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References

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. *J. Wildl. Manag.* 59: 228-237.

Comita, J. L. 1984. Impacto de los caminos sobre la fauna en el Parque Nacional El Palmar. *Rev. Mus. Arg. Cienc. Nat. "Bernardino Rivadavia" e Inst. Nac. Investig. Cienc. Nat., Zool.* 13: 513-521.

Feldhamer, G. A., Gates, J. E., Harman, D. M., Loranger, A. J. and Dixon, K. R. 1986. Effects of interstate highway fencing on white-tailed deer activity. *J. Wildl. Manag.* 50: 497-503.

Gibson, G. 1980. Road kills. *Wildl. Rev.* 9: 3-5.

Hansen, C. S. 1983. Cost of deer-vehicle accidents in Michigan. *Wildl. Soc. Bull.*, 11: 161-164.

Lefranc, M. N. and Millsap, B. A. 1984. A summary of state and federal agency raptor management programs. *Wildl. Soc. Bull.* 12: 274-282.

O'Gara, B. W. and Harris, R. B. 1988. Age and condition of deer killed by predators and automobiles. *J. Wildl. Manag.* 52: 316-320.

Oxley, D. J., Fenton, M. B. and Carmody, G. R. 1974. The effects of roads on populations of small mammals. *J. Appl. Ecol.* 11: 51-59.

Polaco, O. J. and Guzmán, A. F. 1993. Mortalidad anual de mamíferos en una carretera al sur de Nuevo León. In: *Avances en el Estudio de los Mamíferos de México*, R. A. Medellín and G. Ceballos (eds.), pp.394-407. Publicaciones Especiales, Vol. 1. Asociación Mexicana de Mastozoología, A. C., México, D. F.

Reed, D. F. 1981. Mule deer behavior at a highway underpass exit. *J. Wildl. Manag.* 45: 452-543.

Reed, D. F. and Woodward, T. N. 1981. Effectiveness of highway lighting in reducing deer-vehicle accidents. *J. Wildl. Manag.* 45: 721-726.

Schafer, J. A. and Penland, S. T. 1985. Effectiveness of Swareflex reflectors in reducing deer-vehicle accidents. *J. Wildl. Manag.* 49: 774-776.

Steenhof, H., Kochert, M. N. and Roppe, J. A. 1993. Nesting by raptors and common ravens on electrical transmission-line towers. *J. Wildl. Manag.* 57: 271-281.

Valladares-Padua, C., Cullen Jr., L. and Padua, S. 1995. A pole bridge to avoid primate road kills. *Neotropical Primates* 3(1): 13-15.

Wilkins, K. T. 1982. Highways as barriers to rodent dispersal. *The Southwestern Naturalist* 27: 459-460.

Wilkins, K. T. and Schmidly, D. J. 1980. Highway mortality of vertebrates in southeastern Texas. *Texas J. Sci.*, 22: 343-350.

Habitat and Distribution of the Buffy-tufted-ear Marmoset *Callithrix aurita* in São Paulo State, Brazil, with Notes on Its Natural History

The buffy-tufted-ear marmoset, *Callithrix aurita* is an endangered primate endemic to the states of Minas Gerais, Rio de Janeiro and São Paulo, in southeastern Brazil (Coimbra-Filho, 1991), living in forests between 500 and 800 m altitude (Rylands, 1994). The species has only recently been studied in the field (Torres de Assumpção, 1983; Muskin, 1984; Bueno, 1989; Corrêa, 1995). Here we discuss the former and present-day distribution of the species in the state of São Paulo in the southern limit of its distribution, and also its habitat and ecology.

