

# *Mico humeralifer* (Primates: Callitrichidae)

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**Abstract:** *Mico humeralifer* (É. Geoffroy Saint-Hilaire, 1812) is a callitrichid monkey commonly called the Santarém marmoset or black-and-white tassel-eared marmoset. It is a small (280–310 g), sexually monomorphic anthropoid primate with a diet of insects, fruits, and plant exudates (nectar and gum). It is endemic to northern Brazil, occurring in the states of Pará and Amazonas, south of the Rio Amazonas, along the western margin of the Rio Tapajós in dense ombrophilous forests of the Amazon. *M. humeralifer* is the smallest primate in its distribution range. It lives in small groups and inhabits primarily terra firme forested regions in the Amazon Basin, adapting quickly to second-growth forests. Due to the lack of knowledge about its demographics and its remote habitat, its current conservation status is “Data Deficient.”

**Key words:** Amazonia, black-and-white tassel-eared marmoset, Brazil, *Callithrix humeralifera*, *Callithrix santaremensis*, primate, Santarém marmoset

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## *Mico humeralifer* (É. Geoffroy Saint-Hilaire, 1812) Santarém Marmoset

*Simia humeralifera*: É. Geoffroy Saint-Hilaire in Humboldt, 1812:360. Type locality “le Bresil [= Brazil];” restricted to Paricatuba, left bank Rio Tapajós, near mouth, Pará, Brazil, by Hershkovitz (1966:331).

*Jacchus humeralifer*: É. Geoffroy Saint-Hilaire, 1812:120. Type locality “le Bresil?”

*Hapale humeralifer*: Kuhl, 1820:48. Name combination.

*Hapales humeralifer*: Jardine, 1833:228. Name combination.

*Jachus humeralifer*: Schlegel, 1876:271. Name combination.

*Hapale santaremensis* Matschie, 1893:227. Type localities “Paricatuba, Südufer des Amazonas [...] und Santarem;” restricted to Paricatuba, margem esquerda do Rio Tapajós, Pará, Brasil, by de Vivo (1991:38).

*Callithrix humeralifer*: Trouessart, 1904:28. Name combination.

*Callithrix santaremensis*: Trouessart, 1904:28. Name combination.

*Callithrix humeralifer humeralifer*: Hershkovitz, 1968:565. Name combination.

*Callithrix hemeralifer hemeralifer* Rylands, 1979:589. Incorrect subsequent spelling of *Simia humeralifer* É. Geoffroy Saint-Hilaire in Humboldt, 1812.

*Callithrix humeralifera*: de Vivo, 1991:37. Corrected original spelling of *Callithrix humeralifera* Trouessart, 1904.

*Mico humeralifer*: Rylands et al. 2000:67. First use of current name combination.

*Callithrix (Mico) humeralifera*: Groves, 2001:133. Name combination.

CONTEXT AND CONTENT. Order Primates, suborder Haplorhini, infraorder Simiiformes, parvorder Platyrrhini, family Callitrichidae, subfamily Callitrichinae (Rylands and Mittermeier 2013). No subspecies of *Mico humeralifer* are recognized.



**Fig. 1.**—An adult captive *Mico humeralifer* (unknown sex) from Japan Monkey Centre, Aichi. Used with permission of photographer Noel Rowe/alltheworldsprimates.org.

**NOMENCLATURAL NOTES.** According to the principle of priority (International Commission on Zoological Nomenclature 1999, Article 23), the name *Liocephalus* Wagner, 1839 (not 1840 as stated by Hershkovitz 1977 [Sherborn 1927]), used originally as a subgenus of *Hapale*, is a senior synonym of *Mico* Lesson, 1840. If, however, the junior synonym has been used in more than 25 works of 10 different authors in the preceding 50 years and if the senior synonym has not been used as a valid name after 1899, the former takes priority under prevailing usage (International Commission on Zoological Nomenclature 1999, Article 23). Because *Liocephalus* was never used again after Wagner (1839), and *Mico* has been extensively used as a valid name of a subgroup of the marmosets (e.g., Thomas 1922; Lönnberg 1940; Hill 1957, 1959; Rylands et al. 2000; Groves 2001, 2005; Alperin 2002; Sena et al. 2002; Pimenta and Silva-Júnior 2005; Noronha et al. 2007, 2008a, 2008b; Ferrari 2008; Ford and Davis 2009; Ferrari et al. 2010; Fialho 2010; Forsythe and Ford 2011; Garbino 2011; Schneider et al. 2011), the name *Mico* Lesson, 1840 can be considered as valid, instead of *Liocephalus* Wagner, 1839.

