

Short communication

Introduced primate species of an Atlantic Forest region in Brazil: present and future implications for the native fauna

Leonardo C Oliveira^{1,2,3*} and Carlos Eduardo Viveiros Grelle⁴

¹ Programa de Pós-graduação em Ecologia, Universidade Federal do Rio de Janeiro, RJ, Brazil

² Programa de Pós-graduação em Ecologia e Conservação da Biodiversidade, Universidade Estadual de Santa Cruz, BA, Brazil

³ Bicho do Mato Instituto de Pesquisa, Belo Horizonte, MG, Brazil

⁴ Departamento de Ecologia, Universidade Federal do Rio de Janeiro, RJ, Brazil

*Corresponding author Email: leonardoco@gmail.com; leonardo@bichodomato.net.br

Abstract

The Atlantic Forest of the state of Rio de Janeiro was the habitat of six native primate species: *Callithrix aurita*, *Leontopithecus rosalia*, *Alouatta guariba clamitans*, *Brachyteles arachnoides*, *Callicebus nigrifrons* and *Cebus nigritus*; a seventh species, *Brachyteles hypoxanthus*, possibly occurs in the state. In the literature, the number of non-native primate species for the state was less (three) than the native species (six or seven). Our study reviews the list of primate species, both native and non-native, within the state of Rio de Janeiro and discusses the possible impacts of the introduced primates on the native fauna. Using data from the literature, personal communication with experts, data from Brazilian Federal datasets (Linha Verde and CETAS), and specimens deposited in scientific collections of museums, we recorded 17 primate species with at least one record within the state of Rio de Janeiro. At least eight taxa can be considered non-native to the state. Conservation implications for native fauna may include food resource depletion and competition, hybridization, and disease transmission. Some of these effects were already recorded on the native fauna. We believe the removal of non-native primate species from the state is necessary in order to preserve native fauna regardless of political and ethical issues.

Key words: Invasive species, Primates, Atlantic Forest, Conservation, Rio de Janeiro

Resumo

A Mata Atlântica do Estado do Rio de Janeiro, originalmente, abrigava seis espécies de primatas: *Callithrix aurita*, *Leontopithecus rosalia*, *Alouatta guariba clamitans*, *Brachyteles arachnoides*, *Callicebus nigrifrons* e *Cebus nigritus*; entretanto, uma sétima espécie, *Brachyteles hypoxanthus*, possivelmente ocorre no Estado. Na literatura, o número de espécies não nativas registrado para o Estado é bem menor (três espécies) do que nativas (seis ou sete). Nosso estudo revisou a lista de espécies de primatas, entre nativos e não nativos, no Estado do Rio de Janeiro e discute os possíveis impactos dos primatas introduzidos para a fauna nativa. Usando dados da literatura, comunicação pessoal de especialistas, de um conjunto de dados governamentais (Linha Verde e CETAS) e de espécimes depositados em coleções científicas de museus, registramos 17 espécies de primatas com pelo menos um registro para o estado do Rio de Janeiro. Pelo menos oito taxa são não nativos ao estado do Rio de Janeiro. Implicações para a conservação da fauna nativa podem variar desde a super-exploração e competição por recursos alimentares, hibridação e transmissão de doenças. Alguns destes efeitos já foram observados na fauna nativa. Acreditamos que a remoção das espécies de primatas não nativas ao Estado é necessária para a preservação da fauna nativa, mesmo que questões políticas e éticas possam existir.

Palavras –chave: Espécies invasoras, Primatas, Mata Atlântica, Conservação, Rio de Janeiro

Received: 28 December 2011; Accepted: 22 January 2012; Published: 19 March 2012.

Copyright: © Leonardo C. Oliveira and Carlos Eduardo de Viveiros Grelle. This is an open access paper. We use the Creative Commons Attribution 3.0 license <http://creativecommons.org/licenses/by/3.0/> - The license permits any user to download, print out, extract, archive, and distribute the article, so long as appropriate credit is given to the authors and source of the work. The license ensures that the published article will be as widely available as possible and that the article can be included in any scientific archive. Open Access authors retain the copyrights of their papers. Open access is a property of individual works, not necessarily journals or publishers.

Cite this paper as: Oliveira, L. C. and Grelle, C.E.V.. 2012. Introduced primate species of an Atlantic Forest region in Brazil: present and future implications for the native fauna. *Tropical Conservation Science* Vol. 5(1):112-120. Available online: www.tropicalconservationscience.org

Introduction

Invasive species are a worldwide conservation problem, threatening species and ecosystems; after habitat loss, they are among the most important causes of species extinction or threat [1, 2]. Competition, predation and diseases are often considered the final causes for endangerment following invasions [3]. However, the effects of invasions are associated with more than one cause, mainly habitat disturbance [3]. Disturbance can be a key factor allowing the invasion of an environment by non-native species. Thus, in a fragmented landscape with altered natural habitats, biological invasions can have an additional negative effect on the native fauna [4].

The Atlantic Forest is one of the most biologically diverse and anthropogenically impacted biomes in the world, currently with only around 11-16% of its original cover [5]. The Atlantic Forest in the state of Rio de Janeiro was historically the habitat for six native primate species (*Callithrix aurita*, *Leontopithecus rosalia*, *Alouatta guariba clamitans*, *Brachyteles arachnoides*, *Callicebus nigrifrons* and *Cebus nigritus*), and contains today three additional non-native primate species (*Callithrix jacchus*, *C. penicillata* and *Saimiri sciureus*) with established populations within the state [6]. In addition, Cunha et al. [7] recently raised the possibility that the northern muriqui (*Brachyteles hypoxanthus*) occurs in Itatiaia National Park (INP). Here we present an overview of the primate species in the state of Rio de Janeiro, reviewing the list of native and non-native species, and we discuss the possible impacts of the introduced species on the native primates.

Methods

Information about primate species' (native and non-native) occurrence in the state of Rio de Janeiro was collected from published literature [8-15] of primates occurrence since the year 2000, from personal observations, and from specialists who worked in the state. In addition, we reviewed lists of primates present in the Centro de Triagem de Animais Silvestres CETAS/Rio de Janeiro (an animal rescue and rehabilitation center) and citizen phone complaints made on a state government phone line (Linha Verde) from 2003-2010. For the last two sources (CETAS and Linha Verde), the information on primates was at the genus level only in order to minimize misidentification of species. In our list, we did not use species recorded in captivity. We also used the IUCN red list website (www.iucnredlist.org) [16, 17] and data from specimens deposited in the scientific collection of the Zoological Museum of São Paulo University (MZUSP) and from the National Museum of Rio de Janeiro (MNRJ).

Results

Based on our survey, we recorded 17 species of primates with at least one record in the state of Rio de Janeiro, including eight genera and four families (Appendix 1). At least eight species are known to be non-native to the state of Rio de Janeiro (Fig. 1). Six of the seven species considered native to the state were recorded in scientific collections, although an individual of buffy-headed marmoset (*Callithrix flaviceps*), not recorded previously for the state, was captured in 2011 in the municipality of Varre-e-Sai, state of Rio de Janeiro, and deposited in the National Museum of Rio de Janeiro.

From the literature we found four non-native species for the state of Rio de Janeiro. Cunha [12] reported the highest density of *Cebus* sp. a hybrid of introduced robust tufted capuchin (*Cebus robustus*) and the bearded capuchin (*Cebus libidinosus*) with the native black-horned capuchin (*Cebus nigrinus*). The northern masked titi (*Callicebus personatus*) was reported to the state of Rio de Janeiro [8, 15, 17] although its occurrence needs to be confirmed. Another species is the golden-headed lion tamarin (*Leontopithecus chrysomelas*). The species was introduced accidentally by a private collector and was seen for the first time in 2002 in a forest fragment, part of Serra da Titirica, municipality of Niteroi, state of Rio de Janeiro [14].

From specialists, in 1998, a biologist recorded an individual of black spider monkey (*Ateles paniscus*) in a forest fragment within the city of Rio de Janeiro (Isabela Deiss, personal communication). The most recent record of a non-native primate species within the state of Rio de Janeiro happened in November 2011. An adult male of black-and-gold howler monkey (*Alouatta caraya*) was captured on the west part of the municipality of Rio de Janeiro near the Pedra Branca State Park (Cristiane Rangel, personal communication).

Around 457 specimens were captured by or delivered to the CETAS while another 438 were recorded in citizen phone complaints (Linha Verde) from 2003 to 2010. Most of the records are of the genera *Callithrix* (363 and 415 records) and *Cebus* (86 and 17 records) respectively. However, other genera (*Leontopithecus*, *Callicebus*, *Lagothrix* and *Alouatta*) were also recorded.

Discussion

Our study shows that the number of primate species present in Rio de Janeiro is higher than reported on the previous list [6], with an additional five non-native and at least one native species to the state. However, not all recorded species have established populations within the state. For instance, the non-native species from the genera *Alouatta* and *Ateles* are unlikely to harm the native primates since there have been no further records of their presence and are therefore unlikely to have formed established populations in the state.

On the other hand, the non-native species of the genera *Callithrix* and *Saimiri* have definitely established populations within the state of Rio de Janeiro [6], and golden-headed lion tamarins (*L. chrysomelas*) may have as well. The estimated number of golden-headed lion tamarins in 2009 was around 107 individuals [14]; however, this number may currently be higher because there have been four reproductive seasons since the survey and lion tamarins can produce twins in each reproductive season [18]. Also, the hybrids of the genus *Cebus* recorded by Cunha [12] have established populations mainly in the city of Rio de Janeiro. For these hybrids, a monitoring program of their progress outside the city of Rio de Janeiro and the evaluation of their current status within the state are necessary especially within the range of the native black-horned capuchin, *C. nigrinus*.

The confirmation of the occurrence of the northern masked titi, *C. personatus* within the state of Rio de Janeiro, and therefore its classification as native or non-native, remains uncertain. The species has been suggested to occur in the Atlantic Forest of south-eastern Brazil in the states of Espírito Santo, north-western Minas Gerais and northern Rio de Janeiro [8, 15, 17] but was not reported in Rocha et al. [6]. In their article, Roosmalen et al. [8] cited an expert personal communication and added the northern masked titi, *C. personatus* to the state of Rio de Janeiro, and Printes et al. [15], citing Roosmalen's et al. [11] work, also suggested the species to occur within the state of Rio de Janeiro. However, Grelle [19], evaluating the distribution of primate species endemic to the Atlantic Forest with records from scientific collections housed at MZUSP and MNRJ and from the literature, recorded only specimens of black-fronted titi, *Callicebus nigrifrons* at MZUSP. This information was recently confirmed (Carla C. Aquino, personal communication). We think that misinterpretation of the literature may cause this mismatching. The status of the buffy-headed marmoset, *C. flaviceps*, still needs to be confirmed. Its record in the municipality of Varre-e-Sai may represent an increase in its geographic distribution, as this portion of the state of Rio de Janeiro is inside the climatic and vegetational distribution of the species [20] and it is near the border of the species' geographical distribution [16, 21]. This could explain why it was not recorded previously in the state of Rio de Janeiro [6], but this assertion still needs to be confirmed as well.

Implications for conservation

It is widely accepted that a normal functioning ecosystem provides society with ecological services very important for human well-being [22]. Impoverished ecosystems, on the other hand, may function less efficiently as ecological processes are lost, and gradually lose their ability to deliver ecosystem services to human societies [22]. Thus, the problem of introduced primate species within the state of Rio de Janeiro requires attention, because the ecological costs of these outsiders may be the irretrievable loss of native species [23]. Although invasive species are a worldwide problem, in the state of Rio de Janeiro the problem is worse, as more non-native than native primate species were recorded within the state. Some of these species, such as the white-tufted-ear marmoset *Callithrix jacchus* and black-tufted-ear marmoset, *Callithrix penicillata*, have established populations in many parts of the state, and already threaten the native and endangered golden lion tamarin [24]. Also, the white-tufted-ear marmoset, *C. jacchus* as well as capuchin monkeys, *Cebus* sp. are known to prey on bird nestlings and eggs [25] which may have a strong negative effect on the restinga antwren (*Formicivora littoralis*), a critically endangered bird with very restricted geographical distribution [26] where white-tufted-ear marmoset, *C. jacchus* has already been recorded.

Inter-specific competition for food is expected among species with similar foraging behaviors like the con-generics of genera *Cebus*, *Callithrix* and *Leontopithecus*, and between the genera *Callithrix* and *Leontopithecus* due to similarities in their ecology and behavior. For instance, Ruiz-Miranda et al. [24] showed that white-tufted-ear marmoset (*C. jacchus*) and the black-tufted-ear marmoset (*C. penicillata*) compete for food with the golden-lion tamarin, *L. rosalia*. Both *Callithrix* species occur with the golden lion tamarin in many parts of the tamarin's geographical range [27].

Hybridization is probably the worst effect of these introductions. In general, con-generics can hybridize, and the hybrids may ultimately compete with the native species. Hybrids from the genus *Callithrix* were already recorded in the wild [28, 29]. Hybrids between the native buffy-tufted marmosets (*C. aurita*) with con-generics have been reported within Serra dos Orgãos National Park [30] where both white-

tufted-ear marmoset (*C. jacchus*) and the black-tufted-ear marmoset (*C. penicillata*) also occur [10, 30]. The buffy-tufted marmosets, *C. aurita* is considered vulnerable by the IUCN due to the decline of its populations [29], and hybridization may be another serious risk to the species, mainly in protected areas such as Itatiaia National Park where the black-tufted-ear marmoset (*C. penicillata*) was also observed [31]. The high densities of hybrids between the black-horned capuchin (*C. nigritus*), the native species, robust tufted capuchin (*C. robustus*) and the bearded capuchin (*C. libidinosus*), recorded within the municipality of Rio de Janeiro [12] indicate that these hybrids are well adapted to the forested areas of the city. Specimens of *Cebus* with different phenotypes have been recorded in many parts of the state of Rio de Janeiro, suggesting that the hybrids may not be restricted to the city of Rio de Janeiro, implying another threat for the native the black-horned capuchin (*C. nigritus*). The presence of golden-headed lion tamarins (*L. chrysomelas*) within the geographic range of the native and endangered golden lion tamarin (*L. rosalia*) may represent another threat for the latter species [14]. In case of an encounter between the two species, the chances are high that the two species will hybridize [14] as has been observed in captivity [32]. There is also the risk that the golden-headed lion tamarins will introduce diseases previously absent from the region of the golden lion tamarin [14].



Fig. 1. Introduced (and one native) primate species recorded in the state of Rio de Janeiro. From top right to left: *Saimiri sciureus* (Photo Gustavo Pedro de Paula), *Callithrix jacchus* (Photo Cristiane Rangel), *Leontopithecus chrysomelas* (Photo Leonardo Oliveira) and *Callithrix penicillata* (Photo Roberto Murta). These four species have established population within the state of Rio de Janeiro. From bottom left: *Ateles paniscus* (Photo Leonardo Oliveira), *Alouatta caraya* (Photo Roberto Murta) which are unlikely to form established population within the state, and *Leontopithecus rosalia* with a hybrid of *C. penicillata* and *C. jacchus* (Photo Leonardo Oliveira) within the range of the golden-lion tamarin.

Recommendations

It can be very difficult to control intentional and unintentional introductions that occur through diverse and unique means; therefore preventing new introductions is imperative [23]. Because hundreds of primates from different species were recorded as pets, we recommend an awareness campaign to prevent the use of primates as pets, showing the negative impacts of released primate species on the native fauna. Sterilization of the non-native species is an alternative to avoid population increase, spread and hybridization; although it would not halt ongoing negative effects on the native biodiversity and may be effective only for small populations [33], it nevertheless may be used as complementary action. The removal of introduced species is a difficult task in a large geographical range, but where achievable, removal is the best management option for dealing with invasive species where prevention has failed [23].

The first step in removing introduced species is to identify the areas where they occur. A monitoring program is necessary to determine the geographical range of the problem and to identify priority areas where removal of introduced primates is urgent, such as in protected areas and near endangered species. The National Action Plan for Endangered Mammals of Southeastern Brazil (PAN MAMAC), developed by Instituto Chico Mendes de Conservação da Biodiversidade-(ICMBio) in November 2010, includes as one of its recommendations the removal of all introduced primate species in the state of Rio de Janeiro [34]. Though this recommendation will likely cause political and social concern, it is the most appropriate action considering the potential effects on the native primate species as well as on the whole biodiversity of the state.

Acknowledgments

We thank Isabella Deiss for providing information about *Ateles paniscus*, Cristiane Rangel about *Alouatta caraya*, and Márcio Urselino for providing data from CETAS and Linha Verde. We thank Alcides Pissinati from the Rio de Janeiro Primate Center (CPRJ), Anthony Rylands, Fabiano Melo, and José de Souza Silva Junior for the identification of an individual of *Callicebus* and Carla C. Aquino for providing information about the specimens of *Callicebus* deposited on MUZUSP. We also thank James M. Dietz and Sara Zeigler for the English review. Leonardo C. Oliveira received a PNPd-CAPES fellowship and Carlos E V Grelle received grants by CNPq (productivity fellowship) and FAPERJ (*Jovem Cientista do Estado*).

Literature Cited

- [1] Vié, J. C., Hilton-Taylor, C. and Stuart, S. N. 2009. *Wildlife in a changing world: an analysis of the 2008 IUCN Red List of threatened species*. Gland, Switzerland: IUCN. 180 p.
- [2] Schipper, J., Chanson, J. S., Chinozza, F., et al. 2008. The status of the world's land and marine mammals: diversity, threat and knowledge. *Science* 322: 225-230.
- [3] Gurevitch, J. and Padilla, D. K. 2004. Are Invasive species a major cause of extinctions? *Trends in Ecology and Evolution* 19(9): 470-474.
- [4] With, K. A. 2002. The landscape ecology of invasive spread. *Conservation Biology* 16(5): 1192-1203.
- [5] Ribeiro, M. C., Metzger, J. P., Martensen, A. C., Ponzoni, F. J. and Hirota, M. M. 2009. The Brazilian Atlantic Forest: how much is left, and how is the remaining forest distributed? Implications for conservation. *Biological Conservation* 142: 1141-1153.
- [6] Rocha, C. F. D., Bergallo, H., Pombal Jr, J. P., Geise, L., Van Sluys, M., Fernandes, R. and Caramaschi, U. 2004. Fauna de anfíbios, répteis e mamíferos do Estado do Rio de Janeiro, Sudeste do Brasil. *Publicações Avulsas do Museu Nacional do Rio de Janeiro* 104: 3-23.

- [7] Cunha, A. A., Grelle, C. E. V. and Boubli, J. P. 2009. Distribution, population size and conservation of the endemic muriquis (*Brachyteles* spp.) of the Brazilian Atlantic Forest. *Oryx* 43(2): 254–257.
- [8] Roosmalen, M. G. M., Roosmalen, T. and Mittermeier, R. A. 2002. A taxonomic review of the titi monkeys, genus *Callicebus* Thomas, 1903, with the description of two new species, *Callicebus bernhardi* and *Callicebus stephennashi*, from Brazilian Amazonia. *Neotropical Primates* 10: 1-52.
- [9] Alves, S. L. 2005. Records of primates at Itatiaia National Park Brazil. *Neotropical Primates* 13(2): 36-37.
- [10] Cunha, A. A. 2003. Primates in the Serra dos Órgãos National Park: New Records. *Neotropical Primates* 11(1): 49-51.
- [11] Cunha, A. A. and Vieira, M. V. 2004. Present and past primate community of the Tijuca Forest, Rio de Janeiro, Brazil. *Neotropical Primates* 12(3): 153-154.
- [12] Cunha, A. A. 2005. Estratificação vertical, abundância e tamanho populacional do macaco-prego (*Cebus* sp.) e do mico-estrela (*Callithrix jacchus*) no Maciço da Tijuca, Rio de Janeiro, RJ, Brazil. MSc. thesis, Universidade Federal do Rio de Janeiro, Rio de Janeiro.
- [13] Loretto, D.M. and Rajão, H. 2005. Novos registros de primatas no Parque Nacional do Itatiaia, com ênfase em *Brachyteles arachnoides* (Primates, Atelidae). *Neotropical Primates* 13(2): 28-30.
- [14] Kierulff, M. C. M. 2010. Invasive introduced golden-headed lion tamarins - a new threat to golden lion tamarins. *Tamarin Tales* 10: 5-7.
- [15] Printes, R.C, Jerusalinsky, L., Souza, M. C., Ribeiro, L. R, and Hirsch, A. In press. Zoogeography, genetic variation and conservation of the *Callicebus personatus* group. In: *Evolutionary biology and conservation of Titis, Sakis and Uacaris*. Veiga, L., Barnett, A., Norconk, M. A. and Ferrari, S. F. (Eds). Cambridge University Press, Cambridge.
- [16] Rylands, A. B., Ferrari, S. F., Mendes, S. L. 2008. *Callithrix flaviceps*. In: IUCN 2010. IUCN Red List of Threatened Species. www.iucnredlist.org.
- [17] Veiga, L. M., Ferrari, S. F., Kierulff, C. M., Oliveira, M. M. and Mendes, S. L. 2008. *Callicebus personatus*. In: IUCN 2010. IUCN Red List of Threatened Species. www.iucnredlist.org.
- [18] Oliveira, L. C., Neves, L. G., Raboy, B. E. and Dietz, J. M. 2011. Abundance of jackfruit (*Artocarpus heterophyllus*) affects group characteristics and use of space by golden-headed lion tamarins (*Leontopithecus chrysomelas*) in *cabruca* agroforest. *Environmental Management* 48: 248-262.
- [19] Grelle, C. E. V. 2000. Areografia dos Primatas Endêmicos da Mata Atlântica. DSc dissertation, Museu Nacional-Universidade Federal do Rio de Janeiro, Rio de Janeiro.
- [20] Grelle, C. E. V. and Cerqueira, R. 2006. Determinantes da distribuição geográfica de *Callithrix flaviceps* (Thomas). *Revista Brasileira de Zoologia* 23: 414-420.
- [21] Coimbra-Filho, A. F., Mittermeier, R. A., and Constable, I. D. 1981. *Callithrix flaviceps* (Thomas, 1903) recorded from Minas Gerais, Brazil (Callitrichidae, Primates). *Revista Brasileira de Biologia* 41(1): 141-147.
- [22] Loreau, M. 2010. Linking biodiversity and ecosystems: towards an unifying ecological theory. *Philosophical Transactions of the Royal Society B* 365: 49-60.
- [23] IUCN. 2000. *IUCN Guidelines for the prevention of biodiversity loss caused by alien invasive species*. IUCN, Gland, Switzerland. 24p.
- [24]. Ruiz-Miranda, C. R., Affonso, A., Morais, M. M., Verona, C. E. S., Martins, A. and Beck, B. B. 2006. Behavioral and ecological interactions between reintroduced golden lion tamarins (*Leontopithecus rosalia* Linnaeus, 1766) and introduced marmosets (*Callithrix* spp, Linnaeus, 1758) in Brazil's Atlantic Coast Forest fragments. *Arquivos de Biologia e Tecnologia* 49(1): 99-109.
- [25] Coimbra-Filho, A. F. and Aldrighi, A. D. 1971. A restauração da fauna do Parque Nacional da Tijuca, GB, Brasil. *Publicações Avulsas do Museu Nacional* 57:1-30.
- [26] IUCN. 2011. *2011 IUCN Red List of Threatened Species*. www.iucnredlist.org

- [27] Ruiz-Miranda, C. R., Affonso, A. G., Martins, A. and Beck, B. B. 2000. Distribuição do sagüi (*Callithrix jacchus*) nas áreas de ocorrência do mico leão dourado no Estado de Rio de Janeiro. *Neotropical Primates* 8 (3): 98-101.
- [28] Rylands, A. B., Spironelo, W., Tornisielo, V. L., Lemos de Sá, R. L., Kierulff, M. C. M. and Santos, I. B. 1988. Primates of the Rio Jequitinhonha valley, Minas Gerais, Brazil. *Primate Conservation* 9: 100-109.
- [29] Passamani, M., Aguiar, L. M. S., Machado, R. B. and Figueiredo, E. 1997. Hybridization between *Callithrix geoffroyi* and *Callithrix penicillata* in southeastern Minas Gerais, Brazil. *Neotropical Primates* 5(1): 9-10.
- [30] Pereira, D. G., Oliveira, M. E. A and Ruiz-Miranda, C. R. 2008. Interações entre calitriquídeos exóticos e nativos no Parque Nacional da Serra dos Órgãos - RJ. *Espaço e Geografia* 11: 67-94.
- [31] Geise, L., Pereira, L. G., Bossi, D. E. P. and Bergallo, H. G. 2004. Pattern of elevational distribution and richness of non-volant mammals in Itatiaia National Park and its surroundings, in southeastern Brazil. *Brazilian Journal of Biology* 64: 599–612.
- [32] Coimbra-Filho, A. F. and Mittermeier, R. A. 1976. Hybridization in the genus *Leontopithecus*, *Leontopithecus r. rosalia* (Linneus, 1766) x *L. r. chrysomaleas* (Kuhl, 1830) (Callitrichidae, Primates). *Revista Brasileira de Biologia* 36: 129-137.
- [33] Silva, A.G., Kolokotronis, S.O. and Wharton, D. 2010. Modeling the eradication of invasive mammals using the sterile male technique. *Biological Invasions* 12: 751-759.
- [34] Escarlante-Tavares, F.; Jerusalinsky, L. In press. Plano de Ação Nacional para a Conservação dos Mamíferos da Mata Atlântica Central. Brasília: ICMBio (Série Espécies Ameaçadas).

Appendix 1. Native and non-native species of primates recorded for the state of Rio de Janeiro, Brazil with their international status (IUCN) and the source of information.

Species	Vernacular name	Origin	Status	Source
Atelidae				
<i>Alouatta guariba clamitans</i> (Cabrera, 1940)	Southern Brown Howling Monkey	N	LC	MN, B, C, D, G, H, I
<i>Alouatta caraya</i> (Humboldt, 1812)	Black and Gold Howler Monkey	NN	LC	PC
<i>Ateles paniscus</i> (Linnaeus 1958)	Black Spider Monkey	NN	VU	PC
<i>Brachyteles arachnoides</i> (É. Geoffroy 1806)	Southern Muriqui	N	EN	MN, MZ, B, C, D, F, G, H, I
<i>Brachyteles hypoxanthus</i> (Kuhl 1820)	Northern Muriqui	N	CR	F
Callithichidae				
<i>Callithrix aurita</i> (É. Geoffroy, 1812)	Buffy-tufted-ear Marmoset	N	VU	MN, MZ, B, C, D, G, H, I
* <i>Callithrix flaviceps</i> (Thomas, 1903)	Buffy-headed Marmoset		EN	MN, K
<i>Callithrix jacchus</i> (Linnaeus, 1758)	White-tufted-ear Marmoset	NN	LC	C, D, E, J
<i>Callithrix penicillata</i> (É. Geoffroy, 1812)	Black-tufted-ear Marmoset	NN	LC	C, G, J
<i>Leontopithecus chrysomelas</i> (Kuhl, 1820)	Golden-headed lion tamarin	NN	EN	M
<i>Leontopithecus rosalia</i> (Linnaeus, 1766)	Golden lion tamarin	N	EN	MN, B, C, D, G, H
Cebidae				
<i>Cebus libidinosus</i> (Spix 1823)	Bearded Capuchin	NN	LC	E
<i>Cebus nigratus</i> (Goldfuss 1809)	Black-horned Capuchin	N	NT	MN, MZ, B, C, D, E, G, H, I
<i>Cebus robustus</i> (Kuhl 1820)	Robust Tufted Capuchin	NN	VU	E
<i>Saimiri sciureus</i> (Linnaeus 1758)	South American Squirrel Monkey	NN	LC	D
Pitheciidae				
<i>Callicebus nigrifrons</i> (Spix 1823)	Black-fronted Titi Monkey	N	NT	MZ, B, C, D, G, H, I
* <i>Callicebus personatus</i> (É. Geoffroy, 1812)	Northern Masked Titi		VU	A, L, N

N= Native NN= Non-native

CR= Critically Endangered En= Endangered; VU= Vulnerable; NT= Near threatened; LC = Least Concern; PC= Personal communication of an expert; MN= MNRJ = National Museum of Rio de Janeiro; MZ= MZUSP = Zoological Museum of University of São Paulo; A= Roosmalen et al. (2002); B= Cunha (2003); C= Cunha and Vieira (2004); D= Rocha et al. (2004); E= Cunha (2005); F= Cunha (2009); G= Alves (2005) H= Loretto and Rajão (2005); I= Alves (2005); J= Ruiz-Miranda et al. (2006); K= Rylands et al. (2008); L= Veiga et al. (2008); M= Kierulff (2010); N= Printes et al. in press.

*Definition as native or non-native to the state of Rio de Janeiro still needs to be confirmed.