Distribution

Rylands (1994), following Hershkovitz (1977), considered the species' distribution in São Paulo to be limited by the Rio Ribeira de Iguape to the south, stretching west between the upper courses of the Rios Tietê/Piracicaba and Paranapanema, and north to the border with Minas Gerais. Overall, in São Paulo the species has actually been recorded from 16 localities (Hershkovitz, 1977; Coimbra-Filho, 1991; Vivo, 1991; Centro de Monitoramento Ambiental da Serra do Itapety - Mogi das Cruzes). Except for Boracéia (22°10'S, 48°45'W; Hershkovitz, 1977) there is no locality south of the Rio Tietê at the latitude of São Paulo city, and none east of the ridge of the Serra do Mar. The species is absent from the eastern slopes of the Serra do Mar and lowland forests. Four new localities for the species have been recently discovered: Mairiporã (23°19'S, 46°35'W), where two individuals were observed in August 1981; Atibaia (23°07'S, 46°33'W), a recently prepared specimen in the Atibaia Natural History Museum; Santa Isabel (23°15'W, 40°19'W), based on several observations (see below); and Fazenda Lagoa, São Luis do Paraitinga (*c.* 23°15'S, 45°20'W), an adult male collected in 1984, in the Zoology Museum of the Universidade Federal de Mato Grosso. The species also apparently occurs in the Serra do Japi (23°14'S, 46°57'W; see Marinho-Filho, 1992), where suitable habitat exists, but as other *Callithrix* species have been released there the record has still to be confirmed, despite several trips we have

made to the area.

Extensive fieldwork from 1982 to 1995 in the putative range of *Callithrix aurita* in the mountains of the Ribeira de Iguape valley and in southeastern São Paulo, including such well-protected areas as Fazenda Intervales, the State Parks of Alto Ribeira, Ilha do Cardoso and Carlos Botelho, and the Juréia Ecological Station, and also in the municipalities of Juquitiba and Miracatú in the Serra de Paranapiacaba, has consistently failed to find evidence for the presence of the species. The only callithrichids occurring in southern São Paulo are the black-faced lion tamarin, *Leontopithecus caissara* (lowlands and isolated mountain ranges from Cananéia to Guaraqueçaba, Paraná; see Martuscelli and Rodrigues, 1992), and the introduced black-tufted-ear marmoset *Callithrix penicillata* (Fazenda Serrana, municipality of Cajati, and the Serra de Miracatu, municipality of Miracatu).

We believe the actual southern limit of the species' distribution is located around the present-day city of São Paulo, north of the junction of the Rios Pinheiros and Tietê, the last forming the southern boundary of the species' distribution. The only anomalous locality would be Hershkovitz's "Boracéia", apparently located south of the Rio Tietê north-west of present-day Bauru (Rylands, 1994). Nevertheless, Hershkovitz described the locality as in the upper river Tietê, which would be unlikely. In fact, it is more probable that the locality refers to the Boracéia Biological Station, a well-known collecting locality near the headwaters of the Tietê, and not to the town of Boracéia, which is near Bauru.

The southern limit of the distribution of *C. aurita* is close to Ipanema (23°26'S, 47°36'W), today Araçoiaba da Serra, the type locality of the black lion tamarin, *Leontopithecus chrysopygus*, a species originally widespread south of the Tietê and north of the Paranapanema rivers, and formerly found in the low forests characteristic of the hills behind the Serra do Mar. It is possible that ecological interactions between this species and the marmoset, probably competitive as both favor the same viny, tangled microhabitat for foraging (pers. obs.), rather than geographical barriers, limited the distribution of the latter to the south. The low forests characteristic of the transitional hilly area between the Serra do Mar ridge and the inland highlands would not offer enough habitat complexity to allow two callitrichids to co-exist, as occurs with *Callithrix kuhli* and *Leontopithecus chrysomelas* in the taller forests of southern Bahia (Rylands, 1989).

The western limits of the species' distribution are unclear. The junction of the Rios Piracicaba and Tietê seems to be an important natural limit, but further north the limits between the distribution of *aurita* and *penicillata* have still to be determined. In the westernmost locality, the Mogi Guaçu Ecological Station (adjacent to the best-known Fazenda Campininha), on the right bank of the Rio Mogi-Guaçu, *Callithrix aurita* lives in *cerradão* and riverine forest habitat quite similar to that used by *C. penicillata* at the Jataí Ecological Station, about 130 km downstream, also on the right bank of the Mogi. The intermediate area would be worth researching.

Habitat

We have been able to visit most of the localities where *Callithrix aurita* has been recorded in São Paulo. *Callithrix aurita* has been found, currently, to live in montane forest and in gallery forest and *cerradão*, in altitudes ranging from 600 to at least 1,200 m. Although there are specimens from Ubatuba, a lowland locality by the sea (Vivo, 1991), recent fieldwork failed to find the species there. We believe the specimens were probably collected somewhere on the hilly country along the old road from Taubaté to Ubatuba, perhaps close to São Luis do Paraitinga (a known locality) or Natividade da Serra, rather than in the lowlands around Ubatuba itself. The forest in the area is similar to that found at known localities such as Cunha, not too far away.

