challenges, proposing next steps for developing and implementing a binational population management program for the conservation of the brown howler monkey.

#### KEYWORDS

population management, conservation translocations, action plans, primates, health sentinel, seed dispersion

## Introduction

The brown howler monkey, *Alouatta guariba*, is endemic to the Atlantic Forest, one of the largest primates and the one with the widest distribution in this biome. It occurs in eight states along eastern Brazil – Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Rio de Janeiro, Minas Gerais, Espírito Santo, and Bahia (Bicca-Marques et al., 2018; Neves et al., 2018), while in Argentina it is only present in the northeastern province of Misiones (Agostini et al., 2019). There is a persistent controversy about the existence of two different taxa. With a more pronounced sexual dichromatism, being adult male reddish and adult females brown, *A. g. clamitans* (Agc, Cabrera, 1940) has a larger range in the central and southernmost part of the species distribution. With a more

uniform brown coloration in both sexes, *A. g. guariba* is present in the northernmost area, occupying a more restricted and uncertain range (Agg, Rylands et al., 2000; Neves et al., 2018).

The species is increasingly impacted by loss and modification of its native habitat, hunting, trafficking for pet trade and diverse threats associated with infrastructure and urbanization – injuries or deaths due to vehicle collisions, electrocutions, and dog attacks (Agostini et al., 2019; Jerusalinsky et al., 2021; Chaves et al., 2022). Although howler monkeys are resilient and still present in fragmented landscapes and small impoverished forest remnants (Bicca-Marques et al., 2020), the indiscriminate deforestation and destruction of forests, besides the growing exposure to other threats in anthropized areas could severely threaten their survival in the medium and long term (Chaves et al., 2022).

Howler monkeys are also especially susceptible to yellow fever virus and suffer high mortality within a few days of being bitten by the mosquitoes vectors (Rifakis et al., 2006; Fernandes et al., 2021). Thus, they play a key role as public health sentinels, providing early warning of the virus and allowing for increased vaccination of surrounding human populations. Yellow fever outbreaks have decimated many populations or caused drastic population reduction in Argentina and southern Brazil in 2007/2009 (Almeida et al., 2012; Moreno et al., 2015). Another outbreak since 2017 up to date in Brazil caused thousands of monkeys' deaths (Bicca-Marques et al., 2017; Possamai et al., 2022), but has not reached Argentina. Aggravating the situation, due to the false information that contact or proximity with howler monkeys could infect humans, many individuals of this species were injured and

**Abbreviations:** APN DR NEA, Administración de Parques Nacionales - Delegación Regional Noreste; CONICET, Consejo Nacional de Investigaciones Científicas y Técnicas; NPC Argentina, Neotropical Primate Conservation Argentina; EBCo-CECOAL, Estación Biológica Corrientes - Centro de Ecología Aplicada del Litoral; UNNE, Universidad Nacional de Nordeste; MEyRNR Misiones, Ministerio de Ecología y Recursos Naturales Renovables Misiones; ICMBio, Instituto Chico Mendes para la Conservación de la Biodiversidad; CMAG BRASIL; IECEBA, Instituto de Ecología, Genética y Evolución de Buenos Aires; FCEN-UBA, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires; IMiBio, Instituto Misionero de Biodiversidad; INEVH, Instituto Nacional de Enfermedades Virales Humanas “Dr. Julio I. Maiztegui”; MAYDS, Ministerio de Ambiente y Desarrollo Sostenible.

killed in outbreak areas (Bicca-Marques et al., 2017; Bicca-Marques et al., 2018).

All these threats together resulted in reduced and isolated populations with local extinctions throughout its distribution (Jerusalinsky et al., 2021). These local extirpations, likely taking place simultaneously at various locations within the species' range can quickly lead to wider-spread regional extinctions if populations are separated by distances large enough to prevent re-colonization of empty habitats or with physical or anthropogenic barriers that reduce both movement and survivorship of dispersing individuals (Torres-Romero et al., 2023).

*Alouatta guariba* was included in the International Union for the Conservation of Nature's (IUCN) Red List of Threatened Species in the 1990's, being currently categorized as Vulnerable (Jerusalinsky et al., 2021), and has been listed five times (2012–2022) as one of the 25 most endangered primates of the world, first at subspecies level (*A. guariba guariba* – Neves et al., 2017) and later as species (Buss et al., 2019; Oklander et al., 2022a). In Argentina, the situation is particularly alarming, with an estimated population between 20 and 50 individuals exclusively in the province of Misiones, and the species is categorized as Critically Endangered (Agostini et al., 2019; Ministerio De Ambiente y Desarrollo Sostenible de Argentina -MADyS Resolution 316, 2021).