Hershkovitz (1977) originally considered the 3 known species of tufted Amazonian marmosets as subspecies of *Callithrix humeralifer*, de Vivo (1991) considered the subspecific taxa named by Hershkovitz (1977) as full species and, treating *Callithrix* as a feminine noun, corrected the spelling to *Callithrix humeralifera*. Although Groves (2001, 2005) used *Mico* as a subgenus of *Callithrix*, we follow herein Rylands et al. (2000), Ford and Davis (2009), Ferrari et al. (2010), and Rylands and Mittermeier (2013), who treat *Mico* as a full genus. The genus *Mico* contains 13 species (Rylands et al. 2009; Ferrari et al. 2010; Garbino 2014): *Mico acariensis*, *M. argentatus*, *M. chrysoleucos*, *M. emiliae*, *M. humeralifer*, *M. intermedius*, *M. leucippe*, *M. marcai*, *M. mauesi*, *M. melanurus*, *M. nigriceps*, *M. rondoni*, and *M. saterei*.

We disagree with de Vivo (1991:40), who states that the correct authorship of the species should belong to Humboldt (1812), arguing that the work of this author was published a few months (in August, according to Thomas [1913]), before that of É. Geoffroy Saint-Hilaire (1812—published in October of the same year). Because Humboldt cites É. Geoffroy Saint-Hilaire as the author and gives essentially the same diagnosis of the species as that of Geoffroy, changing only the language from French to Latin, according to the *International Code of Zoological Nomenclature* (International Commission on Zoological Nomenclature 1999, Article 50) the author is É. Geoffroy Saint-Hilaire.

The 1st part of the species epithet comes from the Latin word *humeralē* (genitive *humeralīs*), which is an alternative form of *umerālē*, a substantive used to designate a cape that covers the shoulders. The suffix *-fer* means carry or bear. The word *humeralifer* therefore means bearing a cape that covers the shoulders.

## DIAGNOSIS

*Mico humeralifer* is the only small primate (i.e., total body mass < 500 g) in its range and the only callitrichid monkey known to occur in the region, meaning it is the only monkey with clawed fingers, ringed tail, tufted ears, lower incisors subequal to the canines, and triangular upper molars (Fig. 1). The species it is most similar to is the Maués marmoset (*M. mauesi*), differing from it by having a more grayish mantle (darker mantle in *M. mauesi*), tassel-like, horizontally expanded (“neatly trimmed” in *M. mauesi*—Mittermeier et al. 1992:6), and whitish, buffy, or grayish (blackish in *M. mauesi*) ear tufts. The tufts originate from both surfaces of the pinnae, a character exclusive to *M. chrysoleucos*, *M. humeralifer* and *M. mauesi* among the tufted species. The face is pigmented, except for the region around the nostrils and eyes (Fig. 2); species with a similar facial pigmentation are the black-crowned dwarf marmoset (*Callibella humilis*), Marca’s marmoset (*M. marcai*), *M. mauesi*, the black-tailed marmoset (*M. melanurus*), and the black-headed marmoset (*M. nigriceps*). Similar to *M. mauesi*, the saddle and rump of *M. humeralifer* are blackish and mottled with grayish or whitish spots (Fig. 1). The crown of the lower canines and incisors are of subequal height and the anterior portion of the mandible is V-shaped in occlusal view (Fig. 3). Other than *M. mauesi*, *M. humeralifer* is the only *Mico* species with tail rings defined by the black and silvery bands on hair, differing from the golden-white tassel-ear marmoset (*M. chrysoleucos*), the ringed tail of which does not show banded black and silvery pelage.

## GENERAL CHARACTERS

The face of *Mico humeralifer* is pigmented except for the region around the nostrils and eyes; hairs are more sparsely distributed around and between the eyes, being more densely distributed to the sides of the face, to the forehead, and to the mouth; the forehead is grayish; ear tufts are present and formed by buffy to grayish hairs that originate from both the inner and outer surfaces of the pinna (Ávila-Pires 1969; de Vivo 1991; Fig. 2).