Montane forests inhabited by the species are both evergreen and semideciduous, usually with a low (around 15 m) and even canopy with few or no emergents and mostly slender trees, sometimes with multiple trunks. The common denominator of all localities where *C. aurita* is known to live is a dense understorey of tangled vines (in drier forests) or bamboo (in montane areas). Localities where *C. aurita* has been found share a seasonal climate with dry, cold winters when frosts and mist are common due to altitude or proximity to river bottomlands. Most localities are under the influence of the rain-shadow of the Serra do Mar or other mountain ranges, which evidently explains the more seasonal climate and differences in vegetation structure and successional dynamics (see below).

Marmosets have been recorded in habitat patches found mostly on hilltops where the effects of the shallow soil, wind, frost and mist result in a stunted, viny or bamboo-rich forest (contrary to the conditions in the valleys) and, in localities farther inland such as Barreiro Rico and Mogi-Guaçu, in second-growth and edge areas where vines are dominant. *Callithrix aurita*

seems dependent on disturbed areas where some edge effect, resulting in a growth of vines or bamboo, is occurring.

During fieldwork conducted in June 1995 (see below) in a montane site in the Serra da Mantiqueira massif (Santa Isabel) and another located in the planalto (Mogi-Guaçu), we located groups of *C. aurita* only in patches of forest or *cerradão* where tangled vines were common. It is interesting to note that the abundance of vines in the *cerradão* studied is apparently due to the lack of fires for several years, which has allowed a build-up of dead vines. Torres de Assumpção (1983) and Muskin (1984) also found the species to favor vine-tangled areas, spending more time in bamboo and vine-covered trees, where it found most of its food.

The patchy habitat favored by *C. aurita* is similar to that preferred by other species of *Callithrix*, a group favoring, successional, disturbed and edge habitats (Stevenson and Rylands, 1988; Rylands, 1995). Such a preference is probably due to the greater availability of invertebrate prey in such habitats (Janzen, 1973), a result of the low prevalence of plants with chemical defenses against herbivory (see Marquis and Braker, 1994 for an overview). Also many of the gum-producing trees and vines used by the marmosets are edge or early successional species, including legumes.

The dependence on tangled, successional or edge habitats probably explains the absence of *C. aurita* from lower slopes (under 500 m) of the Serra do Mar and of the coastal plain forests. In São Paulo, a dense undergrowth of bamboo (mainly *Guadua, Chusquea* and *Merostachys* spp.) only begins to become common in forest above 500 m altitude. Also the "edge effect" that results in a dense cover of vines sharply marking the forest edge or completely dominating small woodlots observed inland, where there is a marked dry season, is mostly absent from forests in the Serra do Mar and the coastal plain of São Paulo.

Natural History

Population densities of *Callithrix aurita* were obtained in two localities, the montane Santa Isabel and planalto at Mogi-Guaçu (Fig. 1). Santa Isabel is in a 2,200 ha private property, at the southern tip of the Serra da Mantiqueira at an altitude of 700-1,200m. Most (752 ha) of the remaining forested area is covered by montane broadleaved perennial forest (Eiten, 1970), located on the valley bottoms and lower slopes of the hills, while 162 ha of hilltops are covered by montane mesophytic semideciduous forest (Leitão-Filho, 1992). The remaining area is covered by *Eucalyptus*. Mogi-Guaçu covers part of the Mogi-Guaçu Ecological Station and Experimental Station, and the adjoining Mogi-Guaçu Biological Reserve (Fazenda Campininha), with a patchwork of mostly disturbed gallery forest along the Rio Mogi-Guaçu (362 ha), *cerradão* or low sclerophylic forest (619 ha) and old *Pinus* and *Eucalyptus* plantings with an undergrowth of native species (137 ha). The area has been described by Vuono *et al.* (1982), Mantovani (1984, 1987) and Mantovani *et al.* (1989). The only other primate found both at Santa Isabel and Mogi-Guaçu was the black-fronted titi, *Callicebus personatus nigrifrons*.