In Brazil, *Alouatta guariba clamitans* is categorized as Vulnerable (Bicca-Marques et al., 2018) and *Alouatta guariba guariba* as Critically Endangered (Neves et al., 2018), but both taxa were evaluated unifiedly at the species level at the technical-scientific stages for updating the national conservation status assessment coordinated by Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) and the category Endangered was indicated for *A. guariba*. The same is being followed by the IUCN Species Survival Commission's (SSC) Primate Specialist Group, which is preparing the publication of this updated category for the IUCN Red List. In addition, these taxa are classified as threatened in several Brazilian states: Critically Endangered (CR) in Minas Gerais (Agg, Deliberação Normativa COPAM n° 147, 2010), and Bahia (Agg, Portaria n° 37, 2017); Endangered (EN) in São Paulo (Ag, Decreto Estadual N° 63853, 2018) and Espírito Santo (Agc, Decreto Estadual No. 5.237/2022); and Vulnerable (VU) in Rio Grande do Sul (Agc, Decreto Estadual No. 51.797, 2014), Santa Catarina (Agc, Resolução Consema No. 002, 2011) and Minas Gerais (Agc, Deliberação Normativa COPAM No. 147, 2010). In Rio de Janeiro, the species was not listed but it was classified as Presumably Threatened (Bergallo et al., 2000), but the assessment is outdated. Finally, in Paraná the species is not included in the list of threatened species.

The species have a crucial role in the regeneration and maintenance of forests across its distribution, as they are important seed dispersers for numerous plant species (Chaves et al., 2018). Additionally, *A. guariba*, as howlers all over south America are part of the cultural heritage of both native people and settlers inhabiting Brazil and Argentina (Urbani and Cormier, 2015; de Almeida and Voltolini, 2017; Alves and Barboza, 2018; Oliveira, 2022).

Therefore, the conservation of this primate species contributes to the regeneration of the flora of the Atlantic Forest, to preserve

cultural heritage, and to promote public health and awareness towards biodiversity and habitat conservation.

In this context, under such level of risk and diversity of menaces, the long-term persistence of *A. guariba* must depend largely on the refined design and effective implementation of participatory, science-based conservation strategies (Lees et al., 2021). Under the framework of the global biodiversity conservation targets — such as in the Convention of Biological Diversity and the United Nations Sustainable Development Goals — both Brazil and Argentina established public policies for the conservation of the species through National Conservation Action Plans (ICMBio, 2018; MADyS, 2021), including population management in the specific objectives. In the present study, we describe the efforts to create national population management programs in both countries and to advance towards an integrated strategy in order to promote the conservation of *A. guariba* through population restoration. Our purpose is also reflecting on the progress and challenges to coordinate such initiatives and effectively reestablish viable populations of the species throughout its distribution range.

## Policies and guidelines for population management of *Alouatta guariba*

### Brazil

In August 2018, Brazil published the National Action Plan for the Conservation of Primates of the Atlantic Forest and the Maned-sloth (ICMBio, 2018), with strategies for 13 threatened species, including *A. guariba*. One of the six strategic goals established was to manage populations of target species aiming at their viability.

In order to implement this goal, in August 2021, the National Center for Research and Conservation of Brazilian Primates (ICMBio/CPB) and the IUCN SSC Conservation Planning Specialist Group (CPSG) held a virtual workshop using a unified planning approach (One Plan Approach - IUCN/CPSG, Byers et al., 2013) and applying the IUCN *Ex Situ* Guidelines (IUCN, 2014) to assess whether *ex situ* management is a suitable conservation tool for these species, defining what roles it can play in the species' overall conservation strategy, and which ones would need specific *ex situ*, *in situ* or integrated (i.e., *in situ* + *ex situ*) Population Management Programs (ICMBio, 2021; Valença-Montenegro et al., 2024). For *Alouatta guariba*, the decision was made to establish an *ex situ* insurance population primarily to serve as a source of individuals and groups for *in situ* population restoration efforts, while also playing a supportive role in promoting *ex situ* research and conservation education. Another major outcome for the species was the recommendation of creating an integrated Population Management Program (PMP), involving both *in situ* and *ex situ* populations and actions (Valença-Montenegro et al., 2024).