The mantle is light grayish, being conspicuously distinguished from the region around it; the dorsal region, immediately posterior to the mantle, is black with irregular grayish–whitish spots, derived from exposure of the middle white band of the dorsal hair; whitish patches on the hips are present, not reaching the thighs; throat region sparsely haired, chest yellowish brown; dorsal surface of forelimbs colored as the mantle in the proximal region, darkening distally; black manus; dorsal surface of hind limbs similar to coloration of the dorsum, except for the absence of median whitish band; black pes. The nonprehensile tail is ringed. The annulations are formed by a broad, basal black band





followed by a thinner apical grayish one on tail hairs (de Vivo 1991; Figs. 1 and 2). All callitrichids have non-opposable cheirida with claws present on all digits except the hallux (Rosenberger 1984).

*Mico humeralifer*, in common with all marmoset species, has high-crowned and protruding lower incisors, which are almost as large as the canine teeth (Rosenberger 1977). Those teeth are disposed posterolaterally in relation to each other and to the canines (Rosenberger 1977; Kay 1994). All marmosets present an interdigitated occlusion pattern of the upper and lower incisors (Kay 1994; Fig. 3). The hypocone is absent in M1 and M2 (Hershkovitz 1977). The entocingulum of M1 wraps the protocone both mesially and distally (Natori 1986).

The nasal profile is slightly concave, temporal ridges are absent, the bony palate ends caudally to the M2, the pterygoid fossa is reduced to a shallow space between the lateral and medial pterygoid processes, the auditory bulla is inflated, the petrosal spine is present, the postglenoid foramen is small or absent, and paraoccipital processes are absent. The foramen magnum is ventrally oriented. Hershkovitz (1975:166), analyzing the middle ear of *M. humeralifer*, verified the presence of a structure he named “orbicular apophysis” in the malleus that apparently is exclusive to the genus *Mico*. The lower jaw has a developed angular process that protrudes below the horizontal ramus of the dentary, a horizontally oriented mandibular symphysis, a poorly developed coronoid process, and both coronoid and condylar processes at approximately the same level (Aguiar and Lacher 2009; Forsythe and Ford 2011; Fig. 3). The lower dental arcade, in occlusal view of its anterior region, shows a V-shaped pattern (Hershkovitz 1977; Rosenberger 1977). The entepicondylar foramen of the humerus is absent (Ford and Davis 2009). The male and female genitalia are larger and more complex in *Mico* (including *M. humeralifer*) than in *Callithrix* (Hershkovitz 1975). In *M. humeralifer*, a baculum is present and the left lobe of the glans penis that contains it is consistently larger than the right lobe (Hershkovitz 1975). The female circumgenital area in *M. humeralifer* presents a swelling that may be cyclical (Russell and Zuckerman 1935).

Mean ( $\pm$  SD) skull measurements (mm) for *M. humeralifer* (range and  $n$  in parentheses, mixed sexes) were: greatest length of skull,  $46.17 \pm 0.902$  (44.1–48.6, 55); condylobasal length,  $37.1 \pm 0.7832$  (35.3–39.0, 55); zygomatic breadth,  $30.25 \pm 0.9523$  (27.4–32.6, 48); braincase breadth,  $25.84 \pm 0.7474$  (24.6–27.4, 57); interorbital breadth,  $26.59 \pm 0.6955$  (25.1–28.8, 57); distance between upper M1s,  $15.49 \pm 0.3976$  (14.8–16.6, 53); length of mandible,  $28.91 \pm 0.9091$  (27.1–30.9,  $n = 50$ ); height of

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**Fig. 2.**—Face of an adult captive *Mico humeralifer* (unknown sex) taken at Marco Schwarz’s captive facility, Brazil. Used with permission of photographer Noel Rowe/alltheworldsprimates.org.



**Fig. 3.**—Dorsal, ventral, and lateral views of skull and lateral view of mandible of an adult female *Mico humeralifer* (MZUSP [Museu de Zoologia da Universidade de São Paulo mammal collection] 11306)

condylar process,  $16.8 \pm 0.755$  (15.0–18.4, 53); length of inferior postcanine toothrow,  $10.39 \pm 0.3422$  (9.6–11.3, 53); distance between upper Cs,  $11.91 \pm 0.4541$  (11.0–12.9, 51—de Vivo 1991).