Both areas were visited in June 1995, a few weeks apart, and censused by strip transects. A total of 85 km was walked in Santa Isabel during six days (10 km in riverine forest, 12 in forest bordering a water reservoir, 29,5 in montane forest, 25.5 in hilltop forest and eight in planted forest with native undergrowth). At Mogi-Guaçu 48.1 km were walked during four days (26 km in gallery forest, 19.6 in cerradão and 2.5 in planted forest with native undergrowth). Long distance and contact calls made by marmosets could be detected from a distance of at least 100 m, and the means by which most groups were located involved the use of "playback" of recorded vocalizations. Whenever possible the marmosets were followed, but only at Santa Isabel were they tame enough.

Eight different groups were contacted 12 times at Santa Isabel. Eight contacts were made in hilltop forest, two in valley forest and two in the transition between them, suggesting a selection for the hilltop habitat. At Mogi-Guaçu, three groups were located four times, once in *cerradão* and three times in gallery forest. In this case, we consider the sample size too small to characterize any habitat preference. Overall density at Santa Isabel was 1 group/142 ha and 1 group/240 ha at Mogi-Guaçu, but the latter is probably an underestimate. A low population was also estimated for Barreiro Rico (Milton and Lucca, 1984).

In a previous visit to Mogi-Guaçu on 29 April 1988, three different groups were located, one in gallery forest and two in planted forest with native undergrowth. One of the groups was crossing a road from an old *Eucalyptus* grove to native forest. From this observation it is clear that *C. aurita* can use planted forest at least as corridors for moving between habitat patches and, probably, for foraging when there is enough native vegetation growing in the undergrowth.

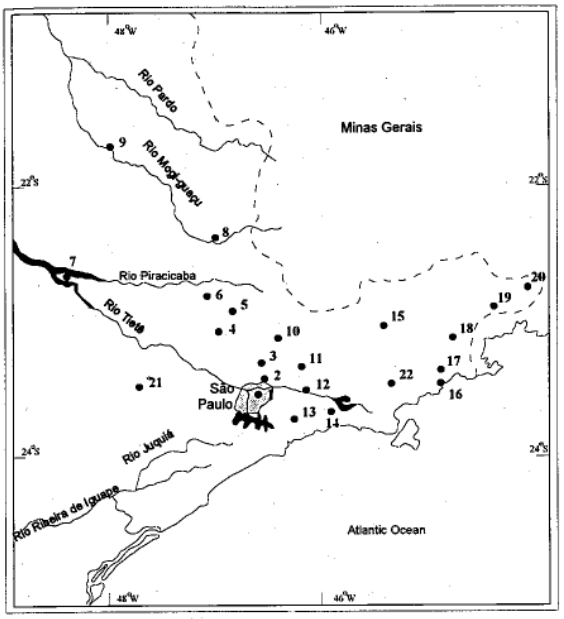

Figure 1. Distribution of *Callithrix aurita* in São Paulo state, Brazil, and other localities cited in the text. 1 - São Paulo city (e), 2 - Serra da Cantareira (c), 3 - Mairiporã (c), 4 - Serra do Japi (?), 5 - Itatiba (?), 6 - Campinas (e), 7 - Fazenda Barreiro Rico (c), 8 - Mogi-Guaçu (c), 9 - Jataí (*C. penicillata* present), 10 - Atibaia (c ?), 11- Santa Isabel (c), 12 - Mogi das Cruzes (c), 13 - Alto da Serra (c), 14 - Boracéia (c ?), 15 - Taubaté (?), 16 - Ubatuba (?), 17 - Serra do Mar (?), 18 - Cunha (c), 19 - Posse (c ?), 20 - Bananal (c), 21 - Araçoiaba da Serra (type locality of *Leontopithecus chrysopygus*), 22 - São Luis de Paraitinga (c). c - currently found in the area, e - locally extinct. ? - status uncertain.

Group sizes at Santa Isabel were 4, 5, 5, 5, 6, 7, 8 and 11. Five groups observed at Mogi-Guaçu in 1988 and 1995 had 4, 5, 5, 6 and 8 individuals. Group composition could not be assessed. No dependent infants were seen at Mogi Guaçu. At Santa Isabel two groups had infants beginning to move independently, one in a group of five, and two in a group of eight.