In June 2022, ICMBio/CPB coordinated another workshop with 24 collaborators from 21 institutions – including researchers and managers, representatives of universities, governmental and non-governmental institutions, environmental agencies from all eight Brazilian states of the species' distribution, and *ex situ* institutions,

to design the *Alouatta guariba* Integrated Population Management Program. Endorsing the workshop decisions, this program was officially approved by ICMBio in February 2023, with the main goal to “develop integrated population management of *Alouatta guariba*, throughout its range of occurrence, to offset the effects of threats and restore populations *in situ*”, with the specific goals of: i) ordering the *ex situ* population; ii) restore *in situ* populations using individuals from *ex situ*; iii) establish the *ex situ* insurance population; and iv) promote education and research actions for the conservation of the species (ICMBio, 2023). The involved stakeholders also recommended that, to restore *in situ* populations, priority be given to those populations at higher risk, aiming to reinforce populations with significant reductions to prevent imminent local extinctions, and to reintroduce populations in areas where the species became extinct within its distribution range.

It is also important to highlight that, due to the threat posed by yellow fever outbreaks, it was decided that all animals from *ex situ* populations to be released must be immunized before their release, in addition to two specific actions being included in the *Alouatta guariba* Integrated Population Management Program in relation to this issue: i) continue research into the effectiveness of the yellow fever vaccine for the species; and ii) establish flow and coordination with the competent institutions to obtain immunization against yellow fever.”

For coordinating and monitoring this Integrated Population Management Program, the Committee for Management of *Alouatta guariba* (CMAG) was also formally established, constituted by taxon specialists, *in situ* and *ex situ* managers, as well as representatives from the Brazilian Environmental Agency (ICMBio) and State Environmental Agencies from all the Brazilian states within the species natural distribution. This group evaluates and monitors population reinforcement and reintroduction projects for the species in Brazil. Furthermore, the Committee for Management of *Alouatta guariba* has the support of specialists in different areas for specific consultations, such as arboviruses, bacteriology, parasitology, assisted reproduction, pathology, etc.

## Argentina

In March 2019, the Argentinian Ministry of Environment and Sustainable Development and the Argentinian Primatological Society promoted a workshop, with support in preparing and facilitating from CPSG and ICMBio/CPB, to design the National Plan for the Conservation of Primates in Argentina. This plan was officially published by the Ministry in December 2021 (RESOL-2021-430-APN-MAD, [Ministerio de Ambiente y Desarrollo Sostenible, 2021](#)) aiming to coordinate conservation initiatives for the five primate species of the country. For the species at highest risk in the country, the Critically Endangered *A. guariba*, the plan set a specific objective to evaluate the recovery of the populations through an *ex situ* conservation program and analyzing the possibility of starting a breeding and reintroduction program and/or translocation of specimens.

Aiming to implement this specific objective, a two-stage workshop was held. First, in December 2022, a virtual meeting was organized as a preparatory step to gather the information needed to evaluate the population management of *A. guariba* in Argentina. Afterwards, in April 2023, an in person workshop with 47 participants, from 25 institutions (APN - DR NEA, Ananda Consultora, Aves Argentinas, Cambio Climático Misiones, Cambio Climático Nación, CONICET, NPC Argentina, EBCo-CECOAL/CONICET-UNNE, Fundación Rewilding Argentina, Fundación Temaikèn, MEyRNR Misiones, ICMBio/CPB, IEGEBA-CONICET, FCEN-UBA, IMiBio, INEVH, ITAIPU BINACIONAL, Ministerio de Ambiente y Desarrollo Sostenible de la Nación, Ministerio Salud Nación, Policía Ambiental Misiones, Programa Conservación Inclusiva MAyDS, Projeto Bugio, Proyecto Zorro Pitoco, Fundación Azara/Centro de Fauna Silvestre Güirá Oga) was held to develop and agree on management actions for the long-term recovery of the *Alouatta guariba* populations in Misiones, Argentina. This meeting counted on the participation of key members of the Brazilian Committee for Management of *Alouatta guariba*, such as the group’s coordinator and the ICMBio/CPB representative, looking for strengthening the connection among the two initiatives. The process followed the CPSG One Plan Approach (Byers et al., 2013), considering both the benefits and risks of population management following the IUCN Guidelines for Reintroductions and other Conservation Translocations (IUCN, 2013; Oklander et al., 2023a).

## Coordinating committees for population management of *Alouatta guariba*

### Brazil

The Brazilian Committee for Management of *Alouatta guariba* has been meeting monthly, with 19 virtual meetings to date. It has prepared, reviewed, and approved the committee’s internal regulations; prepared, tested, and used project and report evaluation forms, project and report presentation forms, and animal handling and release protocols.

Internal regulations were drawn up to establish the rules that are guiding the functioning of the committee. To guide the teams developing translocation projects, two protocols were created:

- *Ex Situ* Management Protocol (Hirano et al., 2023) – which addresses: sex-age classification; sanitary management and biosecurity; installations; nutrition; well-being; reproductive control; management of infants and the elderly; and the transport of animals. This protocol was prepared by the Technical Advisory Group of the National Action Plan for the Conservation of Primates of the Atlantic Forest and the Maned-sloth.
- Release Protocol: addresses the management necessary for the release of howler monkeys, including sanitary issues (disease risk analysis, recommended laboratory tests),

dietary issues (dietary transition to eat food usually eaten by wild howlers in the target or close areas), behavioral evaluation and also specification of acclimation enclosure, decision tree to guide the management, and post-release monitoring advices. This protocol is still under construction by the Committee for Management of *Alouatta guariba* with support from program specialists.

To guide proponents in presenting projects of management actions and also the committee members in analyzing and approving it, the following set of standard forms and documents was prepared, which are available at: <https://drive.google.com/drive/folders/1ft2zb4M8WSMtw6ZfOqLd70Kek1xhICBs>:

- Project submission form: the form contains all the necessary items to be presented when submitting projects, allowing for better targeting;
- Report submission form: to be presented to the committee after one year of project development, the form contains all the items to be evaluated;
- Project evaluation form and report to be used by committee members that contains all the criteria to be considered when evaluating them.

Letter of general opinion from the committee for forwarded projects: after analyzing each project, the committee issues an official opinion to the proponents so that they can continue with the process. This letter is presented by the proponent to ICMBio for registration in the official Brazilian system for submitting, analyzing and issuing permits for scientific activities and management actions, in accordance with pre-established documentation flow (Sisbio – Sistema de Autorização e Informação em Biodiversidade) - The species studbook is under construction: institutions that maintain brown howlers in *ex situ* conditions were contacted requesting information on the animals kept and forwarding documents for officializing the participation of the institution in the Program. In relation to the *ex situ* population, the species' studbook has already recorded 314 individuals in 27 different institutions. Of these, at least 152 meet the criteria to form an insurance population and could also be used in translocation actions (reinforcement and/or reintroduction) if they are approved in the behavioral and health analyses defined by the Program. These 152 individuals selected for the insurance population were also categorized by Management Units based on genetic differences (see description in the Binational actions section), with 19 from the Management Unit of Rio de Janeiro, Espírito Santo and Minas Gerais; 51 from São Paulo; eight from Paraná; and 74 from Santa Catarina, Rio Grande do Sul and Argentina.

Regarding the priority areas to be considered by the Integrated Population Management Program, 16 areas were identified as eligible during the meeting in São Paulo, 2021, indicating population reinforcement in areas where brown howlers still persist or reintroduction in areas where they were extirpated (Table 1, Figure 1). From those 16 potential areas, there are three projects under evaluation by the Committee for Management of

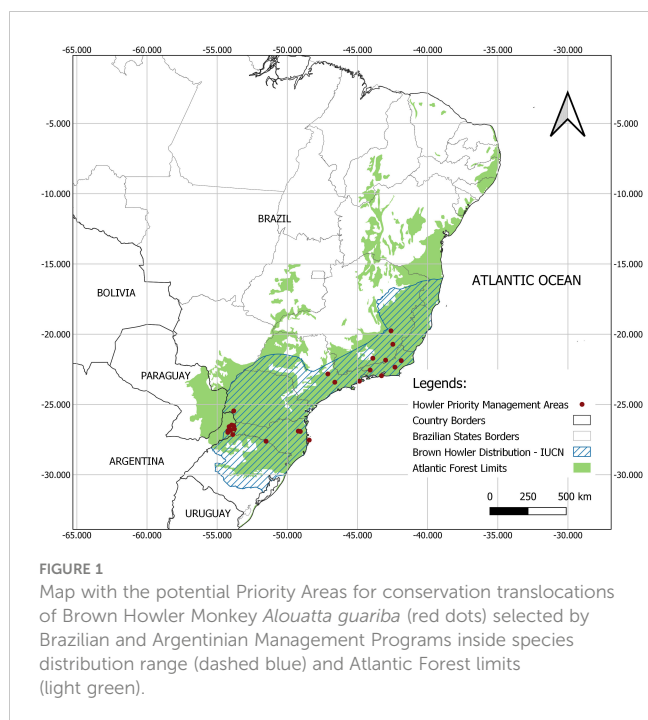
*Alouatta guariba*. Two conservation translocation projects have been already approved and are underway, namely:

- Population reinforcement of *Alouatta guariba* in the Cantareira State Park, in the State of São Paulo;
- Reintroduction of *Alouatta guariba* in Florianópolis, in the State of Santa Catarina.

TABLE 1 List of priority areas in the *Alouatta guariba* Brazilian Management Program, including the name, size, state of the country and the suggested management (reintroduction, reinforcement, no management needed or to be defined) ordered by States from South to North and by Recommended Population Management.

Name of the area	Area size (ha)	State	Recommended Population Management
Espigão Alto State Park	1,332	Rio Grande do Sul	Reintroduction
Morro Geisler, Indaial <sup>2</sup>	40	Santa Catarina	Reintroduction
Rio Vermelho State Park	1,532	Santa Catarina	Reintroduction
São Francisco de Assis Municipal Natural Park <sup>2</sup>	23	Santa Catarina	Reinforcement
Iguaçu National Park	185,262	Paraná	Reinforcement
Area of Relevant Ecological Interest Mata de Santa Genebra <sup>2</sup>	241,55	São Paulo	Reintroduction
Serra da Cantareira State Park	7,916	São Paulo	Reinforcement
Serra do Mar State Park	315,391	São Paulo	Reinforcement
Macaé de Cima Environmental Protection Area	35,037	Rio de Janeiro	Reintroduction
Tijuca National Park <sup>1</sup>	3,953	Rio de Janeiro	Reintroduction
Area of Relevant Ecological Interest Floresta da Cicuta <sup>2</sup>	131	Rio de Janeiro	Reinforcement
Desengano State Park	21,080	Rio de Janeiro	Reinforcement
Alto Douro Private Natural Heritage Reserve and Serra da Prata Private Natural Heritage Reserve	479,05	Minas Gerais	Reinforcement
Ibitipoca State Park and surroundings	1,418	Minas Gerais	Reinforcement
Rio Doce State Park	35,974	Minas Gerais	To be defined
Serra do Brigadeiro State Park	13,210	Minas Gerais	To be defined

<sup>1</sup> Continuation of the Reintroduction process; <sup>2</sup> Areas with less than 250 hectares of area are contiguous to larger forest remnants. Source: ICMBio (2023).



Another reintroduction project is underway in Tijuca National Park, Rio de Janeiro State and, having started 10 years ago, before the Integrated Population Management Program for *A. guariba*. However, important management decisions regarding this project have already been taken with the approval of CMAG. On the other hand, many aspects of the Integrated Population Management Program were inspired and informed by this pioneer experience.

The Brazilian Committee for Management of *Alouatta guariba* is composed by several experts and representatives from the different states of the species distribution range, and it receives requests for support in the destination of animals that are at risk or need to be transferred to another *ex situ* institution. These requests come mainly from state agencies and the ICMBio/CPB itself, considering the importance of recommendations from the Studbook keeper in some cases. A spreadsheet to register and control these cases was established and, to date, some type of support has been provided for 17 cases, coming from five states (Minas Gerais, São Paulo, Espírito Santo, Santa Catarina and Rio Grande do Sul).

Although a plan for systematic communication and dissemination has not yet been developed, several actions to publicize the IPMP have already been carried out, including: two articles in “O Eco” website (O Eco, 2023a, b); two articles in “Jornal O Globo” (O Globo, 2023, 2024); and lectures for Biology and Veterinary graduation courses at FURB (Blumenau Regional University) and for State Environmental Agencies.

Regarding the actions aiming to control the impacts of yellow fever, an intensive investigative effort supported by the Committee for Management of *Alouatta guariba* is underway to verify if vaccination could be an effective tool for preventing the disease in *Alouatta guariba*. Preliminary results demonstrated that the 17DD attenuated yellow fever vaccine was safe and immunogenic for *A.*

*guariba* (Fernandes et al., 2021). After that, other captive populations in Brazil are receiving the 17DD attenuated yellow fever vaccine, such as Centro de Pesquisas Biológicas de Indaial and Instituto Espaço Silvestre (Santa Catarina); Centro de Manejo e Conservação de Animais Silvestres and Instituto Libio (São Paulo) and Centro de Primatologia do Rio de Janeiro (Rio de Janeiro). All the animals involved in the Integrated Population Management Program are being vaccinated against yellow fever and tested if they become immunized prior to being included in reintroduction/reinforcement actions, following the protocol established in this research.

## Argentina

During the two-stage workshop in Argentina, we evaluated strategies for the long-term population recovery in Misiones, resulting in an exhaustive analysis of the existing scientific information on the population and areas where howlers have been recorded before and after the yellow fever outbreaks. The analysis indicated that all four management options evaluated – reintroduction, reinforcement, rescue and *ex situ* management – can be implemented, following the list of criteria and recommendations established for each option by the participants.

Reintroduction was considered as the first measure in specific areas of Misiones because it entails fewer potential risks to natural populations compared to population reinforcement. Reintroduction was also proposed as a priority option, as a way of improving management and translocation techniques to be subsequently applied in the implementation of population reinforcement actions. The simultaneous establishment of an *ex situ* management program was recommended for *Alouatta guariba* in Argentina as part of the comprehensive species management program (One-plan approach) and to contribute to its recovery and conservation. In Argentina nowadays there are no individuals of *A. guariba* in captivity.

Another important output of this workshop was the creation of a multi-sectoral Management Committee, aiming to promote the implementation of the defined population management strategies, thus favoring the restoration of ecological functions in the ecosystems inhabited by these monkeys, as well as to recover their cultural value among local communities, highlighting their role as sentinels for public health and as seed dispersers. This committee is composed of representatives of the national governmental environmental entities of Argentina and Brazil, Misiones province authorities, the IUCN SSC Primate Specialist Group, researchers, forest rangers, NGOs and other important stakeholders.

Ten areas were prioritized to initiate the surveys as possible reintroduction sites, of which Esmeralda Provincial Park was indicated as one with the greatest benefits and lowest potential risks (Table 2). The final report of this workshop is in process to be published, but the preprint is already available (Oklander et al., 2023b). Currently, we are working on obtaining funds in order to develop the agreed actions.

TABLE 2 List of ten priority areas in the *Alouatta guariba* Argentinian Management Program, including the name, size, state of the country and the suggested management (population reinforcement, reintroduction, no management needed or to be defined) ordered by Recommended Population Management.

Name of the area	Area size (ha)	State	Recommended Population Management
Caá-Yari Provincial Park	4,783	Misiones	Reintroduction
Cruce Caballero Provincial Park	600	Misiones	Reintroduction
Guarani Multiple Use Reserve	5,343	Misiones	Reintroduction
Esmeralda Provincial Park	31,700	Misiones	Reinforcement
Moconá Provincial Park	1,000	Misiones	Reinforcement
El Piñalito Provincial Park <sup>3</sup>	3,800	Misiones	To be defined
Papel Misionero Cultural Natural Reserve <sup>4</sup>	10,200	Misiones	To be defined
Private property Arauco <sup>2</sup>	8700	Misiones	To be defined
Private property GBM (former Belgian Forestry) <sup>2</sup>	25,000	Misiones	To be defined
Private property La Mocheta <sup>1</sup>	10,000	Misiones	To be defined

Reasons for not defining the management this date: <sup>1</sup> Permanent deforestation in this area; <sup>2</sup> Private areas that need negotiation with the owner company; <sup>3</sup> Risk of hybridization by the confirmed occurrence of *A. guariba* and *A. caraya*; <sup>4</sup> Presence of Guaraní communities.

## Binational actions and integration process

The processes in the two countries ran in parallel, following the stakeholders' agendas and the governmental directives of each one. Although, the continuous exchange of information and experience was crucial to qualify the proposals and evidenced the need for integration among the two programs, since the distribution of the species transcends political borders. The main evidence of how crucial the binational cooperation is for recovering the brown howler populations is that it became clear that the conservation of the species in Argentina unequivocally depends on population management; which in turn depends on individuals and *ex situ* management experience from Brazil, since in Argentina there are no captive brown howlers and the remnant *in situ* populations are too small to serve as source for conservation translocations.

Genetic analysis including samples from across the species' distribution are key to guarantee correct *ex situ* management and structuring adequate insurance populations. The description of intraspecific conservation units, assessing the levels of genetic diversity and gene flow of remaining populations is fundamental to guide management decisions. Aiming to conserve the genetic pool of *Alouatta guariba*, and provide conservation guidelines and key information for management or conservation translocation

projects, five different Management Units (MU) were defined throughout the actual geographic distribution of the brown howler monkey during the meeting in São Paulo, in 2021. Based on significant differences in allele frequency distributions (Oklander et al., 2007) and significant divergence in mitochondrial and nuclear loci, with the samples analyzed up to 2021, we grouped individuals into three genetic clusters: 1. Misiones (Argentina), Rio Grande do Sul and Santa Catarina (Brazil); 2. São Paulo (Brazil); 3. Rio de Janeiro, Espírito Santo and Minas Gerais (Brazil). Until that moment, there were no available samples analyzed from the Brazilian states of Parana and Bahia, so they were designated as two additional distinct Management Units for precautionary measures. However, more recent analyzes suggest that at least one population analyzed in Paraná near the province of Misiones (Argentina) belongs to the cluster 1. These data, together with a review of previous work on the taxonomy and phylogeography of the species (Rylands et al., 2000; Gregorin, 2006; Povill et al., 2023) are about to be published in an article where updated MU are proposed (Oklander et al., in prep).

The published protocol for *ex situ* management (Hirano et al., 2023) and that for preparation for release (under construction), both developed in the scope of the Brazilian Integrated Population Management Program, counted on the advice of members from Argentina, and is also being adapted to be used by the Argentinian program. These protocols are essential to control and reduce the risks involved in animal translocations and will serve as a guide for conservationist translocations of *ex situ* howlers to be developed.

The first Brazilian translocations began in Santa Catarina, with the reintroduction of three groups of howler monkeys out of a total of six groups planned for the first half of 2024. In São Paulo, there is another project already approved by the management program that aims to reinforce the natural population in one of the priority areas listed for the state and which suffered a decline in the howler monkey population due to yellow fever outbreaks. And there is the third reintroduction in one of the selected areas, the continuation of the reintroduction project at Tijuca National Park, in Rio de Janeiro, with the release of the second group, a family group with six members. In Argentina, surveys are being prepared to select sites for reintroductions in Misiones. Additionally, appropriate enclosures are being planned to receive individuals/groups from Brazil and the Committee is seeking funds to build them. Another important decision in this integration process was that all the individuals exported from Brazil to Argentina must be vaccinated against yellow fever.

## Discussion and next steps

The brown howler monkey has been suffering from hunting, deforestation and habitat fragmentation, in addition to the latest epizootic events of yellow fever, which has led the species to an increased level of extinction risk and being listed among the 25 most endangered primates of the world (Jerusalinsky et al., 2021; Oklander et al., 2022a). This motivated the mobilization of efforts to develop management strategies with an integrative approach to its *ex situ* and *in situ* populations, aiming to restore the largest possible number of populations throughout its distribution area.

Given that the species' distribution includes two countries, Argentina and Brazil, these strategies need to be developed in an integrated manner to be more effective. We present here how the involved teams of the two countries, following the respective national conservation action plans, have acted both independently and cooperatively to develop such strategies, with the step-by-step procedures in each country and to promote integration, as well as the achievements and difficulties in these processes.

In Brazil, the Integrated Population Management Program for *A. guariba* was the first created and officially recognized following the newest national legal framework for such programs (ICMBio, 2021, 2023). However, in its first year (2023-2024), the Committee for Management of *Alouatta guariba* faced numerous difficulties to coordinate and implement the program: 1. the need to update/identify populations/areas which would require management according to the established criteria (considering distribution extremes and management units); 2. the delay in producing a list of dietary species consumed in the occurrence areas, according to the forest types; 3. the need to identify other areas – in addition to those already selected – that could be eligible for population management; 4. the delay to consolidate/update the necessary protocols – collection and allocation of biological samples for genetics, health research, behavioral assessment (associated with ethograms); preparation for release in translocations; post-release monitoring; reproductive assessment; and 5. the lack of an established decision key to evaluate and define the destination of confiscated and *ex situ* individuals.

The Committee for Management of *Alouatta guariba* also experienced difficulties in implementation or application of the following actions due to the insufficiency of financial resources: 1. executing efforts to collect biological samples for genetic analysis in the following areas (sampling gaps): southern Bahia, southeast of Minas Gerais, central and western the São Paulo, the whole state of Paraná, and the highlands of Rio Grande do Sul and Santa Catarina; 2. liaise with laboratories to carry out serological tests for arboviruses; and 3. continue research on the effectiveness of the yellow fever vaccine for the species. Additional challenges were faced due to the low adherence by institutions and their respective managers in: 1. updating/identifying the individuals to be part of the studbook – according to established criteria; 2. assembling the studbook for *Alouatta guariba*; 3. making the annual management recommendations; 4. developing the *ex situ* management according to studbook recommendations; and 5. effectively promoting the establishment of an insurance population.

In the other hand, within just one year, the Committee for Management of *Alouatta guariba* was able to promote the satisfactory implementation of several actions in Brazil, with a continuous work in progress. This includes: 1. promoting the integrated management for the conservation of the species; 2. articulating to obtain serology results for arboviruses carried out in active surveillance by the Health Departments/Research Projects; 3. establishing and implementing a communication and awareness

plan about the species and the Population Management Program; 4. creating forms for project, report, considerations on the project and report evaluation; and 5. evaluating projects proposing management actions in accordance with the Integrated Population Management Program.

In Argentina, to carry out the first reintroductions, several prior steps are necessary such as: 1) survey the presence of brown howler monkeys in the 10 areas prioritized as possible reintroduction sites; 2) survey the presence of black and gold howler monkeys in the same areas, following the recommendation to avoid reintroductions in sites with the presence of *A. caraya* due to the evidence of hybridization between the two species; 3) survey the presence of other mammal species and potential predators in that priority areas; 4) evaluate the state of habitat conservation in the 10 areas prioritized; 5) work together with the local communities on the importance of the brown howlers as sentinels for yellow fever, regenerators of the forest, and cultural values previously to any reintroduction; 6) import groups/individuals from Brazil to carry out the reintroductions. Since the workshop, we have been working on obtaining financing support to progress on all these steps.

So far, we have obtained financing for developing conservation educational workshops – framed for the upcoming reintroduction of brown howler monkeys into these areas, highlighting the importance of the species as a seed disperser and health sentinel – in rural schools within the prioritized areas (Primate Conservation Inc). We plan to start these activities in May 2024 together with an information survey with local people to comply with the scientific-technical requirements necessary to carry out the consensual actions. We have also obtained funding to expand the capacity of enclosures at the rescue center in Misiones Province, complying with international standards, for the reception of individuals imported from Brazil (International Primate Protection League). This Rescue Center called Guira Oga (<https://guiraoga.com.ar/>) will finance the maintenance, medical attention and supplies, and food for howlers, from reception until release. The challenge at hand is to obtain funding to carry out the rest of the prior steps mentioned above. Another key issue refers to obtaining the international movement permits, which we believe will be facilitated by the involvement of competent authorities in the process.

The current categorization of *Alouatta guariba* as Vulnerable, despite the diverse and severe menaces it faces, can be largely attributed to the species' wide geographic distribution range (Jerusalinsky et al., 2021). The consideration that all individuals of the species (or of the currently recognized subspecies) are homogeneous can lead to management errors and the unnoticed loss of populations with exclusive genetic characteristics. This can be prevented by designating intraspecific conservation units such as Evolutionarily Significant Units (ESU) or Management Units (MU). An example of this regrettably late detection exists in the black-and-gold howler monkey (*Alouatta caraya*) where a genetic study after the construction of dams showed that an entire genetic cluster of the species probably became extinct due to the flooding of populations



with exclusive genetic characteristics (Oklander et al., 2022b). In this sense, the designation of MU in *Alouatta guariba* has been a very important precautionary measure.

Following the Guidelines for Reintroductions and other Conservation Translocations (IUCN, 2013), each management action proposed to effectively implement the present strategy, will need to include detailed exposure of its potential risks and benefits for ecological, social and economic interests, which will be carefully evaluated by the corresponding coordination committee and the competent authorities. Particular attention must be given whether there is strong evidence that the threat(s) that caused population reduction or local extinction have been correctly identified and removed or sufficiently reduced, without which it should not proceed, and alternative conservation solutions should be sought (IUCN, 2013). In a local perspective, much of the success of such reintroductions will depend on minimizing typical conflicts with humans (García de la Chica et al., 2023), so working with the community in areas where conservation translocations will be implemented is indispensable. At another extreme of the spatial scale, the effectiveness of this strategy must depend on the continuous binational integration and some type of international formalization of the initiative.

Biodiversity faces the worldwide escalation of an anthropogenic crisis, with extensive modification of natural environments threatening several species, impacted by habitat loss and fragmentation, and emergent challenges to their conservation such as climate change and diseases outbreaks (Bernard and Marshall, 2020). This is the case for many primates, including *A. guariba* (Estrada et al., 2017; Jerusalinsky et al., 2021; Oklander et al., 2022a). Developing and implementing science-based, participatory and integrated strategies – sharing information, work and responsibilities among all those involved (researchers, government agencies, NGOs, zoos and wildlife rescue centers, protected areas and concerned citizens) – can be a decisive factor for the conservation of species (Lees et al., 2021). Several efforts have been made in this sense to develop conservation action plans for primates in the last five decades, including national initiatives (Reuter et al., 2022). A good example on the positive impacts for primate conservation of such approach comes from another Atlantic Forest atelid, the murequis, which benefited from progressive efforts in science, public policies and population management (Strier et al., 2021). In this context, building the present science-based, participatory and integrative strategy to restore populations of *A. guariba* represents an innovative background, and may inspire further initiatives for the conservation of threatened species requiring population management and pluri-national efforts.

## Author contributions

LO: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration,

Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Visualization, Writing – original draft, Writing – review & editing, Validation. RR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing, Validation. SP: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. ZH: Conceptualization, Formal analysis, Investigation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. CM: Data curation, Investigation, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. AD: Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. DD: Investigation, Resources, Writing – original draft, Writing – review & editing. DO: Investigation, Writing – original draft, Writing – review & editing. FM: Investigation, Writing – review & editing. MV-M: Investigation, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. MK: Conceptualization, Investigation, Methodology, Project administration, Writing – review & editing. LJ: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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