External measurements (mm, minimum–maximum), based on information gathered by various collectors and present on the specimen labels, were compiled by de Vivo (1991): body length (including tail), 530–640 ( $n = 30$ ); head and body length, 200–270 ( $n = 10$ ); tail length, 310–370 ( $n = 34$ ); hind-foot length, 58–65 ( $n = 34$ ); ear length, 25–31 ( $n = 7$ ).

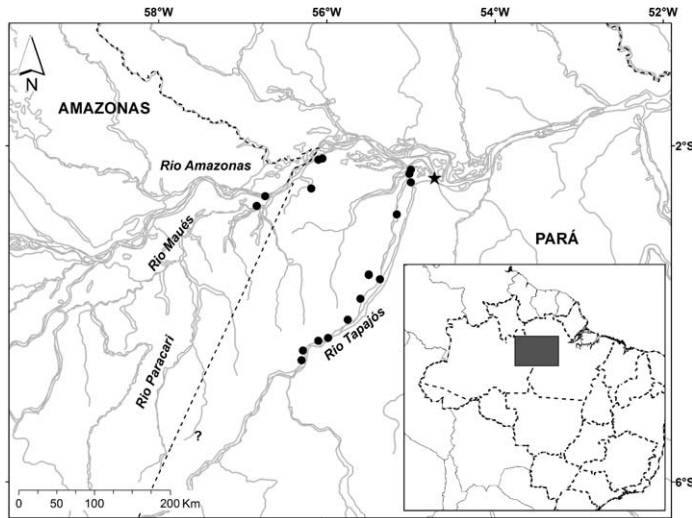
Smith and Jungers (1997) reported a mean body mass for captive individuals of 472 g for females ( $n = 13$ ) and 475 g for males ( $n = 15$ ), although Ayres (1986) reported slightly lower values for this variable for wild-caught individuals: 380 g for females ( $n = 5$ ) and 360 g for males ( $n = 4$ ). In a recent checklist of Brazilian mammals body mass of *M. humeralifer* ranged from 280 to 310 g (Paglia et al. 2012).

### DISTRIBUTION

All *Mico* species, except Emilia's marmoset (*M. emiliae*) and *M. melanurus*, are restricted to the dense ombrophilous forests of the Amazon Basin, east from the southern margin of the Rio Madeira, south of the Rio Amazonas (de Vivo 1991; Rylands et al. 2009). *M. humeralifer* occurs only in the northern Brazilian states of Amazonas and Pará (de Vivo 1991). Its distributional range is restricted to the small region delimited by the western margin of the Rio Tapajós in the east, and the eastern margins of the rios Maués and Parauari in the west, south of the Rio Amazonas. The southern limit of its distribution, however, remains unknown. Rylands et al. (2009) proposed that it might lie in the region of the Rio Paracari, an eastern tributary of the Parauari (Fig. 4). It is unlikely that its range extends beyond the headwaters of the Rio Parauari, to the south of where *M. mauesi* has been recorded (Noronha et al. 2008a; Fig. 4). Ten other species of primates are known to occur in the same area as *M. humeralifer*: the Amazon black howler (*Alouatta nigerrima*—see Gregorin 2006), the Peruvian spider monkey (*Ateles chamek*—see Iwanaga and Ferrari 2002), the gray woolly monkey (*Lagothrix cana*—see Iwanaga and Ferrari 2002), the white-fronted capuchin (*Cebus albifrons*) and the tufted capuchin (*Sapajus* [formerly *Cebus*] *apella*—see Silva-Júnior 2001), the bare-eared squirrel monkey (*Saimiri ustus*—see Hershkovitz 1984), the black-headed night monkey (*Aotus nigriceps*—see Hershkovitz 1983), Hoffmann's titi (*Callicebus hoffmannsi*—see van Roosmalen et al. 2002), the Rio Tapajós saki (*Pithecia irrorata*—see Hershkovitz 1987), and the white-nosed saki

←  
from Brasília Legal, state of Pará, Brazil. Scale bar = 10 mm. Photo by G. S. T. Garbino.