At Santa Isabel, the marmosets were observed probing for invertebrates in mounds of leaves in vine tangles and among the roots of an epiphytic Araceae. They were also observed feeding on the fruits of *Protium* cf. *widgrenii* (Burseraceae), *Ficus organensis* (Moraceae), *Myrcia rostrata* (Myrtaceae), *Prunus sellowi* (Rosaceae) and *Matayba oleaginoides* (Sapindaceae). Two trees of the gum-producing legume *Piptadenia gonoacantha* were found in an area used by a marmoset group with holes probably produced by marmosets, but gum-eating was not actually observed. Crescent-shaped holes and scars were also found to cover most of the trunk of two *Tapirira guianensis* in a riverine forest patch at Mogi-Guaçu. These observations suggest that *C. aurita* feed on gums, as indicated by Torres de Assumpção (1983).

Conservation

Callithrix aurita is presently known from five protected areas in São Paulo: Cantareira State Park, Mogi Guaçu Ecological Station (including the contiguous Biological Reserve), Bananal Ecological Station, Núcleo Cunha of the Serra do Mar State Park and Serra do Itapety Municipal Park. Of these, the largest is Cantareira, with 5,800 ha.

The largest continuous forest fragment where the species is known to occur in São Paulo is a 50 km stretch along the southern Serra da Mantiqueira, from Santa Isabel west to the Serra da Cantareira, and north to Atibaia. The habitat is best preserved along the Cantareira-Santa Isabel axis, where the forest is still continuous, but it is fragmented towards Atibaia and in the peripheral areas. Both Mogi-Guaçu and Barreiro Rico are small and isolated, and may not have viable populations.

The main threat to the survival of the species is habitat fragmentation by real estate enterprises, mainly weekend and small holiday estates, and closed condominiums, and the introduction of other *Callithrix* species from releases made by wildlife officers. Parts of the Cantareira park have also been occupied by shantytowns, and invasions by homeless people are common. Despite the fact that most of the area has some degree of legal protection as an Environmental Protection Area, effective protection and management of the forested areas is wanting. Introduced marmosets occur both at Cantareira and Serra do Japi, threatening the native species with competition and hybridization.

With continuous pressure from people wanting to live in more pleasant locations than São Paulo city, and the growth of the now 12 million inhabitant-megalopolis toward the Serra da Cantareira, long-term viability of the best *Callithrix aurita* habitat so far known in the state, and of most of the known populations, remains uncertain.

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References

Bueno, A. R. 1989. Determinação da área de uso de um grupo de saguis *Callithrix aurita* em um fragmento florestal do sul de Minas Gerais. Bachelor's thesis, Universidade Estadual de São Paulo, Rio Claro.

Coimbra-Filho, A. F. 1991. Apontamentos sobre *Callithrix aurita* (E. Geoffroy, 1812), um sagüi pouco conhecido (Callitrichidae, Primates). In: *A Primatologia no Brasil-3*, A. B. Rylands and A. T. Bernardes (eds.), pp.145-158. Fundação Biodiversitas and Sociedade Brasileira de Primatologia, Belo Horizonte.

Corrêa, H. K. M. 1995. Ecologia e comportamento alimentar de um grupo de saguis-da-serra-escuros (*Callithrix aurita* E. Geoffroy 1812) no Parque Estadual da Serra do Mar, Núcleo Cunha, São Paulo, Brasil. Master's thesis, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, Belo Horizonte.

Eiten, G. 1970. A vegetação do estado de São Paulo. *Bolm. Inst. Bot.* 7: 1-147.

Hershkovitz, P. 1977. *Living New World Monkeys (Platyrrhini), With an Introduction to Primates, Volume 1.* University of Chicago Press, Chicago.

Janzen, D. H. 1973. Sweep samples of tropical foliage: effects of seasons, vegetation types, elevation, time of day and insularity. *Ecology* 54: 687-708.

Leitão-Filho, H. de F. 1992. A flora arbórea da Serra do Japi. In: *História Natural da Serra do Japi: Ecologia e Preservação de Uma Área Florestal no Sudeste do Brasil.* L. P. Morellato (org.), pp.40-62. Editora da Unicamp/FAPESP, Campinas.

Mantovani, W. 1984. Composição e similaridade florística, fenologia e espectro biológico do cerrado da Reserva Biológica de Mogi-Guaçu - SP. M.Sc. Thesis, Universidade Estadual de Campinas, Campinas.

