




Hunting pressure on primates in the southern portion of the Brazilian Northeast: historical threats and current perspectives

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ABSTRACT

Hunting is an ancient human behavior, which likely became complex and efficient gradually through time. We present data from a bibliographic survey (qualitative) and field sampling (quantitative) of primate hunting in Northeastern Brazil. We evaluated hunting threats faced by 14 primate species native to the States of Bahia and Sergipe (three Critically Endangered, three Endangered, three Vulnerable, two Near Threatened, and three Least Concern). Qualitatively, since 2005, we identified 21 academic studies that contained 47 mentions of all six studied genera known to occur in the study area (*Alouatta*=4, *Brachyteles*=2, *Callicebus*=16, *Callithrix*=8, *Leontopithecus*=3, *Sapajus*=14). Approximately half of the citations were for hunting (55.3%; 88.4% of this for bushmeat) and the other half for trapping (44.7%; 90.4% for pet). Quantitatively, we obtained 834 local experts' citations of primate hunting and capturing at 348 sites. All experts cited *Callithrix*, 818 cited *Sapajus*, and 738 cited *Callicebus*. We argued 539 about hunting for bushmeat (164 positive; 30.4%) and 636 about trapping for pet (189 positive; 30.9%). *Callicebus* presented 95 citations as bushmeat (30.1% of 326 queries) and *Sapajus* presented 80 citations as pet (35.7% of 224). Four informants reported hunting *Sapajus* for pest control because of crop damage. There was a significant difference ($\chi^2=33.982$; $df=2$; $p<0.0001$) comparing hunting for bushmeat and pets, with *Callicebus* (higher bushmeat) and *Sapajus* (higher pet) presenting significant differences (both $p<0.01$). The impact of hunting is associated with biological contexts, besides socioeconomic and political, requiring complex-specific attention and efforts in conservation and management strategies, perhaps innovative, even non-prohibitive hunting.

Keywords: Threatened species, *Alouatta*, *Brachyteles*, *Callicebus*, *Callithrix*, *Leontopithecus*, *Sapajus*.

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SIGNIFICANCE STATEMENT

We reviewed the academic literature since 2005, which mentions the hunting of primates from the states of Bahia and Sergipe, and their respective uses. In addition, we investigated the hunting and trapping patterns of primates from these states through field data sampling. The analysis of the field data agreed with the academic literature on primate hunting patterns in northeastern Brazil. Moreover, we found an unexpected hunting pattern in some species. The results highlighted the impact of hunting to the reduction of primate populations and the local extinction of some species. Any strategy for the conservation of primates throughout the study region must consider the regional, biological, socioeconomic, and political contexts of local impacts of game hunting.

INTRODUCTION

Hunting is an ancient human behavior of unknown origin (Hill 1982), which likely became more complex and efficient quite gradually through time over the course of the evolution of *Homo sapiens* (Klein 1987). Hunting was important precursor of agricultural practices, contributing to the advancement of human societies (Nitecki 1987), and is still an important component of the subsistence strategies of some human societies (Sponsel 1997; Peres 2001; Nunes *et al.* 2017). In the present day, however, hunting is second only to habitat loss and fragmentation as a major threat to the planet's terrestrial fauna (Cowlshaw and Dunbar 2000; Benítez-Lopez *et al.* 2017; ICMBio 2018).

In addition to its impact on populations, which includes local extinction, in some cases, hunting may lead to other processes, such as the loss of genetic variability, key ecological processes, and certain plant species, as well as the homogenization of landscapes (see Redford 1992; Cowlshaw and Dunbar 2000; Tabarelli *et al.* 2004; Terborgh *et al.* 2008; Wilkie *et al.* 2011; Bagchi *et al.* 2018). Hunting, combined with habitat loss and fragmentation, imposes severe limitations on a local fauna (Novaro *et al.* 2000), in particular animals, such as Neotropical primates, that are dependent on forest habitats (Gouveia *et al.* 2014).

In addition to subsistence, hunting has a number of alternative objectives, including the trade in bushmeat and medicinal substances (Stanford 1999; Alvard *et al.* 1997; Cowlshaw and Dunbar 2000), pest control (King and Lee 1987; Lee and Priston 2005), and sport (Bekoff and Jamieson 1991; Loveridge *et al.* 2007). Here, we differentiate trapping as the non-lethal harvesting of animals, for the capture of pets or trade, legal or otherwise, although, in the specific case of primates, this may often include the death of certain individuals (Ceballos-Mago *et al.* 2010). Hunting tends to result in a drastic reduction in population size, as observed in some Neotropical mammals (Robinson and Redford 1991), including many Brazilian primates (Costa *et al.* 2005; Chiarello *et al.* 2008; ICMBio 2018). Under certain conditions, hunting may even lead to the local extinction of a primate species (Aguirre 1971; Lane 1990; Cowlshaw and Dunbar 2000).

Under most circumstances, hunting is illegal in

Brazil (Brasil 1998), which means that this activity tends to be under-reported in the extreme, although some insights into the illegal trade in wildlife are provided by the monitoring of government agencies. Between 1999 and 2006, for example, the wildlife screening centers (CETAS: *Centros de Triagem de Animais Silvestres*) of the Brazilian Environment Institute (IBAMA: *Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis*) documented more than 4,500 primates, derived from actions against illegal trade, confiscations, and donations (Levacov *et al.* 2011). A total of approximately 1,300 legal trade transactions in Brazilian primates have also been registered since 1977 (Fialho *et al.* 2016). In fact, considering the trade only for zoos and scientific purposes (between 1977 and 2013), approximately 90,000 live Neotropical monkeys were exported from all South American habitat countries (except Ecuador). During a similar period (1975–2014), night monkeys (*Aotus* spp.) alone contributed more than 13,000 individuals (Svensson *et al.* 2016), which were exported from Brazil, Colombia, Ecuador, Panama, and Peru. While striking, it seems likely that these numbers under-report the real scenario considerably. In fact, Maldonado *et al.* (2009) reported that approximately 4,000 night monkeys (*Aotus* spp.) were captured or traded from the Brazil–Colombia–Peru border region in 2007 and 2008 alone.

A number of Brazilian primates are under some level of threat of extinction (see Costa *et al.* 2005; Chiarello *et al.* 2008; MMA 2014; ICMBio 2018), with the scenario being exacerbated, in many cases, by hunting pressure. This problem is especially intended in eastern Brazil, primarily in the Atlantic Forest and Caatinga domains, which have been subject to the most critical levels of habitat impact (see MapBiomass 2022). In the present study, we review both qualitative (literature search) and quantitative (field sampling) data on the hunting of primates in the southern portion of the Brazilian Northeast region, that is, the states of Bahia and Sergipe. We also applied a quantitative analysis to identify the principal threat faced by each primate genus, considering the focus of the hunting activity affecting each taxon.

MATERIAL AND METHODS

Study Area

We included all sites located within the southern portion of the Brazilian Northeast region, that is, the states of Bahia and Sergipe, including any research that refers to the primate species of this area. This area was inhabited originally by 14 primate species distributed in six genera: *Alouatta caraya*, *Alouatta guariba*, *Brachyteles hypoxanthus*, *Callicebus barbarabrownae*, *Callicebus coimbrai*, *Callicebus melanochir*, *Callithrix geoffroyi*, *Callithrix jacchus*, *Callithrix kuhlii*, *Callithrix penicillata*, *Leontopithecus chrysomelas*, *Sapajus libidinosus*, *S. robustus*, and *Sapajus xanthosternos* (see Rylands and Mittermeier 2009; Rylands *et al.* 2009; Marques *et al.* 2013a,b; Alonso *et al.* 2024). Three of these species – *B. hypoxanthus*, *C. barbarabrownae*, and *S. xanthosternos* – are listed as Critically Endangered (CR) by the IUCN (Canale *et al.* 2021; Melo *et al.* 2021b; Printes *et al.* 2021), and are the study region's most prominent forms, in conservation terms. Three other species – *C. coimbrai*, *L. chrysomelas*, and *S. robustus* – are listed as Endangered (EN) by the IUCN (Jerusalinsky *et al.* 2020; Martins *et al.* 2021b; Oliveira *et al.* 2021). Three of the other eight species are listed as Vulnerable, VU (Jerusalinsky *et al.* 2021; Neves *et al.* 2021; Printes *et al.* 2020), two are Near Threatened, NT (Bicca-Marques *et al.* 2021; Martins *et al.* 2021a), and three as Least Concern, LC (Melo *et al.* 2021a; Valença-Montenegro *et al.* 2021; Valle *et al.* 2021).

Qualitative Data Sampling

We surveyed and assessed the published academic literature and unpublished reports from research projects produced since 1997 up to 2023 that refer to the hunting and trapping of primates within the study area. We search the Web of Science catalogue and Google Scholar using the names (scientific and common names, former and current typos) of all primate species and genus occurring in the study area (see above), followed by the terms “hunt”, “hunting”, “pet”, “pet trade” together with the connectors “or” and “and”. We scrutinized the References of the articles and reports we find in order to identify additional documents. These documents were examined to determine the target species and the principal objective of the activity, i.e., hunting or trapping, and the specific subcategories. We also examined the studies to identify the number of citations or hunting events documented for each species, and any other information considered relevant to our goal.

Quantitative Data Sampling

The assessment of the conservation status of a species based on a participative and integrative research depends on the adequate identification of the local residents that are considered to be local experts in their respective communities. In addition, since we knew about the absence of some species at specific sites, we did not argue all the informants comprehensively, thus not arguing about all species or all hunting purposes. Besides, when the needed information is highly sensitive, such as hunting, a practice that is considered illegal in Brazil (Brasil 1998), running the proper research method is crucial to the effectiveness of the survey and assessment. This strategy allowed us to dedicate field effort accurately to sites with a higher probability of occurrence of the assessed primate species or to survey more accurate information concerning its conservation status, besides past and current threats (e.g., Kierulff *et al.* 2005; Jerusalinsky *et al.* 2006; Marques *et al.* 2013a,b; Beltrão-Mendes and Ferrari 2019).

We identified local experts (Davis and Wagner 2003) using a set of approaches, but primarily unprompted and undirected interviews (Chizzotti 2005; Bernard 2011), in particular, by using the snowball technique to identify the most valuable potential interviewer (Goodman 1961; Johnson *et al.* 1989; Browne 2005; Bernard 2011; Printes 2011). In addition to their knowledge of the local wildlife, it was important to select experienced individuals that were resident in the vicinity of primate habitats, and are or were active in the exploitation of natural resources, in particular, hunting. We used colored plates (Mittermeier *et al.* 2007; Reis *et al.* 2015), and recordings of vocalizations (Emmons *et al.* 1998) to ensure the identification of primate species. The colored plates contained local and autochthonous species to ensure the correct identification of local species by the experts.

The data presented here are derived from previous studies of the distribution and occurrence of primate species in northeastern Brazil (Jerusalinsky *et al.* 2006; Marques *et al.* 2013a,b; Beltrão-Mendes and Ferrari 2019; Alonso *et al.* 2024; Jerusalinsky *et al.* unpub. data), together with records compiled by the authors of the present study. We surveyed 348 sites, distributed throughout the study area. Whenever the local occurrence of primates was confirmed, we compiled all possible information on the characteristics of the species and the type of exploitation (hunting or trapping, and their respective subcategories). These data were collected as part of a broader survey that focused on the mammalian fauna of the study area as a whole, although only the data on the hunting of primates are presented and analyzed here.

Data analysis

Given the limited database available for some species, the data were analyzed per genus, which is justifiable given the similar characteristics of congeners, in particular in terms of the threats they face (see ICMBio 2018; IUCN 2024). As the assessment is limited primarily by the number of studies available for each species, the analyses of the qualitative data are descriptive and non-parametric.

The quantitative data were also grouped by genus for analysis, and null data or taxa with a prohibitively small number of records were excluded from the analyses, as necessary. Some hunting subcategories (medicinal use, pest control, and sports) were also excluded due to a reduced number of records. As the data were derived from field studies based on varying approaches and sampling effort, some adjustments were necessary to ensure reliable analyses. We used only the positive answers on hunting or trapping obtained in each study, for example, as a proportion of the number of informants interviewed. We analyzed the variation in the citations among the different primate genera by category (hunting or trapping) using Chi-square, and within each genus with the *post hoc* Bonferroni correction. We ran the analyses on the R platform v. 4.3.2 (R Core Team 2023), using RStudio v. 2023.12.1.402 (Posit team 2024), and the *stats* (R Core Team 2023) and *chisq.posthoc.test* packages (Ebbert 2019), considering $\alpha = 0.05$ in all cases.

RESULTS

Qualitative Data

We identified 21 academic studies that contained 47 citations of species of all the six genera known to occur in the study area. These citations included four of *Alouatta*, two of *Brachyteles*, and three *Leontopithecus*, with eight for *Callithrix*, 14 for *Sapajus*, and 16 for *Callicebus*. Just over half of these citations (55.3%) referred to hunting and the other half (44.7%), to trapping (Figure 1; Additional File 1). In most cases (88.4%), the primates were hunted for bushmeat, although in all but one of the other records, the objective of the activity was not specified. Similarly, most (90.4%) citations of trapping referred to the capture of pets, while the remaining records were derived from scientific studies that involved trapping and trafficking surveillance.

All the citations of both *Alouatta* and *Brachyteles* referred to hunting for bushmeat (Table 1), while *Leontopithecus* was cited twice as game hunting and once for trapping pets. Predictably, based on its body size, *Callithrix* was targeted primarily as a source of pets (Table 1), and *Sapajus* was sought almost equally

by hunters and trappers, whereas *Callicebus* was targeted mainly as game hunting. Titis (*Callicebus*), in turn, are notoriously difficult to maintain in captivity, in addition to their relatively small size (barely reaching one kilo), being a suboptimal target for subsistence hunters. One study (Jerusalinsky *et al.* 2013) indicated *Callithrix* as the most frequent genus as a pet, followed by *Sapajus* (Table 1).

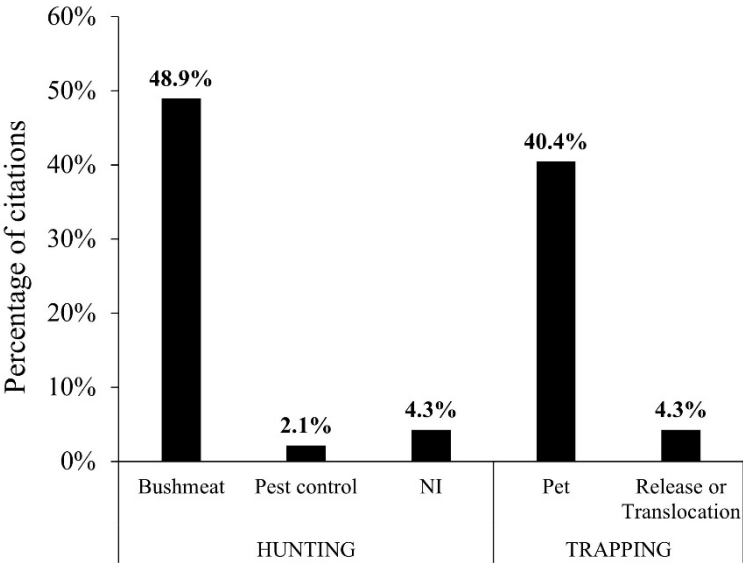
Quantitative Data

Between 2006 and 2019, we surveyed 348 sites across the study area, and obtained 834 reports from local experts on the hunting and trapping of the local primate species. All these experts reported the local presence of *Callithrix*, while 818 cited *Sapajus*, and 738 referred to the genus *Callicebus*. Overall, 164 (30.4%) of the 539 informants questioned about the harvesting of bushmeat provided affirmative answer, while 189 (30.9%) of the 636 individuals consulted on the trapping of pets confirmed the practise. We recorded only one report of subsistence hunting for *Alouatta caraya*. As we did not interview all the informants comprehensively (see Methods), we selected 827 representative citations on subsistence hunting and 731 citations on trapping for analysis (Figure 2). Overall, *Callicebus* was cited most often as game (30.1%: 95 positive answers to 326 questions), while *Sapajus* was cited most often as a pet (35.7%: 80/224). Four informants reported hunting *Sapajus* for pest control because the capuchins damage their crops.

Overall (Figure 2), significant differences ($\chi^2 = 33.982$; $df = 2$; $p < 0.0001$) were found among the three genera in the proportions of hunting and trapping. The *post hoc* analysis indicated that *Callicebus* was hunted significantly more frequently than it was trapped ($p < 0.01$), with the opposite pattern being observed in *Sapajus* ($p < 0.01$). However, while *Callithrix* was targeted more often for the capture of pets, the difference between the two types of exploitation was not significant ($p = 0.607$) in this case.

DISCUSSION

The historical data indicate that hunting and trapping are among the principal threats to primate populations, and that, after habitat loss and fragmentation, subsistence hunting is the principal driver of the local extinction of *B. hypoxanthus*, and the decline in the populations of howlers, *A. caraya* and *A. guariba*. These data also indicate that, while both *Callicebus* and *Sapajus* are targeted by hunters and trappers, *Alouatta* is target exclusively by hunters, and *Callithrix* for the acquisition of pets. The findings of the present study indicate clearly that hunting still threatens the populations of both *Callicebus* and



Hình 1. Relative frequency of reports of the hunting and trapping of the Neotropical primates of the states of Bahia and Sergipe, Northeastern Brazil, based on the academic literature published between 2005 and 2023. NI = Not Informed.

Bảng 1. Number of reports of the different uses of the Neotropical primate genera targeted by hunters in the Brazilian states of Bahia and Sergipe, based on the scientific literature published between 1997 and 2023.

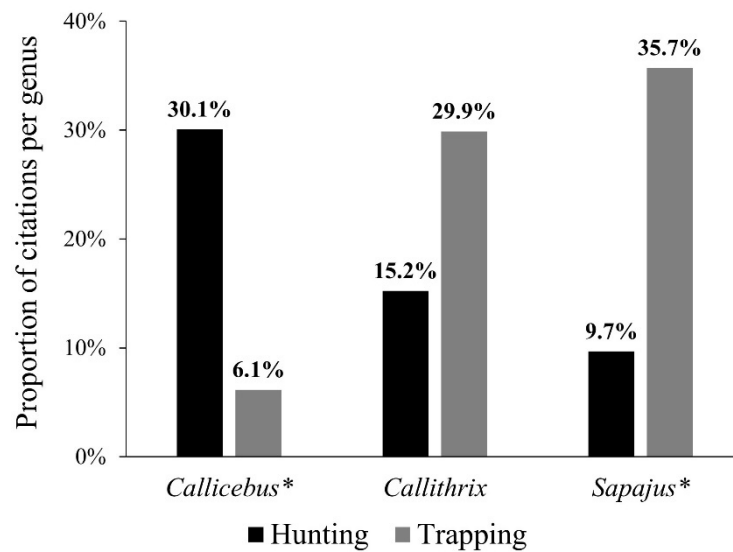
Genus	Number of reports of game hunting for				
	Bushmeat	Pest control	Not informed	Capture of pets	Scientific study
<i>Alouatta</i>	3	-	-	-	-
<i>Brachyteles</i>	2	-	-	-	-
<i>Callicebus</i>	9		2	5	-
<i>Callithrix</i>	3	-	-	6	-
<i>Leontopithecus</i>	2	-	-	1	-
<i>Sapajus</i>	5	1	-	6	2

Sapajus, although *Alouatta* is relatively rare or absent from most of the study area, which was reflected in the general paucity of reports, and may reflect habitat loss and hunting pressure. The absence of citations of *Brachyteles* was the result of local extinction in the areas surveyed.

In contrast with our expectations, *Callicebus* was one of the genera cited most often, both as game and pet, although this may reflect a sampling bias, given the number of the studies that focused specifically on this genus. As hunting is illegal in Brazil, it seems likely that the activity is largely under-reported, not only in monitoring programs (see Svensson *et al.* 2016), but also in specific research projects. The illegal nature of the activity will also likely reduce the presence of vestiges, that is, animal parts kept as trophies. While

these questions almost certainly affected the findings of the present study, they were consistent with the historical data (i.e., *Sapajus* and *Callithrix* mostly trapped as pet; see details below). There is also the synergic effect of the capture of pets – orphaned infants – as a byproduct of hunting for bushmeat, which is not often dealt with adequately in the available studies. The detection of this synergic effect during fieldwork would be limited even more by the illegal nature of hunting.

Overall, in fact, there is a general lack of studies of the impact of hunting on most of the primate species found in the study area, although both *Alouatta* and *Brachyteles* have clearly been impacted extensively, as reported by Castilho *et al.* (2019) for *A. guariba* and *B. hypoxanthus* in southeastern Bahia.



Hình 2. Relative frequency (percent) of citations of hunting and trapping of the three primate genera from the study area, based on interviews with 834 local residents at 348 sites distributed across the states of Bahia and Sergipe, in northeastern Brazil (data collected between 2006 and 2019). The asterisk (*) indicates a significant difference ($p < 0.01$) between the frequency of hunting and trapping in the respective genus.

In addition to being hunted widely as a source of bushmeat (Ramírez-Barajas and Calmé 2015; Alves *et al.* 2016), *Alouatta* is also sometimes targeted for medicinal or magical/religious purposes (Alves *et al.* 2016). While Castilho *et al.* (2019) did not obtain a single record of the hunting of *Leontopithecus chrysomelas* in southeastern Bahia, local residents perceived an increase in the local population of this species as a result of a halt in hunting activity. While *Sapajus* is targeted primarily for bushmeat and pets (Kierulff *et al.* 2005; Nascimento *et al.* 2013), there are some reports of medicinal use (Alves *et al.* 2016). Castilho *et al.* (2019) recorded a perceived decrease in the population of *Sapajus xanthosternos* due to overhunting, even though Teixeira *et al.* (2024) recorded low hunting rates in southern Bahia, which may nevertheless be the result of the few remnant populations that persist in the region.

While Alves *et al.* (2016) reported that *Callicebus barbarabrownae* was targeted only as a pet, Printes (unpub. data) recorded the medicinal use of this species, for the treatment of neurological disorder (for nerves' health, free transcription). According to Printes (pers. obs.), the informant reported eating only the flash (with no fat or organs) and did not describe any specific way of preparing. Almeida *et al.* (2023), on the other, reported the game hunting of *Callicebus coimbrai*, in both mandatory reserves and privately-owned protected areas (RPPN – Reservas Particulares do Patrimônio Natural; Private Natural Heritage Reserves). Castilho *et al.* (2019) and Teixeira *et al.* (2024) recorded the game hunting of *Callicebus*

melanochir in protected areas in southeastern Bahia, albeit at low frequencies.

Callithrix is known to be hunted both for meat and the pet trade (Souza and Alves 2014; Barbosa *et al.* 2022; Alves *et al.* 2023), although (Alves *et al.* 2016) reported the medicinal use of these marmosets. In the present study region, Almeida *et al.* (2023) confirmed the widespread capture of *Callithrix jacchus* for pets, although Castilho *et al.* (2019) did not record any hunting of *Callithrix kuhlii* in southeastern Bahia.

Worldwide, primates are hunted primarily for bushmeat, and secondarily for the pet trade, although traditional medicine and ornamental use are also minor factors in some cases (Ripple *et al.* 2016), but not in the present study. In some cultures, the hunting of primates is enhanced by local traditions (Bobo *et al.* 2015), whereas in other cultures, taboos limit the hunting and consumption of primates (Landim *et al.* 2023). As for other game mammal species (Alves *et al.* 2016, 2023), however, the hunting of primates for food tends to focus on medium- to large-body species (Ripple *et al.* 2016; Constantino 2018), as observed in the cases of *Alouatta*, *Brachyteles*, and *Sapajus* in the present study. Body mass is an important factor driving the decision making of hunters, who require an adequate tradeoff between effort and returns (Castilho *et al.* 2019). A secondary driver in the case of primate hunting is the taste of the meat. In Brazzaville, Congo, for instance, Mbete *et al.* (2011) identified that five species of *Cercopithecus* were preferred over 16 primate species. In the present study, however, the pet trade was the main secondary driver of primate hunting, so

the value of pets should also figure in the equation. The history of local human settlements may also be an important factor, given that primates are commonly used as pets (Parathian and Maldonado 2010) and are an important source of protein (Prado *et al.* 2012) among indigenous tribes. Thus, hunting could be a previous path for primate extinction in current settlements and villages in eastern Brazil, which may have been developed with the contribution of an earlier local indigenous culture.

Hunting inevitably leads to population decline (Silva *et al.* 2005, 2016; Canale *et al.* 2012; Madhusudan and Karanth 2002), although it can also have negative impacts on the behavior, vocalizations, and social structure of the hunted species (Thoisy *et al.* 2000; Papworth *et al.* 2013). In particular, the preference for females carrying young, which can be traded as pets (Silva *et al.* 2005) can have a major impact on social structure, and lead to a much more rapid decline in population numbers (e.g., Silva *et al.* 2016).

The impacts of hunting are determined by local biological, socioeconomic, and political contexts, which require complex conservation solutions (Barboza *et al.* 2016; Alves *et al.* 2023). In the present case, hunting has led to the local extinguished or drastic reduction in the populations of some species, which would require special attention in the planning of conservation strategies for the remaining populations. Protected areas play a crucial role in the protection and conservation of mammals, including game species and primates (Lee and Priston 2005; Canale *et al.* 2012), and the establishment of protected areas throughout the geographic range of the target species would be essential to prevent their extirpation. Despite the adequate federal legislation and the existence of a relatively well-structured monitoring system, it appears to be difficult to suppress hunting activities definitively in Brazil, and historically, most measures have been largely ineffective (Galetti and Dirzo 2013; Tomas *et al.* 2018; Alves *et al.* 2023). A potentially lucrative alternative would be to develop specific hunting agreements (Printes 2011; Oliveira and Calouro 2019) and management strategies (Alves *et al.* 2023; Almeida *et al.* 2023) aligned with the local characteristics of each biome, which could be tested in controlled trails to evaluate their effectiveness for the conservation of the target species.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The author has no conflicts of interest to declare.

CONTRIBUTION STATEMENT

FRS conceived the presented idea, carried out the experiment and the data analysis, as well as composed the final writing of the manuscript.

REFERENCES

- Aguirre AC (1971) **O mono *Brachyteles arachnoides* (E. Geoffroy): situação atual da espécie no Brasil.** Anais da Academia Brasileira de Ciência, Rio de Janeiro, Brasil.
- Almeida MCS, Ferreira FS, Beltrão-Mendes R (2023) **Game mammals and their uses by local hunters in an Atlantic Forest region of Northeast Brazil.** *Etnobiologia* 21(1):31-47.
- Alonso AC, Coelho IP, Marques E, Valença-Montenegro MM, Beltrão-Mendes R, Printes RC, Jerusalinsky L (2024) **On the occurrence of the Critically Endangered blond titi (*Callicebus barbarabrownae*): reassessment of occupied areas and minimum population size.** *International Journal of Primatology* 45(1):35-53. doi: [10.1007/s10764-021-00269-5](https://doi.org/10.1007/s10764-021-00269-5).
- Alvard MS, Robinson JG, Redford KH, Kaplan H (1997) **The sustainability of subsistence hunting in the Neotropics.** *Conservation Biology* 11(4):977-982. doi: [10.1046/j.1523-1739.1997.96047.x](https://doi.org/10.1046/j.1523-1739.1997.96047.x).
- Alves RRN, Barbosa JAA, Borges AKM (2023) **Hunting and Uses of Terrestrial Vertebrates in the Northernmost Region in the Atlantic Forest in Brazil.** In: Pereira Filho GA, França FGR, Alves RRN, Vasconcellos A (eds) Animal Biodiversity and Conservation in Brazil's Northern Atlantic Forest. Springer, Cham, pp. 257-273. doi: [10.1007/978-3-031-21287-1_15](https://doi.org/10.1007/978-3-031-21287-1_15).
- Alves RRN, Feijó A, Barboza RRD, Souto WMS, Fernandes-Ferreira H, Cordeiro-Estrela P, Langguth A (2016) **Game mammals of Caatinga biome.** *Ethnobiology and Conservation* 5(5):1-51. doi: [10.15451/ec2016-7-5.5-1-51](https://doi.org/10.15451/ec2016-7-5.5-1-51).
- Bagchi R, Swamy V, Farfan JPL, Terborgh J, Vela CI, Pitman NC, Sanchez WG (2018) **Defaunation increases the spatial clustering of lowland Western Amazonian tree communities.** *Journal of Ecology* 106(4):1470-1482. doi: [10.1111/1365-2745.12929](https://doi.org/10.1111/1365-2745.12929).
- Barbosa JAA, Aguiar JO, Alves RRN (2022) **Hunting and wildlife use in protected areas of the Atlantic rainforest, Northeastern Brazil.** *Desenvolvimento e Meio Ambiente* 60:249-270. doi: [10.5380/dma.v60i0.74388](https://doi.org/10.5380/dma.v60i0.74388).
- Barboza RRD, Lopes SF, Souto WMS, Fernandes-Ferreira H, Alves RRN (2016) **The role of game mammals as bushmeat In the Caatinga, northeast Brazil.** *Ecology and Society* 21(2):e2. doi: [10.5751/ES-08358-210202](https://doi.org/10.5751/ES-08358-210202).
- Bekoff M, Jamieson D (1991) **Sport hunting as an instinct.** *Environmental Ethics* 13(4):375-378. doi: [10.5840/enviroethics199113436](https://doi.org/10.5840/enviroethics199113436).
- Beltrão-Mendes R, Cunha AA, Ferrari SF (2011) **New localities and perspectives on the sympatry between two endangered primates (*Callicebus coimbrai* and *Cebus xanthosternos*) in northeastern Brazil.** *Mammalia* 75(1):103-105. doi: [10.1515/mamm.2010.077](https://doi.org/10.1515/mamm.2010.077).
- Beltrão-Mendes R, Ferrari SF (2019) **Mangrove Forests as a Key Habitat for the Conservation of the Critically Endangered Yellow-breasted Capuchin, *Sapajus xanthosternos*, in the Brazilian Northeast.** In: Nowak K, Barnett AA, Matsuda I (eds) Primates in flooded habitats: ecology and conservation. Cambridge University Press, Cambridge, pp. 68-76.
- Benítez-López A, Alkemade R, Schipper AM, Ingram DJ, Verweij PA, Eikelboom JAJ, Huijbregts MAJ (2017) **The impact of hunting on tropical mammal and bird populations.** *Science* 356(6334):180-183. doi: [10.1126/science.aaj189](https://doi.org/10.1126/science.aaj189).
- Bernard HR (2011) **Research methods in anthropology: qualitative and quantitative approaches.** AltaMira Press (Rowman and Littlefield Publishers), Lanham, United States.
- Bicca-Marques JC, Rumiz DI, Ludwig G, Rímoli J, Martins V, Cunha RGT, Alves SL, Valle RR, Miranda JMD, Jerusalinsky L, Messias MR, Cornejo FM, Boubli JP, Cortes-Ortiz L, Wallace RB, Talebi M, Melo FR (2021) ***Alouatta caraya* (amended version of 2020 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T41545A190414715. doi: [10.2305/IUCN.UK.2021-1.RLTS.T41545A190414715.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T41545A190414715.en). Accessed on 16 March 2024.
- Bobo KS, Aghomo FFM, Ntumwel BC (2015) **Wildlife use and the role of taboos in the conservation of wildlife around the Nkwende Hills Forest Reserve; South-west Cameroon.** *Journal of Ethnobiology and Ethnomedicine* 11(1):1-24. doi: [10.1186/1746-4269-11-2](https://doi.org/10.1186/1746-4269-11-2).
- Brasil (1998) **Lei de Crimes Ambientais – nº 9.605, de 12 de fevereiro de 1998: dispõe sobre as sanções penais e administrativas derivadas de condutas e atividades lesivas ao meio ambiente, e dá outras providências.** Diário Oficial da República Federativa do Brasil, Brasília, DF, 13 de fevereiro de 1998. Disponível em http://www.planalto.gov.br/ccivil_03/leis/L9605.htm. Acesso em setembro de 2019.
- Browne K (2005) **Snowball Sampling: Using Social Networks to Research Non-heterosexual Women.** *International Journal*

of *Social Research Methodology* 8(1):47-60. doi: [10.1080/1364557032000081663](https://doi.org/10.1080/1364557032000081663).

Canale GR, Alonso AC, Martins WP, Jerusalinsky L, Melo FR, Kierulff MCM, Mittermeier RA, Lynch Alfaro JW (2021) *Sapajus xanthosternos* (amended version of 2020 assessment). *The IUCN Red List of Threatened Species* 2021:e.T4074A192592138. doi: [10.2305/IUCN.UK.2021-1.RLTS.T4074A192592138.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T4074A192592138.en). Accessed on 16 March 2024.

Canale GR, Peres CA, Guidorizzi CE, Gatto CAF, Kierulff MCM (2012) **Pervasive defaunation of forest remnants in a tropical biodiversity hotspot.** *PLoS ONE* 7(8):e41671. doi: [10.1371/journal.pone.0041671](https://doi.org/10.1371/journal.pone.0041671).

Castilho LC, De Vleeschouwer KM, Milner-Gulland EJ, Schiavetti A (2019) **Hunting of mammal species in protected areas of the southern Bahian Atlantic Forest, Brazil.** *Oryx* 53(4):687-697. doi: [10.1017/S0030605317001247](https://doi.org/10.1017/S0030605317001247).

Ceballos-Mago N, González CE, Chivers DJ (2010) **Impact of the pet trade on the Margarita capuchin monkey *Cebus apella margaritae*.** *Endangered Species Research* 12(1):57-68. doi: [10.3354/esr00289](https://doi.org/10.3354/esr00289).

Chiarello AG, Aguiar LMS, Cerqueira R, Melo FR, Rodrigues FHG, Silva VMF (2008) **Mamíferos Ameaçados de Extinção no Brasil.** In: Machado ABM, Drummond GM, Paglia AP (eds) *Livro Vermelho da Fauna Brasileira Ameaçada de Extinção* (vol. 2). Ministério do Meio Ambiente, Brasília, pp. 681-880.

Chizzotti A (2005) **Pesquisa em ciências humanas e sociais (7^a ed.).** Cortez, São Paulo, Brazil.

Constantino PAL (2018) **O perfil da caça nos biomas brasileiros: um Panorama das Unidades de Conservação Federais a partir dos autos de infração lavrados pelo ICMBio.** *Biodiversidade Brasileira* 8(2):106-129. doi: [10.37002/biodiversidadebrasileira.v8i2.786](https://doi.org/10.37002/biodiversidadebrasileira.v8i2.786).

Costa LP, Leite YLR, Mendes SL, Ditchfield AD (2005) **Mammal Conservation in Brazil.** *Conservation Biology* 19(3):672-679. doi: [10.1111/j.1523-1739.2005.00666.x](https://doi.org/10.1111/j.1523-1739.2005.00666.x).

Cowlishaw G, Dunbar RI (2000) **Primate Conservation Biology.** University of Chicago Press, Chicago, United States.

Davis A, Wagner JR (2003) **Who knows? On the importance of identifying “experts” when researching Local Ecological Knowledge.** *Human Ecology* 31(3):463-489. doi: [10.1023/A:1025075923297](https://doi.org/10.1023/A:1025075923297).

Ebbert D (2019) ***chisq.posthoc.test*: A Post Hoc Analysis for Pearson’s Chi-Squared Test for Count Data.** R package version 0.1.2, <<https://CRAN.R-project.org/package=chisq.posthoc.test>>.

Emmons LH, Whitney BM, Ross Jr DL (1998) **Sounds of Neotropical Rainforest Mammals: an audio field guide (2 volumes, 109 tracks).** Audio CD; Cornell Laboratory of Ornithology, New York.

Estrela AR, Nogueira EMS, Porfírio S (2011) ***Callicebus barbarabrownae* (Hershkovitz, 1990) (Primates: Pitheciidae) de Lamarão/BA: resultados preliminares.** In: Melo FR, Mourthé Í (eds) *A Primatologia no Brasil* (vol. 11). Sociedade Brasileira de Primatologia, Belo Horizonte, pp. 93-102.

Fialho MS, Ludwig G, Valença-Montenegro MM (2016) **Legal international trade in live Neotropical primates originating from South America.** *Primate Conservation* 30:1-6.

Galetti M, Dirzo R (2013) **Ecological and evolutionary consequences of living in a defaunated world.** *Biological Conservation* 163:1-6. doi: [10.1016/j.biocon.2013.04.020](https://doi.org/10.1016/j.biocon.2013.04.020).

Goodman LA (1961) **Snowball sampling.** *Annals of Mathematical Statistics* 32(1):148-170. <https://www.jstor.org/stable/2237615>.

Gouveia SF, Villalobos F, Dobrovolski R, Beltrão-Mendes R, Ferrari SF (2014) **Forest structure drives global diversity of primates.** *Journal of Animal Ecology* 83(6):1523-1530. doi: [10.1111/1365-2656.12241](https://doi.org/10.1111/1365-2656.12241).

Hilário RR, Jerusalinsky L, Santos S, Beltrão-Mendes R, Ferrari SF (2017) **A primate at risk in Northeast Brazil: local extinctions of Coimbra Filho’s titi (*Callicebus coimbrai*).** *Primates* 58(2):343-352. doi: [10.1007/s10329-017-0599-6](https://doi.org/10.1007/s10329-017-0599-6).

Hill K (1982) **Hunting and human evolution.** *Journal of Human Evolution* 11(6):521-544. doi: [10.1016/S0047-2484\(82\)80107-3](https://doi.org/10.1016/S0047-2484(82)80107-3).

ICMBio – Instituto Chico Mendes de Conservação da Biodiversidade (2018) **Livro Vermelho da Fauna Brasileira Ameaçada de Extinção: Volume II - Mamíferos.** Ministério do Meio Ambiente, Brasília, Brazil.

IUCN (2024) **The IUCN Red List of Threatened Species. Version 2023-1.** <<https://www.iucnredlist.org>>. Accessed on 14nd August, 2024.

Jerusalinsky L, Bicca-Marques JC, Neves LG,

- Alves SL, Ingberman B, Buss G, Fries BG, Alonso AC, Cunha RGT, Miranda JMD, Talebi M, Melo FR, Mittermeier RA, Cortes-Ortiz L (2021) *Alouatta guariba* (amended version of 2020 assessment). *The IUCN Red List of Threatened Species* 2021:e.T39916A190417874. doi: [10.2305/IUCN.UK.2021-1.RLTS.T39916A190417874.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T39916A190417874.en). Accessed on 16 March 2024.
- Jerusalinsky L, Souza-Alves J, Ferrari S (2020) *Callicebus coimbrai*. *The IUCN Red List of Threatened Species* 2020:e.T39954A17972422. doi: [10.2305/IUCN.UK.2020-3.RLTS.T39954A17972422.en](https://doi.org/10.2305/IUCN.UK.2020-3.RLTS.T39954A17972422.en). Accessed on 16 March 2024.
- Jerusalinsky L, Oliveira MM, Pereira RF, Santana V, Bastos PCR, Ferrari SF (2006) Preliminary evaluation of the conservation status of *Callicebus coimbrai* Kobayashi and Langguth, 1999 in the Brazilian state of Sergipe. *Primate Conservation* 21:25-33.
- Jerusalinsky L, Beltrão-Mendes R, Hilário R, Ferrari SF (2013) Impacto de caça e cativeiro sobre primatas em Sergipe e litoral norte da Bahia. II Congresso Latino Americano de Primatologia e XV Congresso Brasileiro de Primatologia, 2013, Recife – PE. Editora da UFPE, Recife.
- Johnson JC, Boster JS, Holbert D (1989) Estimating relational attributes from snowball samples through simulation. *Social Networks* 11(2):135-158. doi: [10.1016/0378-8733\(89\)90009-9](https://doi.org/10.1016/0378-8733(89)90009-9).
- Kierulff MCM, Santos GR, Canale GR, Carvalho CEG, Cassano CR, Gouveia PS, Gatto CAFR, Araújo M, Vila Nova P, Marques AC, Santos PS, Pádua JC (2005) Plano de Manejo para a conservação do macaco-prego-do-peito-amarelo, *Cebus xanthosternos*. Relatório FNMA/PROBIO não publicado. Instituto de Estudos Sócio-ambientais do Sul da Bahia, Ilhéus, Brasil.
- King FA, Lee PC (1987) A brief survey of human attitudes to a pest species of primate – *Cercopithecus aethiops*. *Primate Conservation* 8:82-84.
- Klein RG (1987) Reconstructing how early people exploited animals: problems and prospects. In: Nitecki MH, Nitecki DV (eds) *The evolution of human hunting*. Springer, Boston, pp. 11-45.
- Landim AS, Souza JM, Santos LB, Lins-Neto EMF, Silva DT, Ferreira FS (2023) Food taboos and animal conservation: a systematic review on how cultural expressions influence interaction with wildlife species. *Journal of Ethnobiology and Ethnomedicine* 19(1):31. doi: [10.1186/s13002-023-00600-9](https://doi.org/10.1186/s13002-023-00600-9).
- Lane F (1990) A hunt for “monos” (*Brachyteles arachnoides*) in the foothills of the Serra de Paranapiacaba, São Paulo, Brazil. *Primate Conservation* 11:23-25.
- Lee PC, Priston NE (2005) Human attitudes to primates: perceptions of pests, conflict and consequences for primate conservation. In: Paterson JD, Wallis J (eds) *Commensalism and Conflict: the human-primate interface* (vol. 4). American Society of Primatologists, Norman, pp. 1-23.
- Lernould JM, Kierulff MCM, Canale G (2012) Yellow-breasted capuchin *Cebus xanthosternos*: support by zoos for its conservation—a success story. *International Zoo Yearbook* 46(1):71-79. doi: [10.1111/j.1748-1090.2012.00169.x](https://doi.org/10.1111/j.1748-1090.2012.00169.x).
- Levacov D, Jerusalinsky L, Fialho MS (2011) Levantamento dos primatas recebidos em Centros de Triagem e sua relação com o tráfico de animais silvestres no Brasil. In: Melo FR, Mourthé Í (eds) *A Primatologia no Brasil*, (vol. 11). Sociedade Brasileira de Primatologia, Belo Horizonte, pp. 281-305.
- Loveridge AJ, Reynolds JC, Milner-Gulland EJ (2007) Does sport hunting benefit conservation? In: David W, Macdonald DW, Service K (eds.) *Key Topics in Conservation Biology*. Blackwell Publishing, Malden, pp. 222-238.
- Madhusudan MD, Karanth KU (2002) Local hunting and the conservation of large mammals in India. *AMBIO: A Journal of the Human Environment* 31(1):49-55. <https://www.jstor.org/stable/4315210>.
- Maldonado AM, Nijman V, Bearder SK (2009) Trade in night monkeys *Aotus* spp. in the Brazil–Colombia–Peru tri-border area: international wildlife trade regulations are ineffectively enforced. *Endangered Species Research* 9(2):143-149. doi: [10.3354/esr00209](https://doi.org/10.3354/esr00209).
- MapBiomas (2022) MapBiomas Project-Collection 7 of the Annual Series of Land Use and Land Cover Maps of Brazil. <https://brasil.mapbiomas.org/en/colecoes-mapbiomas>. Accessed January 2024.
- Marinho-Filho J, Veríssimo EW (1997) The rediscovery of *Callicebus personatus barbarabrownae* in Northeastern Brazil with a new western limit for its distribution. *Primates* 38(4):429-433. doi: [10.1007/BF02381883](https://doi.org/10.1007/BF02381883).
- Marques ELN, Beltrão-Mendes R, Ferrari SF

- (2013a) **Primates, Pitheciidae, *Callicebus barbarabrownae* Hershkovitz, 1990: new localities for the critically endangered titi monkey in the São Francisco basin, state of Sergipe, Brazil [with erratum].** *Check List* 9(1):113-115. doi: [10.15560/9.1.113](https://doi.org/10.15560/9.1.113).
- Marques ELN, Jerusalinsky L, Rocha JCA, Santos PM, Beltrão-Mendes R, Ferrari SF (2013b) **Primates, Pitheciidae, *Callicebus coimbrai* Kobayashi and Langguth, 1999: new localities for an endangered titi monkey in eastern Sergipe, Brazil.** *Check List* 9(3):696-699. doi: [10.15560/9.3.696](https://doi.org/10.15560/9.3.696).
- Martins AB, Fialho MS, Jerusalinsky L, Valença-Montenegro MM, Bezerra BM, Laroque PO, Melo FR, Lynch Alfaro JW (2021a) ***Sapajus libidinosus* (amended version of 2019 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T136346A192593226. doi: [10.2305/IUCN.UK.2021-1.RLTS.T136346A192593226.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T136346A192593226.en). Accessed on 22 March 2024.
- Martins WP, Melo FR, Kierulff MCM, Mittermeier RA, Lynch Alfaro JW, Jerusalinsky L (2021b) ***Sapajus robustus* (amended version of 2019 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T42697A192592444. doi: [10.2305/IUCN.UK.2021-1.RLTS.T42697A192592444.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T42697A192592444.en). Accessed on 16 March 2024.
- Mbete RA, Banga-Mboko H, Racey P, Mfoukou-Ntsakala A, Nganga I, Vermeulen C, Doucet JL, Hornick JL, Leroy P (2011) **Household bushmeat consumption in Brazzaville, the Republic of the Congo.** *Tropical Conservation Science* 4(2):187-202. doi: [10.1177/194008291100400207](https://doi.org/10.1177/194008291100400207).
- Melo FR, Pereira DG, Kierulff MCM, Bicca-Marques JC, Mittermeier RA (2021a) ***Callithrix geoffroyi* (amended version of 2018 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T3572A191701212. doi: [10.2305/IUCN.UK.2021-1.RLTS.T3572A191701212.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T3572A191701212.en). Accessed on 16 March 2024.
- Melo FR, Boubli JP, Mittermeier RA, Jerusalinsky L, Tabacow FP, Ferraz DS, Talebi M (2021b) ***Brachyteles hypoxanthus* (amended version of 2019 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T2994A191693399. doi: [10.2305/IUCN.UK.2021-1.RLTS.T2994A191693399.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T2994A191693399.en). Accessed on 16 March 2024.
- Mittermeier RA, Coimbra-Filho AF, Kierulff MCM, Rylands AB, Mendes SL, Pissinatti A, Almeida LM (2007) **Monkeys of the Atlantic Forest of Eastern Brazil Pocket Identification Guide.** *Conservation International Tropical Pocket Guide, Series #3*. Conservation International, Arlington.
- MMA (MINISTÉRIO DO MEIO AMBIENTE) (2022) **Portaria nº 300, de 13 de dezembro de 2022. Reconhece a Lista Nacional de Espécies Ameaçadas de Extinção, conforme Anexo I desta presente Portaria.** *Diário Oficial da União, República Federativa do Brasil, Brasília, DF* 234(1):75.
- Myers N, Mittermeier RA, Mittermeier CG, Fonseca GA, Kent J (2000) **Biodiversity hotspots for conservation priorities.** *Nature* 403(6772):853. doi: [10.1038/35002501](https://doi.org/10.1038/35002501).
- Nascimento RA, Schiavetti A, Montaña RAM (2013) **An assessment of illegal capuchin monkey trade in Bahia State, Brazil.** *Neotropical Biology and Conservation* 8(2):79-87. doi: [10.4013/nbc.2013.82.03](https://doi.org/10.4013/nbc.2013.82.03).
- Neves LG, Jerusalinsky L, Pereira DG, Bicca-Marques JC, Rylands AB, Mittermeier RA (2021) ***Callithrix kuhlii* (amended version of 2019 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T3575A191701453. doi: [10.2305/IUCN.UK.2021-1.RLTS.T3575A191701453.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T3575A191701453.en). Accessed on 16 March 2024.
- Nitecki MH (1987) **The idea of human hunting.** In: Nitecki MH, Nitecki DV (eds) *The evolution of human hunting*. Springer, Boston, pp. 1-9.
- Novaro AJ, Redford KH, Bodmer RE (2000) **Effect of hunting in source-sink systems in the Neotropics.** *Conservation Biology* 14(3):713-721. doi: [10.1046/j.1523-1739.2000.98452.x](https://doi.org/10.1046/j.1523-1739.2000.98452.x).
- Nunes AV, Vilela JS, Saldo PÁ, Santos BA, Fischer E (2017) **Conhecimento e uso de primatas por uma população extrativista no Vale do Juruá, Amazônia.** *Biodiversidade Brasileira* 2017(2):123-132. doi: [10.37002/biodiversidadebrasileira.v7i2.636](https://doi.org/10.37002/biodiversidadebrasileira.v7i2.636).
- Oliveira LC, Neves LG, Kierulff MCM, Jerusalinsky L, Mittermeier RA, Rylands AB (2021) ***Leontopithecus chrysomelas* (amended version of 2020 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T40643A192327573. doi: [10.2305/IUCN.UK.2021-1.RLTS.T40643A192327573.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T40643A192327573.en). Accessed on 16 March 2024.
- Oliveira MA, Calouro AM (2019) **Hunting agreements as a strategy for the conservation of species: the case of the Cazumbá-Iracema Extractive Reserve, state of Acre, Brazil.** *Oecologia Australis* 23(2):357-366. doi: [10.4257/oeco.2019.2302.13](https://doi.org/10.4257/oeco.2019.2302.13).
- Papworth S, Milner-Gulland EJ, Slocumbe K (2013) **Hunted woolly monkeys (*Lagothrix***

- poeppigii*) show threat-sensitive responses to human presence. *PLoS One* 8(4):e62000. doi: [10.1371/journal.pone.0062000](https://doi.org/10.1371/journal.pone.0062000).
- Parathian HE, Maldonado AM (2010) **Human–nonhuman primate interactions amongst Tikuna people: perceptions and local initiatives for resource management in Amacayacu in the Colombian Amazon.** *American Journal of Primatology* 72(10):855–865. doi: [10.1002/ajp.20816](https://doi.org/10.1002/ajp.20816).
- Peres CA (2001) **Synergistic effects of subsistence hunting and habitat fragmentation on Amazonian forest vertebrates.** *Conservation Biology* 15(6):1490–1505. doi: [10.1046/j.1523-1739.2001.01089.x](https://doi.org/10.1046/j.1523-1739.2001.01089.x).
- Posit team (2024) **RStudio: Integrated Development Environment for R.** Posit Software, PBC, Boston, MA. URL <http://www.posit.co>.
- Prado HM, Forline LC, Kipnis R (2012) **Hunting practices among the Awá-Guajá: towards a long-term analysis of sustainability in an Amazonian indigenous community.** *Boletim do Museu Paraense Emílio Goeldi: Ciências Humanas* 7(2):479–491. doi: [10.1590/S1981-81222012000200010](https://doi.org/10.1590/S1981-81222012000200010).
- Printes RC (2007) **Avaliação taxonômica, distribuição e status do guigó-da-Caatinga (*Callicebus barbarabrownae*, Hershkovitz, 1990).** PhD Thesis, Universidade Federal de Minas Gerais, Brazil.
- Printes RC (2011) **Etnoprimatologia, distribuição geográfica e conservação do guigó-da-Caatinga (*Callicebus barbarabrownae* Hershkovitz, 1990).** In: Miranda JMD, Hirano ZMB (eds) *A Primatologia no Brasil*. Vol. 12. UFPR/SBPr, Curitiba, pp. 15–29.
- Printes RC, Jerusalinsky L, Alonso AC, Mittermeier RA (2021) ***Callicebus barbarabrownae* (amended version of 2020 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T39929A191703041. doi: [10.2305/IUCN.UK.2021-1.RLTS.T39929A191703041.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T39929A191703041.en). Accessed on 16 March 2024.
- Printes RC, Jerusalinsky L, Melo FR, Mittermeier RA (2020) ***Callicebus melanochir*.** *The IUCN Red List of Threatened Species* 2020:e.T39930A17975106. doi: [10.2305/IUCN.UK.2020-3.RLTS.T39930A17975106.en](https://doi.org/10.2305/IUCN.UK.2020-3.RLTS.T39930A17975106.en). Accessed on 16 March 2024.
- R Core Team (2023) **R: A Language and Environment for Statistical Computing.** R Foundation for Statistical Computing, Vienna, Austria <<https://www.R-project.org>>.
- Ramírez-Barajas PJ, Calmé S (2015) **Subsistence Hunting and Conservation.** In: Islebe SG, Calmé S, León-Cortés J, Schmook B (eds) *Biodiversity and Conservation of the Yucatán Peninsula*. Springer, Cham, pp. 333–351. doi: [10.1007/978-3-319-06529-8_13](https://doi.org/10.1007/978-3-319-06529-8_13).
- Redford KH (1992) **The empty forest.** *BioScience* 42(6):412–422. doi: [10.2307/1311860](https://doi.org/10.2307/1311860).
- Reis NR, Peracchi AL, Batista CB, Rosa GLM (2015) **Primates do Brasil: guia de campo.** Technical Books Editora, Rio de Janeiro, Brasil.
- Ripple WJ, Abernethy K, Betts MG, Chapron G, Dirzo R, Galetti M, Levi T, Lindsey PA, Macdonald DW, Machovina B, Newsome TM, Peres CA, Wallach AD, Wolf C, Young H (2016) **Bushmeat hunting and extinction risk to the world's mammals.** *Royal Society Open Science* 3(10):160498. doi: [10.1098/rsos.160498](https://doi.org/10.1098/rsos.160498).
- Robinson JG, Redford KH (1991) **Neotropical wildlife use and conservation.** University of Chicago Press, Chicago, United States.
- Rylands AB, Mittermeier RA (2009) **The diversity of the New World primates (Platyrrhini): an annotated taxonomy.** In: Garber PA, Estrada A, Bicca-Marques JC, Heymann EW, Strier KB (eds) *South American Primates: comparative perspectives in the study of behavior, ecology, and conservation*. Springer, Chicago, pp. 23–54. doi: [10.1007/978-0-387-78705-3_2](https://doi.org/10.1007/978-0-387-78705-3_2).
- Rylands AB, Coimbra-Filho AF, Mittermeier RA (2009) **The systematics and distributions of the marmosets (*Callithrix*, *Callibella*, *Cebuella*, and *Mico*) and callimico (*Callimico*) (*Callitrichidae*, *Primates*).** In: Ford SM, Porter LM, Davis LC (eds) *The Smallest Anthropoids*. Springer, Boston, pp. 25–61. doi: [10.1007/978-1-4419-0293-1_2](https://doi.org/10.1007/978-1-4419-0293-1_2).
- Santos JG, Martinez RA (2015) **Compartilhando espaços verdes urbanos: interações entre macacos-prego (*Sapajus* sp.) e humanos numa reserva florestal na Bahia, Brasil.** *Revista Brasileira de Biociências* 13(4):272–280.
- Silva FA, Canale GR, Kierulff MCM, Duarte GT, Paglia AP, Bernardo CS (2016) **Hunting, pet trade, and forest size effects on population viability of a critically endangered Neotropical primate, *Sapajus xanthosternos* (Wied-Neuwied, 1826).** *American Journal of Primatology* 78(9):950–960. doi: [10.1002/ajp.22565](https://doi.org/10.1002/ajp.22565).
- Silva MNF, Shepard Jr. GH, Douglas WY (2005) **Conservation implications of primate hunting practices among the Matsigenka of Manu National Park.** *Neotropical Primates* 13(2):31–36.

doi: [10.1896/1413-4705.13.2.31](https://doi.org/10.1896/1413-4705.13.2.31).

Sousa MC, Santos SS, Valente MCM (2008) **Distribuição e variação na pelagem de *Callicebus coimbrai* (Primates, Pitheciidae) nos estados de Sergipe e Bahia, Brasil.** *Neotropical Primates* 15(2):54-59. doi: [10.1896/044.015.0208](https://doi.org/10.1896/044.015.0208).

Souza JB, Alves RRN (2014) **Hunting and wildlife use in an Atlantic Forest remnant of northeastern Brazil.** *Tropical Conservation Science* 7(1):145-160. doi: [10.1177/19400829140070010](https://doi.org/10.1177/19400829140070010).

Sponsel LE (1997) **The human niche in Amazonia: explorations in ethnoprimateology.** In: Kinzey WG (ed) *New World Primates: ecology, evolution, and behavior*. De Gruyter, New York, pp. 143-165.

Stanford CB (1999) **The hunting apes: Meat eating and the origins of human behavior.** Princeton University Press, Princeton, United States.

Svensson MS, Shantee S, Shantee N, Bannister FB, Cervera L, Donati G, Huck M, Jerusalinsky L, Juarez CP, Maldonado AM, Mollinedo JM, Méndez-Carvajal PG, Argandoña MAM, Vito ADM, Nekaris KAI, Peck M, Rey-Goyeneche J, Spaan D, Nijman V (2016) **Disappearing in the night: An overview on trade and legislation of night monkeys in South and Central America.** *Folia Primatologica* 87(5):332-348. doi: [10.1159/000454803](https://doi.org/10.1159/000454803).

Tabarelli M, Silva JMC, Gascon C (2004) **Forest fragmentation, synergisms and the impoverishment of Neotropical forests.** *Biodiversity and Conservation* 13(7):1419-1425. doi: [10.1023/B:BIOC.0000019398.36045.1b](https://doi.org/10.1023/B:BIOC.0000019398.36045.1b).

Teixeira JVS, Santos JS, Guanaes DHA, Rocha DW, Schiavetti A (2020) **Uses of wild vertebrates in traditional medicine by farmers in the region surrounding the Serra do Conduru State Park (Bahia, Brazil).** *Biota Neotropica* 20(1):e20190793. doi: [10.1590/1676-0611-BN-2019-0793](https://doi.org/10.1590/1676-0611-BN-2019-0793).

Teixeira JVS, Rocha WD, Miranda JES, Schiavetti A (2024) **Wildlife Consumption Dynamics: Unveiling Conduru Park in Southern Bahia, Brazil.** *Ethnobiology and Conservation* 13:e02. doi: [10.15451/ec2024-01-13.02-1-20](https://doi.org/10.15451/ec2024-01-13.02-1-20).

Terborgh J (1983) **Five New World primates: a study in comparative ecology.** Princeton University Press, Princeton, United States.

Terborgh J, Nuñez-Iturri G, Pitman NCA, Valverde

FHC, Alvarez P, Swamy V, Pringle EG, Paine CET (2008) **Tree recruitment in an empty forest.** *Ecology* 89(6):1757-1768. doi: [10.1890/07-0479.1](https://doi.org/10.1890/07-0479.1).

Thoisy B, Massemin D, Dewynter M (2000) **Hunting impact on Neotropical primates: a preliminary case study in French Guiana.** *Neotropical Primates* 8(4):141-144. doi: [10.62015/np.2000.v8.466](https://doi.org/10.62015/np.2000.v8.466).

Tomas WM, Magnusson WE, Mourão G, Bergallo HG, Linares SFTP, Crawshaw Jr PC, Campos Z, Camilo AR, Verdade LM, Tortato FR, Peres CA (2018) **Meio século da proibição da caça no Brasil: consequências de uma política inadequada de gestão de vida selvagem.** *Biodiversidade Brasileira* 8(2):75-81. doi: [10.37002/biodiversidadebrasileira.v8i2.798](https://doi.org/10.37002/biodiversidadebrasileira.v8i2.798).

Valença-Montenegro MM, Bezerra BM, Ruiz-Miranda CR, Pereira DG, Miranda JMD, Bicca-Marques JC, Oliveira L, Cruz MAOM, Valle RR, Mittermeier RA (2021) ***Callithrix jacchus* (amended version of 2018 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T41518A191705043. doi: [10.2305/IUCN.UK.2021-1.RLTS.T41518A191705043.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T41518A191705043.en). Accessed on 16 March 2024.

Valle RR, Ruiz-Miranda CR, Pereira DG, Rímoli J, Bicca-Marques JC, Jerusalinsky L, Valença-Montenegro MM, Mittermeier RA (2021) ***Callithrix penicillata* (amended version of 2018 assessment).** *The IUCN Red List of Threatened Species* 2021:e.T41519A191705321. doi: [10.2305/IUCN.UK.2021-1.RLTS.T41519A191705321.en](https://doi.org/10.2305/IUCN.UK.2021-1.RLTS.T41519A191705321.en). Accessed on 16 March 2024.

Wilkie DS, Bennett EL, Peres CA, Cunningham AA (2011) **The empty forest revisited.** *Annals of the New York Academy of Sciences* 1223(1):120-128. doi: [10.1111/j.1749-6632.2010.05908.x](https://doi.org/10.1111/j.1749-6632.2010.05908.x).

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Additional Files

Add File 1. Citations of the hunting and trapping of primates (qualitative data) in the Brazilian states of Bahia and Sergipe, northeastern Brazil, identified in the academic literature published between 2005 and 2023.

FAMILY / Genus / Species	HUNTING				TRAPPING		
	Bushmeat	Pest control	Not Informed	References	Pet	Release /	References
						Translocation	
CALLITRICHIDAE							
Callithrix							
Callithrix geoffroyi					1		Levacov et al. (2011) Levacov et al. (2011);
Callithrix jacchus	1			Jerusalinsky et al. (2013)	3		Jerusalinsky et al. (2013); Almeida et al. (2023)
Callithrix penicillata					1		Levacov et al. (2011)
Callithrix spp.	1			Canale et al. (2012)	1		Nascimento et al. (2013)
Leontopithecus							
Leontopithecus chrysomelas	2			Castilho et al. (2019); Teixeira et al. (2020)	1		Nascimento et al. (2013)
CEBIDAE							
Sapajus							
Sapajus libidinosus					1		Nascimento et al. (2013)
						1	Santos and Martinez (2015)
Sapajus robustus					1		Nascimento et al. (2013)

Continua...ou to be continued...

FAMILY / Genus / Species	HUNTING				TRAPPING	
	Bushmeat	Pest control	Not Informed	References	Pet Release / Translocation	References
					1	Santos and Martinez (2015)
				Kierulff et al. (2005);		
				Canale et al. (2012);		Kierulff et al. (2005);
<i>Sapajus xanthosternos</i>	5			Lernould et al. (2012); J	3	Jerusalinsky et al. (2013);
				erusalinsky et al. (2013);		Nascimento et al. (2013)
				Castilho et al. (2019)		
		1		Beltrão-Mendes et al. (2011)		
<i>Sapajus</i> spp.					1	Levacov et al. (2011)
PITHECIIDAE						
Callicebus						
				Marinho-Filho and Veríssimo (1997);		
<i>Callicebus barbarabrownae</i>	3			Printes (2007); Estrela et al. (2011)	1	Present study
			1	Marques et al. (2013a)		
				Sousa et al. (2008);		
<i>Callicebus coimbrai</i>	4			Jerusalinsky et al. (2013);	3	Jerusalinsky et al. (2006, 2013);
				Hilário et al. (2017); Almeida et al. (2023)		Nascimento et al. (2013)
			1	Marques et al. (2013b)		
<i>Callicebus melanochir</i>	1			Castilho et al. (2019)		
<i>Callicebus</i> spp.	1			Canale et al. (2012)	1	Present study
ATELIDAE						
Alouatta						

Continua...ou to be continued...

FAMILY / Genus / Species	HUNTING			TRAPPING		
	Bushmeat	Pest control	Not Informed	References	Pet Release / Translocation	References
<i>Alouatta caraya</i>	1			Printes (2007)		
<i>Alouatta guariba</i>	1			Kierulff et al. (2005)		
<i>Alouatta</i> spp.	1			Canale et al. (2012)	1	Nascimento et al. (2013)
Brachyteles						
<i>Brachyteles hypoxanthus</i>	2			Kierulff et al. (2005); Canale et al. (2012)		
Total	23	1	2		19	2