**Fig. 4.**—Geographic distribution of *Mico humeralifer*. Black dots obtained from de Vivo (1991) and museum specimens analyzed by the authors. The star represents the type locality.

(*Chiropotes albinus*—see Hershkovitz 1985). No fossils of *M. humeralifer* or of any marmosets are known.

## FORM AND FUNCTION

*Mico humeralifer* has the typical callitrichid dental formula of i 2/2, c 1/1, p 3/3, m 2/2, total 32 (Ford 1980). The vertebral formula of *Hapale santaremensis* (= *M. humeralifer*) given by Hill (1957) is 7 C, 12 T, 7 L, 2 S, 30 Ca, total 58. The number of caudal and sacral vertebrae varies (Hershkovitz 1977:425).

Marmosets are the only anthropoid primates that are craniodentally adapted to tree-gouging (Forsythe and Ford 2011), one of those morphological adaptations, the en echelon spacing of the lower incisors, is present on all marmosets and more fully developed in *Callithrix* than it is in *Cebuella* and *Mico* (Hershkovitz 1975, 1977; Rosenberger 1977). The posteriorly developed angular process, horizontally oriented mandibular symphysis, shortened coronoid process, and mandibular condyle closer to the dental plane are all mandibular adaptations to tree-gouging (Forsythe and Ford 2011).

The oldest traditionally used defining characteristic of callitrichids, that is claws on all digits except the hallux, is probably associated with vertical-clinging behavior, which also is present to a lesser degree in callimicos (*Callimico*), tamarins (*Saguinus*), lion tamarins (*Leontopithecus*), and to a greater extent in the marmosets (*Callibella*, *Callithrix*, *Cebuella*, and *Mico*—Garber 1992).

A combination of quadrupedal walking and running and trunk-to-trunk leaping define the locomotion of callitrichid monkeys (Fleagle 1999). The vertical-clinging posture is

used when it gouges holes in tree trunks, branches, and vines to obtain exudates (Garber 1992; Fleagle 1999).

## ONTOGENY AND REPRODUCTION

Juvenile *Mico humeralifer* usually present a distinctive longitudinal black stripe along the head. The ear is densely haired but the tufts are not developed until later stages (Hershkovitz 1977).

The dominant female may copulate with 1 or more males (Garber 1994). The gestation period is unknown for the species. Despite having a simple unicornuate uterus and 1 pair of nipples, all callitrichids (except Goeldi's marmoset [*Callimico goeldii*]) normally give birth to dizygotic (fraternal) twins (Ford 1980). Marmosets normally have 2 litters per year (Garber 1994).

## ECOLOGY

The only published ecological data available for *Mico humeralifer* come from Branch (1983) and Ayres and Milton (1981). De Vivo (1988) also provided important behavioral data for the species. The other references to *M. humeralifer* made by Rylands (1979, 1986a, 1986b, 1990) are actually based on studies made with Hershkovitz's marmoset (*M. intermedius*), then considered a subspecies of *M. humeralifer*.

Branch (1983) reported a density of 6.52 individuals/10 km in secondary growth, 0.68 in selective cut, and 1.98 in low primary terra firme forests. The species was absent from high primary terra firme forests.

*Mico humeralifer* is restricted to forest formations and elevations below 200 m (de Vivo 1988, 1991). Branch (1983) and M. de Vivo (1988, in litt.) reported that the species is common in second-growth forests in Amazonia National Park, being recorded exclusively in this type of habitat by the former author. In a primate census, carried out by boat and also by foot, *M. humeralifer* was the most commonly sighted primate in second-growth forests, being also recorded in selective-logging forests and natural low-strata (10–15 m) forests with high liana density (George et al. 1988).

Marmosets in general occupy the lower strata (sub-canopy) of the forest (Fleagle 1999). Marmosets of the genus *Mico* are thought to be primarily frugivorous and insectivorous and secondarily exudativorous (Fleagle 1999). Although the reliance on exudates has been inferred to be seasonal in Amazonian *Mico* (Garber 1992), it has been reported by Rylands (1979, 1986b) for *M. intermedius* that this source of nutrients is still used, albeit in lesser degrees, when fruit availability is high. In a drier region of the Amazonian biome, the silvery marmoset (*M. argentatus*) is known to make a greater use of exudates than does *M. intermedius* (Veracini 2009).

## BEHAVIOR

*Mico humeralifer* lives in groups with a mean of 5.7 individuals (ranging from 5 to 6,  $n=4$ —Branch 1983). Ayres and Milton (1981), however, reported groups that ranged from 6 to 9 individuals, whereas M. de Vivo (1988, in lit.) reported groups with 6–10 individuals.

*Mico humeralifer* is sexually monomorphic (Ford 1994). Information about the social structure of groups is unknown for *M. humeralifer*. Other *Mico* species live in groups with only 1 dominant breeding female and 1 or more breeding males, although polygyny also can exist (Rylands 1986a). Marmosets in general emit high-pitched long calls (between 5 and 10 kHz—Snowdon 1993) that can be used in various contexts such as warning calls, intragroup cohesion, or sexual mate attraction (Mendes et al. 2009). Hershkovitz (1977:599) noted that a captive *M. humeralifer* made a “stridulous or cricketlike” vocalization with the mouth open and tongue rapidly vibrating on one instance. In another instance, the same individual made the same sound at a lower volume, with the mouth closed and the tongue vibrating between the lips. B. M. Whitney (in Emmons et al. 1997) recorded disturbance chirps and chips and also long calls of wild *M. humeralifer* in Apacy, state of Pará. A sonogram analysis (by GSTG) of these recordings shows that the long calls are frequency modulated, with the frequency gradually descending in each long note, which also showed an inverted “U” format, similar to what was found for the buffy-tufted marmoset (*Callithrix aurita*) and the buffy-headed marmoset (*C. flaviceps*) by Mendes et al. (2009).

## GENETICS

*Mico humeralifer* has a diploid number of  $2n = 44$  chromosomes (Egozcue et al. 1968—misidentified as *Callithrix aurita* [Peixoto et al. 1984; Canavez et al. 1996]) and a fundamental number (FN) of 78 (34 biarmed + 10 acrocentric—Peixoto et al. 1984). Based on interspecific chromosomal differences in the amount or location of the distal constitutive heterochromatin, a sister-group relation between *M. humeralifer* and *M. mauesi* was proposed (Nagamachi et al. 1996). Chimerism between fraternal twins of the same sex was found in *M. humeralifer* by Nagamachi et al. (1996).

Molecular phylogenies using sequences from the D-loop of the mitochondrial DNA (mtDNA) control region (1,081–1,142 base pairs [bp]—Tagliaro et al. 1997) and based on a partial segment of the control region (905 bp—Schneider et al. 2011) resulted in *M. humeralifer* nested within *M. mauesi*, making the latter paraphyletic. Analyses using only mitochondrial cytochrome oxidase (COII) gene sequences (549 bp) also resulted in *M. humeralifer* being placed within *M. mauesi* (Sena et al. 2002). The nuclear DNA $\beta_2$ -microglobulin

(B2M) gene, 1st sequenced for *M. humeralifer* by Canavez et al. (1999) when included in a phylogenetic analysis, using the intron 2 of the referred gene (635 bp) and 902 bp of the mtDNA control region, resulted in a sister-group relationship between *M. humeralifer* and *M. mauesi* (van Roosmalen et al. 2000). In an analysis of 4 concatenated nuclear DNA regions including the 4 genes containing *Alu* elements (2,034 bp), a sister-group relationship with *M. mauesi* also was found (Schneider et al. 2011).

## CONSERVATION

According to the latest update of the *International Union for Conservation of Nature and Natural Resources Red List of Threatened Species*, *Mico humeralifer* is classified as “Data Deficient” (Rylands and Silva-Júnior 2008). Throughout its distributional range, *M. humeralifer* occurs in 11 protected areas: the Parque Nacional da Amazônia, Área de Proteção Ambiental Tapajós, Área de Proteção Estadual Praia do Sapo, Área de Proteção Estadual Bom Jardim/Passa Tudo, Reserva Extrativista Tapajós-Arapuins, Floresta Nacional de Amaná, Floresta Nacional Pau-Rosa, Floresta Nacional Itaituba I, Floresta Nacional Itaituba II, Floresta Estadual Maués, and also in the Andirá-Marau Indigenous Area. It deserves mentioning that the Brazilian government will build hydroelectric reservoirs along the Rio Tapajós and tributaries, thus reducing the area of some of these protected zones.

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