Mantovani, W. 1987. Análise florística e fitossociológica do estrato herbáceo-subarbustivo do cerrado na Reserva Biológica de Mogi-Guaçu e em Itirapina. Ph.D. Thesis, Universidade Estadual de Campinas, Campinas.

Mantovani, W., Rossi, L., Romaniuc Neto, S., Assad-Ludewigs, I. Y., Wanderley, M. das G. L., de Melo, M.M. da R. F., and de Toledo, C. B. 1989. Estudos fitossociológicos da área de mata ciliar em Mogi-Guaçu - SP. In: *Simpósio sobre a Mata Ciliar*, L. M. Barbosa (coord.), pp. 235-267. Fundação Cargill, São Paulo.

Marinho-Filho, J. 1992. Os mamíferos da Serra do Japi. In: *História Natural da Serra do Japi: Ecologia e Preservação de uma Área Florestal no Sudeste do Brasil,* L.P. Morellato (org.), pp. 264-286. Editora da Unicamp/FAPESP, São Paulo.

Marquis, R. J. and Braker, H. E.. 1994. Plant-herbivore interactions: diversity, specificity and impact. In: *La Selva: Ecology and Natural History of a Neotropical Rain Forest*, L. A. McDade, K. S. Bawa, H. A. Hespenheide and G. S. Hartshorn (eds.), pp. 261-281. University of Chicago Press, Chicago.

Martuscelli, P. and Rodrigues, M. G. 1992. Novas populações do mico-leão caiçara *Leontopithecus caissara* (Lorini e Persson, 1990) no sudeste do Brasil (Primates-Callitrichidae). *Rev. Inst. Flor. São Paulo* 4: 920-924.

Milton, K. and Lucca, C. de 1984. Population estimate for Brachyteles at Fazenda Barreiro Rico, São Paulo State, Brazil. *IUCN/SSC Primate Specialist Group Newsletter* (4): 27-28.

Muskin, A. 1984. Field notes and geographic distribution of *Callithrix aurita* in eastern Brazil. *Am. J. Primatol.* 7: 377-380.

Rylands, A.B. 1989. Sympatric Brazilian callitrichids: the black-tufted-ear marmoset *Callithrix kuhli* and the golden-headed lion tamarin *Leontopithecus chrysomelas. J. Hum. Evol.* 18: 679-697.

Rylands, A. B. 1994. Sagüi-da-serra-escuro *Callithrix aurita* (É. Geoffroy, 1812). In: *Livro Vermelho dos Mamíferos Brasileiros Ameaçados de Extinção*, G. A. B. Fonseca, A. B. Rylands, C. M. R. Costa, R. B. Machado, Y. L. R. Leite (eds.), pp.47-54. Fundação Biodiversitas, Belo Horizonte.

Rylands, A. B. 1995. Habitat and the evolution of social and reproductive behavior in Callitrichidae. *Am. J. Primatol.* 37. In press.

Stevenson, M.F. and Rylands, A. B. 1988. The marmosets, genus *Callithrix*. In: *Ecology and Behavior of Neotropical Primates, Vol. 2,* R. A. Mittermeier, A. F. Coimbra-Filho, A. B. Rylands and G. A. B. Fonseca (eds.), pp.131-222. World Wildlife Fund, Washington, D. C.

Torres de Assumpção, C. 1983. An ecological study of the primates of southeastern Brazil, with a reappraisal of *Cebus apella* races. Ph. D. Thesis, University of Edinburgh, Edinburgh.

Vivo, M. de 1991. *Taxonomia de* Callithrix *Erxleben, 1777 (Callitrichidae, Primates).* Fundação Biodiversitas, Belo Horizonte.

Vuono, Y.S. de, Barbosa, L. M. and Batista, E. A. 1982. A Reserva Biológica de Mogi-Guaçu. *Silvic. São Paulo* 16A: 548-556.

A New Record for *Callithrix mauesi* Mittermeier, Schwarz & Ayres, 1992

The Rio Maués marmoset (*Callithrix mauesi*) was recently described by Mittermeier *et al.* (1992), based on one specimen deposited in the scientific collection of the Museu Paraense Emílio Goeldi (holotype: