

## Re-description and assessment of the taxonomic status of *Saguinus fuscicollis cruzlimai* Hershkovitz, 1966 (Primates, Callitrichinae)

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**Abstract** Cruz Lima's saddle-back tamarin *Saguinus fuscicollis cruzlimai* Hershkovitz, 1966, was described from a painting by Eládio da Cruz Lima in his book *Mammals of Amazonia, Vol. 1, Primates* (1945). The painting was of four saddle-back tamarins from the upper Rio Purus, one of them distinct and the inspiration for Hershkovitz to describe it as a new subspecies. Its exact provenance was unknown, however, and the specimen was lost. Surveys in the Purus National Forest in 2011 resulted in sightings of this tamarin along the north bank of the Rio

Inauni, a left-bank tributary of the middle Purus, and also on the left bank of the Purus, north and south of the Rio Inauni. It is possible that it extends north as far as the Rio Pauini, and that *S. f. primitivus* Hershkovitz, 1977, occurs north of the Pauini as far the Rio Tapauá, both also left-bank tributaries of the Purus. Morphometric and molecular genetic analyses and the coloration of the pelage indicate that this tamarin differs from its neighbors sufficiently to be considered a full species. In his doctoral dissertation [2010, Taxonomy, Phylogeny and Distribution of Tamarins (Genus *Saguinus* Hoffmannsegg, 1807) Georg-August Universität, Göttingen], C. Mataushek found that saddle-back and black-mantle tamarins diverged from the tamarin lineage around 9.2 million years ago; time enough to warrant their classification in a distinct genus. *Leontocebus* Wagner, 1840, is the first name available. In this article we re-describe Cruz Lima's saddle-back tamarin. We propose a neotype with a precise locality, and make it a full species in the genus *Leontocebus*.

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### Introduction

The white-mouthed tamarins — the *nigricollis* group of Hershkovitz (1977) — are small insectivore–frugivores of the forests of the upper Amazon, in Bolivia, Brazil, Peru, Ecuador and Colombia (Rylands and Mittermeier 2008b). For Hershkovitz (1977, 1982) this group comprised two species: the black-mantle tamarin *Saguinus nigricollis* with three subspecies and the saddle-back tamarin *Saguinus fuscicollis* with 14 subspecies (Table 1). The *nigricollis* group was defined as having “facial skin, rhinarium, ears,

**Table 1** Species and subspecies of saddle-back tamarins, *Saguinus*, in the taxonomic listings of Hershkovitz (1977), Rylands et al. (2000), Matauschek et al. (2011), and Rylands and Mittermeier (2013)

	Hershkovitz (1977)	Rylands et al. (2000)	Matauschek et al. (2011) Rylands and Mittermeier (2013)
	<i>S. fuscicollis fuscicollis</i>	<i>S. f. fuscicollis</i>	<i>S. f. fuscicollis</i>
	<i>S. f. avilapiresei</i>	<i>S. f. avilapiresei</i>	<i>S. f. avilapiresei</i>
	<i>S. f. primitivus</i>	<i>S. f. primitivus</i>	<i>S. f. primitivus</i>
	<i>S. f. cruzlimai</i>	<i>S. f. cruzlimai</i>	<i>S. f. cruzlimai</i>
	<i>S. f. acrensis</i>	–	–
	–	–	<i>S. f. mura</i>
	<i>S. f. leucogenys</i>	<i>S. f. leucogenys</i>	<i>S. leucogenys</i>
	<i>S. f. illigeri</i>	<i>S. f. illigeri</i>	<i>S. illigeri</i>
	<i>S. f. fuscus</i>	<i>S. f. fuscus</i>	<i>S. fuscus</i>
	<i>S. f. nigrifrons</i>	<i>S. f. nigrifrons</i>	<i>S. nigrifrons</i>
	<i>S. f. lagonotus</i>	<i>S. f. lagonotus</i>	<i>S. lagonotus</i>
	<i>S. f. tripartitus</i>	<i>S. tripartitus</i>	<i>S. tripartitus</i>
	<i>S. f. weddelli</i>	<i>S. f. weddelli</i>	<i>S. weddelli weddelli</i>
	<i>S. f. melanoleucus</i>	<i>S. melanoleucus melanoleucus</i>	<i>S. w. melanoleucus</i>
	<i>S. f. crandalli</i>	<i>S. m. crandalli</i>	<i>S. w. crandalli</i>

and external genitalia blackish; cheeks, temples, forehead, and crown densely covered with long hairs; broad circumbuccal band thickly haired whitish and not encircling muzzle; long and conspicuous moustache absent in adults; ears thinly haired and mostly or entirely exposed, not concealed by mane or periauricular tufts; color of middle or lower back more or less well defined from shoulders; terminal half or more of tail uniformly colored, not banded, barred, or with nearly entire dorsal surface sharply defined from ventral” (p.621). The diagnostic characteristics of the saddle-back tamarins, as defined by Hershkovitz (1977), are “dorsal coloration trizonal, that is, with mantle, saddle, and rump more or less well defined except in extremely bleached or albinistic forms [...]; thighs and forelegs not black” (p.637).

The taxonomy of the saddle-back tamarins has been revised somewhat since Hershkovitz’s synthesis of 1977, but the composition remains essentially the same (see Rylands et al. 2012). One has been lost — *S. f. acrensis* considered to be a hybrid — and one gained — *S. f. mura* described in 2009. Thorington (1988), believing that the form *tripartitus* was sympatric with *lagonotus*, raised the former to a full species (see Rylands et al. 2011). The distinctive white *melanoleucus* was listed by Coimbra-Filho (1990) as a full species, with *crandalli* (of unknown provenance) and *acrensis* as subspecies. Coimbra-Filho’s taxonomy in this case was taken up by Groves (2001, 2005) and Rylands and Mittermeier (2008b). Peres et al. (1996) argued cogently, however, that *S. f. acrensis* was a hybrid of *S. f. fuscicollis* × *S. f. melanoleucus* along the upper Rio Juruá, and it is possible that *S. f. crandalli* too is a hybrid, as suggested by Rylands and Mittermeier (2008b). Molecular genetic analyses by Tagliaro et al. (2005) and Matauschek et al. (2011)

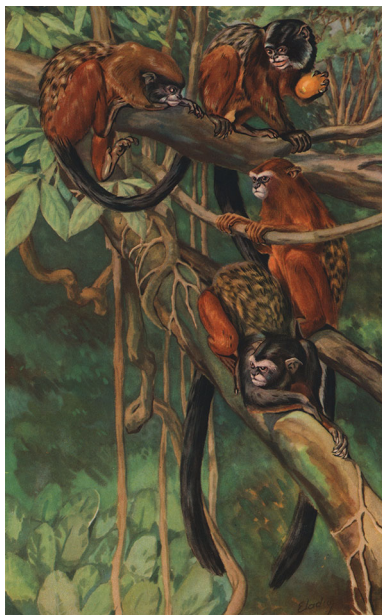
showed a close affiliation between *melanoleucus* and *weddelli*, to the extent even that the validity of *melanoleucus* as a distinct taxon was doubtful. Matauschek et al. (2011) proposed its classification as a subspecies of *Saguinus weddelli* only because it has such distinct pelage coloration. A new taxon from the Rio Purus, *Saguinus fuscicollis mura*, was described by Röhe et al. (2009). The northernmost of Hershkovitz’s (1977) saddle-back tamarins, *S. f. fuscus*, occurring north of the Río Putumayo-Içá, in Colombia and Brazil, is evidently geographically isolated from other saddle-back tamarins (*S. n. nigricollis* occurs along the right bank of the Putumayo-Içá) (see Rylands et al. 2011). The geographical proximity of *S. f. fuscus* and *S. nigricollis* is concordant with the phylogenetic affinity of the two found by Cropp et al. (1999), and they suggested that *fuscus* should be considered a separate species as a result; a suggestion supported by Cheverud and Moore (1990), who studied facial morphology.

In their molecular genetic analysis of the Peruvian saddle-back tamarins and black-mantle tamarins, Matauschek et al. (2011) identified four clades and recommended that Hershkovitz’s (1977) *Saguinus fuscicollis* subspecies *tripartitus*, *lagonotus*, *leucogenys*, *illigeri*, *nigrifrons*, and *weddelli* be considered species. In their revision, the Brazilian saddleback tamarins — *avilapiresei*, *cruzlimai*, *primitivus* and *mura* — remained as subspecies of *S. fuscicollis* pending an equivalent molecular phylogenetic analysis. The taxonomy of the saddle-back tamarins of Rylands and Mittermeier (2013), influenced particularly by Matauschek et al. (2011), included eight species and 14 taxa (species and subspecies) (Table 1). Of the five subspecies of *S. fuscicollis* currently recognized, one, *S. f. cruzlimai*, is enigmatic. It was described by Hershkovitz

(1966) on the basis of a painting by the naturalist Eládio da Cruz Lima in his 1945 *Mammals of Amazonia, Volume 1, Primates*. The painting illustrates four tamarins (see Fig. 1), one of which was used by Hershkovitz (1966) as the holotype. It had not been seen in the wild and its exact provenance was unknown.

### Cruz Lima's (1945) painting of four tamarins (plate 38)

Hershkovitz (1966) described *S. f. cruzlimai* based on a painting by the naturalist Eládio Cruz Lima of a tamarin captioned ‘*Tamarin fuscicollis* jovem’ [juvenile], which Hershkovitz believed to have been mounted and preserved in the Museu Paraense de História Natural e Etnografia, BÉlem do Pará, Brazil (Cruz Lima 1945 [pl. 38, Figure 3a]; see Fig. 1). The painting shows four tamarins of the *Saguinus fuscicollis* complex, two of which, according to Hershkovitz (1966), were said to have been collected in the upper Rio Purus basin for the collection in what is now called the Museu Paraense Emílio Goeldi (MPEG). The two tamarins in the upper half of the figure can be identified as *S. f. nigrifrons* (on the left and labeled by Cruz Lima as *Tamarin nigrifrons nigrifrons*) and *S. f. illigeri* (sensu Hershkovitz, 1977) (on the right and labeled by Cruz Lima



**Fig. 1** Cruz Lima's painting (Cruz Lima 1945 [pl. 38, Figure 3a]) used by Hershkovitz (1966) to describe *Saguinus fuscicollis cruzlimai*. The two tamarins in the upper half of the figure can be identified as *S. f. nigrifrons*. The two portrayed in the lower half of the painting, were identified by Cruz Lima (1945) as a juvenile (above) and an adult (below) *Tamarin fuscicollis* (= *Midas fuscicollis* Spix, 1823 = *Saguinus fuscicollis fuscicollis*; sensu Hershkovitz, 1977), but they are currently identified as *S. f. cruzlimai* (above) and *S. weddelli* (below). Reproduced with the permission of Ângela Pinheiro

as *Tamarin devilli devilli*). They are both from Peru. The two portrayed in the lower half of the painting were identified by Cruz Lima (1945) as a juvenile (sitting up in the lower half in Fig. 1), and an adult (sprawled along the branch in the lower half in Fig. 1) *Tamarin fuscicollis* (= *Midas fuscicollis* Spix, 1823 = *Saguinus fuscicollis fuscicollis*; sensu Hershkovitz, 1977).

According to Hershkovitz (1966), Cruz Lima (1945) had been influenced by Goeldi (1907, p.96), who had been incorrect in his identification of the eight specimens from the Rio Purus. An unpublished illustration of Goeldi (1907) entitled “Macacos novos e pouco conhecidos da região alto-amazonica (Rio Purus),” also illustrated the adult and young *Tamarin fuscicollis* of Cruz Lima (Fig. 2). The two tamarins in the center of the illustration are identified as “*Midas fuscicollis* (Spix) adult. [Rio Purus]” and “*M. fuscicollis* (Spix) juv.,” numbered 3 and 3a, respectively. They have very similar coloration to the adult and juvenile illustrated by Cruz Lima (1945; see Fig. 1), but Goeldi's illustration of the juvenile (3a; Fig. 2) is slightly browner (less orangey) on the mantle, crown and arms.

Hershkovitz (1966) argued that the individual identified by Cruz Lima as an adult *Tamarin fuscicollis* is in fact an



**Fig. 2** The unpublished illustration of Goeldi (1907) “Macacos novos e pouco conhecidos da região alto-amazonica (Rio Purús).” Caption accompanying the plate: 1 *Midas griseo-vertex* Goeldi nov. spec. (1907) (Rio Purús); currently identified as *S. labiatus*. 2 *M. pileatus* (Js. Geoffroy et Deville) (Rio Purús); currently identified as *S. mystax pileatus*. 3 *M. fuscicollis* Spix adult. (Rio Purús); currently identified as *S. weddelli*. 3<sup>a</sup> *M. fuscicollis* Spix juv.; currently identified as *S. f. cruzlimai*. 4 *M. mystax* Spix (Rio Juruá); currently identified as *S. mystax*. 5 *M. imperator* Goeldi nov. spec. (1907) ♂ adult (Rio Purús); currently identified as *S. imperator*. Reproduced with the permission of Maria Astrogilda Ribeiro Silva, Coordenadora CID, MCTI/MPEG/CID

adult *S. f. weddelli* (sensu Hershkovitz, 1977). A careful reading of the descriptions by Goeldi (1907) showed that for seven of the eight Purus specimens the diagnostic characters are indeed those of *S. f. weddelli*, and not *S. f. fuscicollis*. Likewise, a direct comparison of the illustration with other specimens in the MPEG shows that its pelage color and pattern conform to that of *S. f. weddelli*. The eighth Purus specimen has a distinct coloration, which Goeldi (1907) interpreted as being that of the juvenile of the same taxon. Hershkovitz (1966) indicated that Cruz Lima's error was based on Goeldi's suggestion that the pelage coloration of "*Tamarin fuscicollis*" changed with age. Hershkovitz (1966) questioned the age of the animal, being as it was the same size as the others that are labeled as adults. Hershkovitz (1966, 1977) noted, however, that under any circumstances juvenile and adult saddle-back tamarins do not show chromatic differences. An examination of specimens in the collection of the MPEG confirms that the coloration of juvenile *S. f. weddelli* and *S. f. fuscicollis* is entirely similar to that of the adults.

Recognizing the skill and detail of Cruz Lima's (1945) illustrations, Hershkovitz (1966) concluded that the specimen indicated as a young *Tamarin fuscicollis* was in fact an undescribed subspecies. Hershkovitz (1966) attempted, without success, to ascertain the fate of the specimen that Cruz Lima had illustrated. His description of the new species was as such based entirely on Cruz Lima's (1945) Plate 38, Figure 3a, which he named as the holotype, presuming it was preserved in the collection of the MPEG. Hershkovitz visited the collection in 1976, but was unable to locate the specimen. In 1987, José de Sousa e Silva-Júnior searched again in the mammal collection of the MPEG, investigating as well the department responsible for specimens on permanent exhibition. His search failed and he concluded that the type specimen *S. f. cruzlimai* had

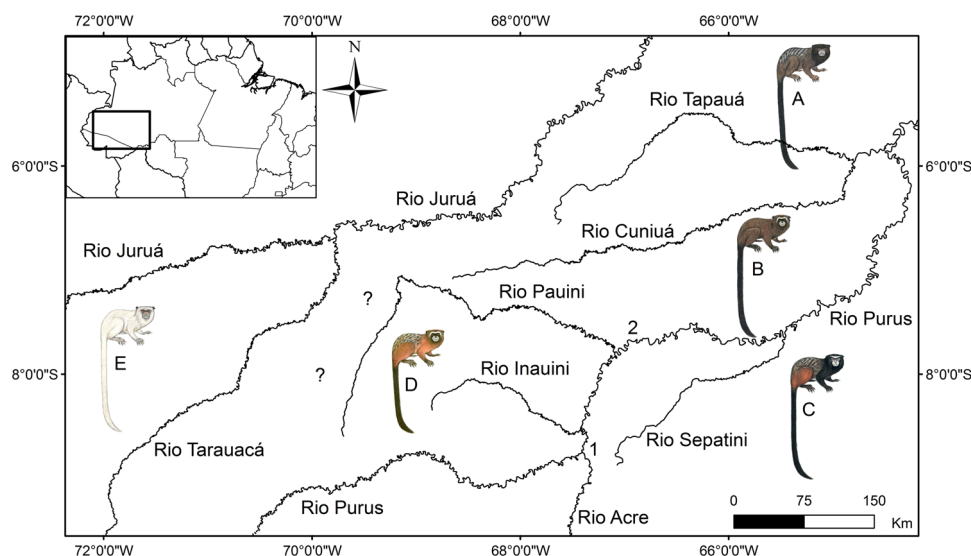
been lost. In the 1950s, Dr. Fernando da Costa Novaes, then curator of the bird and mammal collections, catalogued and removed all the specimens that were types or possible types that were on exhibition. This material, including the lectotype of *Saguinus imperator*, remains preserved in the collection to this day. The "jovem *Tamarin fuscicollis*" of Cruz Lima (1945) and the other seven specimens from the Rio Purus basin recorded by Goeldi (1907), not being considered type specimens, were evidently not included and probably remained on exhibition but were eventually discarded.

Although he had not seen the type specimen, Hershkovitz (1966) provided a description based on the painting in plate 38 of the "jovem *Tamarin fuscicollis*" in Cruz Lima's 1945 treatise. The diagnostic characters given by Hershkovitz (1966) were as follows: "Crown, mantle, legs, arms and upper surface of hands reddish orange; forehead with well defined whitish transverse band or 'eyebrows'." (p.388). Commenting on the tail, Hershkovitz noted that: "The seeming whitish ventral surface of the proximal part of the surface of the tail shown in the cited figure is an artistic device for defining the black tail against a black background" (p.388).

### Rediscovery of Cruz Lima's saddle-back tamarin

The type locality of *S. f. cruzlimai* was recorded by Hershkovitz (1966) as "Said to be from the upper Rio Purus region, Amazonas, Brazil" (p.388). Based on the known and supposed distributions of other saddleback tamarins in the Rio Purus basin, Hershkovitz (1968, 1977) suggested that it occurred on the west bank of the upper Rio Purus (see Fig. 3), and possibly between it and its tributary the Rio Tapauá (1977; p.662; see Figures III.16. X.24 and

**Fig. 3** The middle and upper Rio Purus and its major tributaries, Brazilian Amazon, showing the current occurrence of *S. f. avilapiresei* (A); *S. f. primitivus* (B); *S. w. weddelli* (C); *S. f. cruzlimai* (D); and *S. w. melanoleucus* (E). Illustration © Stephen D. Nash. 1 Town of Boca do Acre; 2 town of Pauini; ? occurrence of saddle-back tamarins unknown

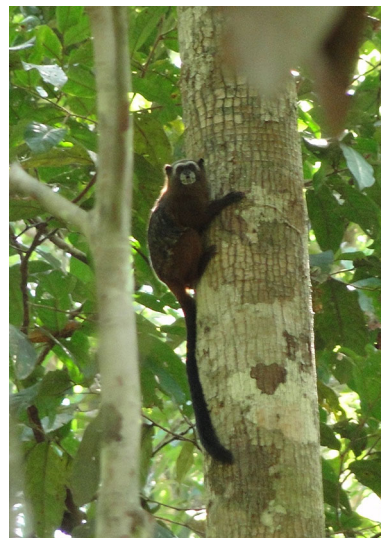




X.26; Plate III, between pp.638 and 639) (see Fig. 3). In an addendum to his 1977 treatise, however, Hershkovitz described *S. f. primitivus* (p.1022) from a skin and skull in the Museu Nacional, Rio de Janeiro, of a tamarin collected live by C. Lako from the Rio Juruá, Amazonas, Brazil, and exhibited in the Zoological Garden in Rio de Janeiro. He also examined specimens he ascribed to *S. f. primitivus* collected in Pauini, Rio Purus, by Paulo E. Vanzolini in 1974. The type locality is given as “Rio Juruá, Amazonas, Brazil,” but with specimens collected from “Pauini, Rio Purus, below the mouth of the Rio Pauini, and from the upper Rio Purus region, presumably the east bank” [sic] (p.1023). Hershkovitz was in fact suggesting that it occurred west of the middle Purus between the rios Tapauá (in the north) and Pauini (in the south), east as far as the Rio Juruá (1977, p.1023; Figure X.15). *Saguinus f. cruzlimai* was, as such, displaced, and Hershkovitz (1977) suggested that it could have evolved directly from a dominantly agouti prototype similar to *S. f. primitivus* and that it may occur north, not south, of the Rio Tapauá (p.1023; Figure X.15), south of the range of *S. f. avilapiresi*.

The first apparent sighting of *S. f. cruzlimai* in the wild since its description was reported by van Roosmalen and van Roosmalen (2003). On 21 June 2002, T. van Roosmalen saw a group of four tamarins in a terra firma forest on the west bank of the Rio Purus, opposite the mouth of the Rio Sepatini (65°25'W, 07°37'S; Fig. 3), which he believed to be *S. f. cruzlimai*. The tamarins were described as follows: “uniformly light brown, with a black tail, and white ocular half rings. The saddleback of the wild individuals was, however, less pronounced than is illustrated in the above plate (the unpublished illustration from Goeldi 1907; see Fig. 2). Due to the ocular half-rings and dark coloration, we surmise that its closest relative is *S. weddelli*. The latter, however, has a reddish rump and belly, while *S. f. cruzlimai* is uniformly light brown.”

During primate surveys in the region of the towns of Boca do Acre (mouth of the Rio Acre, a south bank tributary of the Purus) and Pauini (left bank of the middle Rio Purus, in the state of Amazonas, Brazil) in April–October 2011, the first author (RS) saw tamarins with a coloration (Fig. 4) that largely coincided with that of Hershkovitz’s (1966) description of *S. f. cruzlimai*. Four specimens were collected and deposited in the scientific collections of the Instituto Nacional de Pesquisas da Amazônia (INPA), Manaus, and the MPEG. They were compared with the descriptions of *Tamarin fuscicollis* of Cruz Lima (1945) and of *S. f. cruzlimai* by Hershkovitz (1966, 1977), as well as the original painting by Cruz Lima, which is preserved in the library of the MPEG. Hershkovitz (1977, p.1023) indicated that his 1966 description of *S. f. cruzlimai* may have been imprecise because it was



**Fig. 4** Adult *Leontocebus cruzlimai*, Purus National Forest, Amazonas, Brazil. Photo by Ricardo Sampaio

based entirely on Cruz Lima’s printed depiction in plate 38 of his book — the colors may have been altered in the printing, and Cruz Lima painted them with relatively broad brush strokes, possibly obscuring, as such, any finer details of the hairs and pelage. An examination of the original painting showed that Hershkovitz’s (1966) description was accurate. The specimens we collected, however, differed slightly from Cruz Lima’s painting in having a more rusty than reddish-orange color on the crown, mantle, arms and legs, which agrees with the unpublished illustration of Goeldi. Also, the upper surface of the hands and feet are darker, tending to blackish rather than red. Despite these differences, the specimens collected were positively identified as *Saguinus fuscicollis cruzlimai* Hershkovitz (1966), on the basis of the combined characters.

The original specimen — the holotype used in the illustration by Cruz Lima — has been lost, and in this paper we redescribe *S. f. cruzlimai*, naming a neotype which, although we believe is the same species, differs just slightly from that depicted by Cruz Lima. We also carried out a molecular phylogenetic analysis, which indicates that it should be considered a species distinct from *S. fuscicollis*, and report on some observations of its habitat and behavior in the wild.

#### ***Leontocebus* Wagner, 1840 — the *nigricollis* group tamarins?**

Molecular phylogenetic studies have identified a clear and early division of the tamarins into smaller-bodied (the *nigricollis* or white-mouth tamarin group) and larger-bodied clades (all others) (Canavez et al. 1999; Cropp et al.

1999; Tagliaro et al. 2005; Matauschek 2010; Matauschek et al. 2011; Buckner et al. 2015). Matauschek (2010) identified the date of this separation as around 9.2 million years ago, in the Middle Miocene, a conclusion confirmed by Buckner et al. (2015). Matauschek (2010), invoking the time-based phylogenetic classification proposed by Goodman et al. (1998) in which a divergence time of up to 6 million years ago is indicative of separation at the generic level, indicated the genus *Leontocebus* Wagner, 1840, for the *nigricollis* group tamarins. Buckner et al. (2015), agreeing with Matauschek (2010), also suggested the genus name *Leontocebus*. *Leontocebus* is the earliest name available with a type species that is a member of the *nigricollis* group — *Simia leonina* Humboldt, 1805. The name *Leontocebus* derives from the fact that *Simia leonina* was thought to be a lion tamarin (see Hershkovitz 1949). In fact it was a saddle-back tamarin (see Hershkovitz 1957). Humboldt's "lion marmoset" was renamed by Lesson (1840, *Spec. Mamm. Bim. et Quadrum*, p.202) as *fuscus*. Taking up the suggestion of Matauschek (2010) and Buckner et al. (2015), from here on we refer to the black-mantled tamarins and the saddle-back tamarins as belonging to the genus *Leontocebus* Wagner, 1840.

### Molecular phylogenetic analyses

Total genomic DNA was extracted from muscle tissues preserved in alcohol using the standard protocol of Sambrook et al. (1989). We amplified the complete mitochondrial cytochrome b gene (cyt b) via the polymerase chain reaction (PCR), using the primers developed by Matauschek et al. (2011). Amplification was carried out in a 15- $\mu$ l reaction, containing 2.5  $\mu$ l of dNTPs (2.5 mM); 2.5  $\mu$ l of 10  $\times$  buffer (100 mM Tris-HCl, 500 mM KCl); 2  $\mu$ l from each primer (0.2  $\mu$ M), 3  $\mu$ l of MgCl<sub>2</sub> (25 mM); 1  $\mu$ l of DNA (ca. 10 ng), and 1 U of Taq DNA polymerase. We carried out the amplification cycles under the following conditions: denaturing at 92 °C for 1 min; annealing at 52 °C for 35 s; and extension at 72 °C for 90 s, with a final extension at 72 °C for 7 min. PCR products were purified using exo-sap (Fermentas), and sequence reactions were carried out using the BigDye™ Terminator V3.1 Cycle Sequencing Kit (Life Technologies) following the manufacturer's instructions. Sequences were resolved using the ABI 3130XL (Life Technologies) sequencer. As stated in the Introduction, there were no samples of the taxon *cruzlimai* in any museum, and we sequenced samples from three individuals of this taxon (RS 40, RS 41, and RS 43; where the first two were in the group and the third was in a neighbor group), which were collected at the FLONA (Floresta Nacional) do Purus (see above), edited in BioEdit (Hall 1999), and assembled and aligned with the subset of

the data set from Matauschek et al. (2011) using Clustal W (Thompson et al. 1996), using the default settings. Sequences of *cruzlimai*, have been deposited in GenBank under accession numbers KP182174, KP182175 and KP182176, corresponding to the vouchers MPEG 42984, MPEG 42985 and MPEG 42986, respectively.

We conducted a Bayesian phylogenetic analysis in the BEAST package (Drummond and Rambaut 2007) using a subset of the data and identical parameters to those of Matauschek et al. (2011). We used secondary calibration points obtained from Matauschek et al. (2011) for the roots of *Saguinus*, the *S. mystax* group, the *L. nigricollis* group, and the clade 2 of Matauschek et al. (2011). We set age priors to be normally distributed with the mean and the 95 % CIs reported by Matauschek et al. (2011) for the four clades. The recovered phylogenetic topology was identical to that of Matauschek et al. (2011). The taxon *cruzlimai* was inferred to be a sister to *L. weddelli* with 80 % posterior probability. The time of divergence was estimated at 1.16 (0.70–1.62 95 % HPD) Mya.

### The taxonomic status of Cruz Lima's saddle-back tamarin based on molecular data

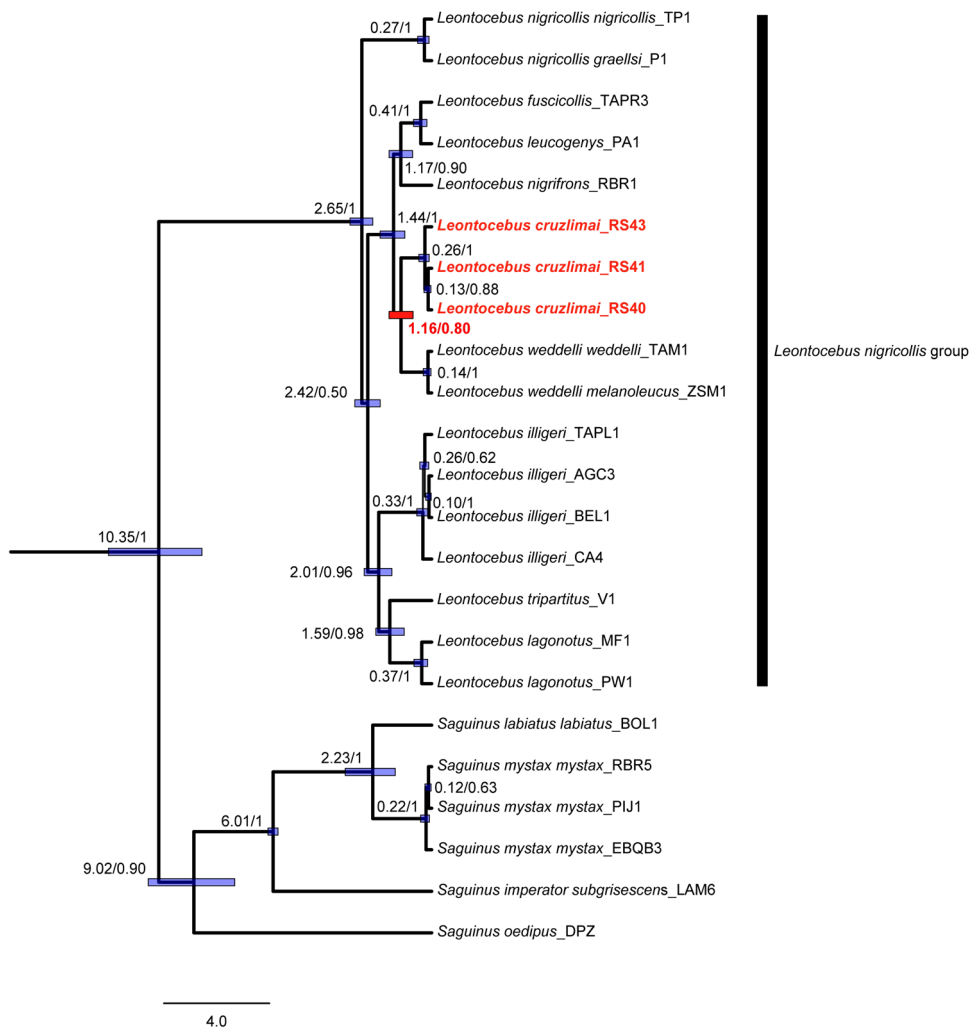
Bayesian analysis recovered a tree topology identical to that reported by Matauschek et al. (2011), but with the inclusion of *cruzlimai* as a sister clade to *L. weddelli* (Fig. 5) in the *L. nigricollis* group, clade 2. The estimated time of divergence between *cruzlimai* and *L. weddelli* was 1.16 Mya, which is in the range of the species' divergence times found by Matauschek et al. (2011); for example, between the sister species *L. nigrifrons* and *L. leucogenys* (1.68 Mya) and between *L. tripartitus* and *L. lagonotus* (1.58 Mya). On average, the cytochrome b genetic distance between *cruzlimai* versus other *L. nigricollis* group taxa was 4 %, with a minimum divergence of 2 % from *L. weddelli weddelli* and *L. w. melanoleucus*, and a maximum divergence of 5 % from *L. leucogenys*, *L. illigeri*, *L. tripartitus*, *L. nigricollis nigricollis*, and *L. n. graellsii*. Cruz Lima's saddle-back tamarin is monophyletic and a sister to the monophyletic *L. weddelli* group, and thus satisfies the diagnostic criteria of the phylogenetic species concept. For these reasons, we believe that Cruz Lima's saddle-back tamarin should be considered a distinct species.

### *Leontocebus cruzlimai* (Hershkovitz, 1966)

#### Neotype

INPA-6742, field number RS 33, adult male, skin and skeleton, tissue sample. Collected by Ricardo Sampaio, 28

**Fig. 5** Bayesian phylogenetic analysis and divergence time estimation in BEAST v2.0.2 using the complete mitochondrial DNA cytochrome *b* gene. Numbers at nodes represent estimates of divergence times with highest posterior probability, while bars around each divergence time estimate represent 95 % highest posterior density of the estimate. The taxonomy in the phylogenetic tree follows Matuschek et al. (2011)



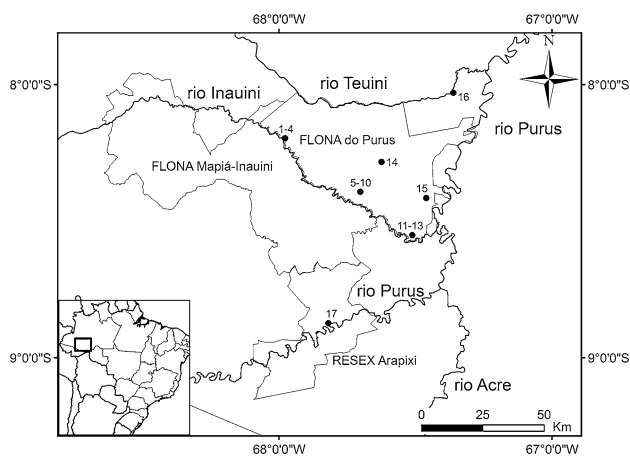
April 2011, left bank of the Rio Inauini, Purus National Forest (FLONA do Purus; 8°11'12.3"S; 67°11'12.3"W; record # 2 (see “Natural History”; Fig. 6).

#### Additional specimens

MPEG-42984, field number RS 40, adult female, skin and skull, tissue sample. Collected by Ricardo Sampaio, 30 June 2011, left bank of the Rio Inauini, Purus National Forest (FLONA do Purus; 8°24'49.8"S; 67°42'31.9"W; record # 7 (see “Natural History”; Fig. 6).

MPEG-42985, field number RS 41, juvenile female, skin and skull, tissue sample. Collected by Ricardo Sampaio, 1 July 2011, left bank of the Rio Inauini, Purus National Forest (FLONA do Purus; 8°24'49.8"S; 67°42'31.9"W; record # 7 (see “Natural History”; Fig. 6).

MPEG-42986, field number RS 43, adult male, skin and skull, tissue sample. Collected by Ricardo Sampaio, 1 July



**Fig. 6** Records of *Leontocebus cruzlimai* in the south of the state of Amazonas, western Brazilian Amazon. The numbers correspond to the localities listed in Table 5. FLONA = Floresta Nacional; RESEX = Reserva Extrativista

2011, left bank of the Rio Inauini, Purus National Forest (FLONA do Purus; 8°24'16.0"S; 67°42'19.4"W; record # 8 (see “Natural History”; Fig. 6).

Type locality: neotype

Vicinity of the Cujuri community (about six families) in the Purus National Forest, left bank of the Rio Inauini (left bank affluent of the middle Rio Purus), municipality of Pauini, Amazonas, Brazil (8°11'12.3"S; 67°11'12.3"W; record # 2 (see “Natural History”; Fig. 6).

Geographic distribution

*Leontocebus cruzlimai* occurs in terra firma forests in the interfluvium of the rios Purus and Juruá, left bank of the middle Rio Purus, municipalities of Pauini and Boca do Acre, in the south of the state of Amazonas, Brazil (Fig. 6). Additional surveys (2013) have shown that its range extends between the rios Teuini and Inauini and south of the Rio Inauini to the left bank of the Purus (8°52'25.6"S, 67°49'08.5"W; Fig. 6). The limits of this tamarin's range, however, remain unclear. It extends to the left (west and north) bank of the Rio Purus; *Leontocebus weddelli* occurs east of the river. Hershkovitz (1977) described *L. fuscicollis primitivus* as occurring on the left (northern) bank of the Rio Pauini, a left bank affluent downstream (to the north) of the Rio Teuini. This would indicate that the Rio Pauini might be the northern limit to the range of *L. cruzlimai*, if not the Teuini. Hershkovitz (1977) suggested that *cruzlimai* occurred north of the Rio Tapauá, north of the range of *L. f. primitivus* (map on page 622). Our findings show that, on the contrary, it occurs to the south of the range of *L. f. primitivus*. To the west, *L. cruzlimai* may occur as far the Rio Tarauacá, a right bank tributary of the upper Rio Juruá. Fábio Röhe observed *L. f. primitivus* north of *L. cruzlimai*, north of the Rio Tarauacá, between the rios Tarauacá and Juruá (see Fig. 3). Preliminary analyses of voucher specimens of these populations reveal morphological, genetic and fur color patterns that require a re-description of this taxon (Röhe et al., in prep.).

The sighting of *L. cruzlimai* on the left bank of the Rio Purus opposite the mouth of the Rio Sepatini reported by T. van Roosmalen (van Roosmalen and van Roosmalen 2003, see Fig. 3) in this case is an anomaly as it is north of the Rio Pauini. As reported by Hershkovitz (1977), the Pauini paratypes of *L. f. primitivus* have a superciliary grayish-white band, which extends to the outer canthus (corner) of the eye; “a greyish crescentic transverse band.” This he considered diagnostic. Hershkovitz (1966) described *L. cruzlimai* as having a “forehead with well-defined whitish transverse band or “eyebrows,” describing accurately the *weddelli*-like chevron in the painting, Plate 38, of Cruz

Lima (1945). The van Roosmalens, on the other hand, used as their guide the unpublished illustration of Goeldi (1907) (shown in van Roosmalen et al., undated), which clearly shows a crescentic transverse band that curves around the eye to the outer canthus (see Figs. 1, 2). The van Roosmalens (2003) also reported that the saddle was less pronounced than in the illustration of *L. f. cruzlimai* (*Midas fuscicollis*, 3a) in Goeldi's (1907) unpublished illustration. The saddle of *L. f. primitivus* is “weakly defined” (Hershkovitz 1977). The possibility is that T. van Roosmalen was in fact looking at what Hershkovitz would have considered to be *L. f. primitivus*. Based on T. van Roosmalen's identification, however, van Roosmalen et al. (undated) plotted distributions that have *L. cruzlimai* between the rios Tapauá and Pauini, extending west to the Rio Juruá, and *L. f. primitivus* to the south of it, south of the Pauini, extending west to the Rio Tarauacá—a supposition belied by our findings. Further research is needed to clarify the distributions of these two tamarins, and the variation in their coloration over their respective ranges.

Diagnostic characters

The diagnostic characters include a trizonal coloration of the back, typical of the saddle-back tamarins (black, white/beige, and rusty reddish-orange), reasonably well-defined, and which extends from the crown to the saddle; grayish-white hairs around the mouth, and a white transverse band above the eyes which extends around the eyes to just below the outer canthus; crown, mantle, ventrum, arms and legs orangey-rusty red, with the upper hands and feet tending to be more blackish than red (Fig. 7).



Fig. 7 *Leontocebus cruzlimai*. Illustration © Stephen D. Nash



## Description of the neotype

Coloration of the crown and dorsum is trizonal; crown, mantle, arms and hind legs a rusty-reddish orange; thorax and abdomen orangey-red, becoming rather paler in the abdominal region; upper surface of the hands and feet orangey red, with a slightly more blackish tone from the wrists and ankles than that of the arms and legs; tail is black, except at the base, which is mottled black and reddish brown similar to the posterior portion of the saddle; the forehead is dark brown, with a wide, white, well-defined transverse band (chevron) that extends around the eyes to the outer canthus; the sides of the face have sparse dark brown hairs, which are redder and longer around the ears, throat, and behind the throat; the hairs of the muzzle are grizzled, grayish white around the mouth and nose; facial vibrissae are present; ears are black, with sparse dark brown hair; the saddle is mottled black and yellowish brown on the anterior two-thirds, beginning in the scapular region, with the mottling gradually getting redder in the posterior third of the back and down the outer surfaces of the thighs and onto the dorsal surface of the base of the tail; the hairs are black at their base and the apical portion is yellowish or reddish brown; the coloration of the flanks is similar to that of the saddle.

## Morphological variation

Pictures of vouchers taken in the field and the prepared skins of specimens of *L. cruzlimai* were used to do a preliminary analysis of morphological variation in this taxon. Characters related to coloration of the pelage are effectively identical. Specimens MPEG-42984, 42985 and 42986 are very similar to the neotype, with almost imperceptible differences in the extent of the saddle, in the

coloration of the circumbuccal area, and in the reddish-orange tones of the dorsum and ventrum.

## Chromatic differences and similarities compared with neighboring taxa

*Leontocebus cruzlimai* differs from its neighboring saddle-back tamarins (*L. fuscicollis avilapirensi*, *L. f. primitivus*, *L. f. mura*, *L. weddelli weddelli*, and *L. w. melanoleucus*) by its exclusive combination of pelage colors, mainly the rusty-reddish orange of the crown, mantle and arms. *Leontocebus w. melanoleucus* is entirely white. *L. cruzlimai* is similar to *L. f. mura* and *L. w. weddelli* in the color of the rump and legs; to *L. w. weddelli* and *L. f. primitivus* in the large and well-defined white chevron above the eyes; and to *L. f. avilapirensi* and *L. f. primitivus* in the tail color.

## Morphometric differences from neighboring taxa

Some specific external measurements were collected from the *L. cruzlimai* vouchers in the field and their variation was compared with the measurements of the five neighboring saddle-back tamarins (*L. f. avilapirensi*, *L. f. primitivus*, *L. f. mura*, *L. w. weddelli*, and *L. w. melanoleucus*; see Table 2). This analysis reveals that the body and feet of *L. cruzlimai* are a little longer. Tail length, however, is shorter, and the ear a little larger than in the other saddle-back tamarins, except for *L. f. mura*. Regarding body weight, *L. cruzlimai* is more robust than all except for *L. w. melanoleucus*, even though all the specimens were collected between April and July, the beginning of dry season, when fruit abundance tends to be at its lowest during the year. During this time, tamarins tend to lose weight (Röhe et al. 2009).

**Table 2** External measurements of *Leontocebus cruzlimai*, *L. f. avilapirensi*, *L. f. primitivus*, *L. f. mura*, *L. w. weddelli* and *L. w. melanoleucus*

	H and B (mm)	Tail (mm)	Hindfoot (mm)	Ear (mm)	Mass (g)
<i>L. cruzlimai</i> , mean ( $n = 4$ )	251.5	296.25	72.5	33.5	390.75
<i>L. f. avilapirensi</i> , mean ( $n = 2;2;1$ ) <sup>a</sup>	245	307.5	65	–	–
<i>L. f. primitivus</i> ( $n = 4$ ) <sup>b</sup>	227.5	321.3	63.8	20.6	–
<i>L. f. mura</i> , mean ( $n = 5$ ) <sup>c</sup>	237.8	318.2	67.2	34.2	311.8
<i>L. w. weddelli</i> , mean ( $n = 18$ ) <sup>c</sup>	212.9	308.1	62.7	26.5	341.7
<i>L. w. melanoleucus</i> , mean ( $n = 7$ ) <sup>d</sup>	249.8	338.0	65.9	27.4	412.5

<sup>a</sup> Hershkovitz (1977; Appendix, Table 2.  $n$  number of specimens measured for H and B; Tail; Hindfoot)

<sup>b</sup> Hershkovitz (1977; page 1023); FR 54

<sup>c</sup> Röhe et al. (2009)

<sup>d</sup> RS 17; collected by Ricardo Sampaio, Rio Gregório, Amazonas; MPEG 22944; MPEG 750; MPEG 22945; MPEG 22946; MPEG 21845; MPEG 21843

*Leontocebus cruzlimai* did not overlap with *L. f. avilapirensi* in three of the five cranial measurements (Tables 3 and 4). The condylobasal length, zygomatic breadth and the orbital breadth were all larger in *L. cruzlimai*. Comparing *L. cruzlimai* and *L. f. primitivus*, the orbital distance, interorbital distance, length of upper canine, height of the articular process, width of the mandibular ramus, gnathic index and the three palate measures (length a, b and width) were larger in *L. cruzlimai*. The height of the articular process, the width of the mandibular ramus, the gnathic index, the nasal-prosthion

distance (NPRa), the palate (length b) and the palate width were larger in *L. f. primitivus*. Comparing *L. cruzlimai* and *L. w. weddelli*, condylobasal length, gnathic index, the length of the mandibular condyle, and the palate (lengths a and b) were larger in *L. cruzlimai*. Between *L. cruzlimai* and *L. f. mura*, condylobasal length, zygomatic breadth, orbital breadth, interorbital distance, length of the upper molar + canine tooth row, distance between the lateral surfaces of the mandibular condyles, the breadth of mandibular condyle, and the distance between the medial surfaces of the mandibular condyles were larger in *L.*

**Table 3** Thirty-six cranial measurements of four specimens of *Leontocebus cruzlimai*: RS 33, adult male (neotype); RS 43, adult male (paratype); RS 40, adult female (paratype); RS 41, juvenile female (paratype)

Characters	RS 33	RS 43	RS 40	RS 41	
Cranium length (distance prosthion-opisthocranial)	46.68	47.84	46.82	40.63	
Condylobasal length	37.95	38.88	38.30	37.63	
Zygomatic breadth	32.09	33.36	31.21	31.08	
Brain case width	27.04	26.82	25.15	24.35	
Orbital width	26.75	25.53	25.78	25.62	
Interorbital distance	5.37	5.57	5.63	5.19	
Width across upper molars	15.89	15.86	15.41	15.42	
Length of mandible—mandibular length	31.32	30.87	28.67	28.93	
Height of articular process	—	18.79	16.20	16.38	
Length of upper molar series	8.32	8.95	8.05	8.32	
Width across upper canines	14.61	13.44	14.26	13.70	
Length of upper molar series including canines	11.07	11.62	10.94	10.73	
Mandibular ramus (width)	11.31	11.57	10.72	10.52	
Width across lower molars	13.72	14.06	13.51	13.19	
Gnathic index	—	9.27	8.97	8.58	
Width between lateral surfaces of mandibular condyles	27.64	28.44	27.87	26.68	
Width between coronoids	26.56	27.22	24.47	23.21	
Mandibular condyle (width)	4.49	4.21	4.16	4.18	
Lower canine (width)	10.79	8.37	9.26	8.38	
Width between medial surfaces of mandibular condyles	19.80	20.16	20.24	18.71	
Nasal-prosthion distance (NPRa)	15.77	14.94	15.01	14.25	
Nasal-prosthion distance (NPRb)	7.24	7.58	7.50	7.72	
Nasal-opisthocranial distance	43.52	42.68	41.96	40.34	
Cranium height	23.89	24.85	22.98	22.78	
Nasal width	5.93	5.16	5.47	5.44	
Upper canine	6.16	6.00	5.82	5.91	
Palate (length) (PALb)	11.70	11.38	11.51	11.41	
Palate (length) (PALa)	—	15.39	15.78	15.09	
Palate (width)	11.18	11.00	10.39	10.42	
Orbit height	10.06	10.94	10.76	10.92	
Palate (length a)— total length between the front of the two incisor teeth to the back edge of the palatal spine, at the medial line of the palate. Palate (length b)— total length between the incisive foramen to the back edge of the palatal spine, at the medial line of the palate	Pterion-pterion distance	21.25	23.22	22.58	22.79
	Coronoid height	18.18	19.14	17.72	17.45
	Lower molar series (length)	10.17	10.50	10.11	10.15
	Foramen magnum (width)	6.78	7.10	7.20	6.76
	Foramen magnum (length)	6.12	6.74	6.48	6.42
	Width between occipital condyles	10.34	11.27	11.14	10.50
	Brain case length	42.13	43.42	42.09	40.63

**Table 4** Cranial measurements of *Leontocebus cruzlimai*, *L. f. primitivus*, *L. f. avilapiresti*, *L. w. weddelli* and *L. f. mura*

Characters	<i>Saguinus cruzlimai</i>				<i>Saguinus f. avilapiresti</i>				<i>S. f. primitivus</i>				<i>Saguinus w. weddelli</i>				<i>Saguinus f. mura</i>								
	Mean	Min.	Max.	SD	N	Mean	Min.	Max.	SD	N	Mean	Min.	Max.	SD	N	Mean	Min.	Max.	SD	N					
Cranium length (distance prosthion-opistocranial)	45.49	40.63	47.84	3.28	4	46.8	46.3	47.5	0.509	4	44.73	40.1	47.1	3.2	4	44.47	39.47	46.05	1.92	15	44.67	43.63	45.71	0.91	5
Condylbasal breadth	38.19	37.63	38.88	0.54	4	37.2	36.3	37.6	0.860	4	37.07	35.2	38.38	1.39	4	36.04	34.5	37.09	0.82	14	35.82	34.77	37.17	1.01	5
Zygomatic breadth	31.93	31.08	33.36	1.05	4	29.0	27.0	30.4	1.184	4	29.61	25.9	32.64	2.79	4	31.15	28.77	32.22	1.04	15	29.13	28.26	30.28	0.78	5
Brain case width	25.84	24.35	27.04	1.30	4	24.9	24.3	25.8	0.238	4	26.24	24.8	27.7	1.23	4	25.99	25.14	27.15	0.52	15	25.29	24.51	25.99	0.59	5
Orbital width	25.92	25.53	26.75	0.56	4	25.0	24.7	25.2	0.675	4	23.96	22.8	25.33	1.08	4	24.99	23.41	26.06	0.80	15	23.47	23.02	24.14	0.42	5
Interorbital distance	5.44	5.19	5.63	0.20	4	-	-	-	-	-	5.64	-	-	-	1	5.31	4.84	5.87	0.31	15	4.75	4.13	5.1	0.41	5
Width across upper molars	15.64	15.41	15.89	0.26	4	-	-	-	-	-	15.37	14.8	16.19	0.62	4	15.44	14.52	15.96	0.38	15	15.11	14.92	15.32	0.17	4
Length of mandible	29.94	28.67	31.32	1.34	4	-	-	-	-	-	28.66	26.9	31.62	2.07	4	28.93	27.57	30.11	0.80	15	28.38	27.28	28.91	0.69	5
Height of articular process	17.12	16.2	18.79	1.45	3	-	-	-	-	-	20.06	-	-	-	1	17.42	15.77	18.4	0.84	15	17.19	16.04	18.03	0.83	5
Length of upper molar series	8.41	8.05	8.95	0.38	4	-	-	-	-	-	8.42	-	-	-	1	8.49	8.03	8.95	0.27	15	8.13	7.93	8.32	0.15	5
Width across upper canines	14.00	13.44	14.61	0.53	4	-	-	-	-	-	14.33	-	-	-	1	13.17	11.8	13.79	0.52	15	13.46	13.14	13.77	0.26	4
Length of upper molar series including canines	11.09	10.73	11.62	0.38	4	-	-	-	-	-	10.92	-	-	-	1	10.88	10.56	11.44	0.25	15	10.54	10.32	10.7	0.20	5
Mandibular ramus (width)	11.03	10.52	11.57	0.49	4	-	-	-	-	-	11.7	-	-	-	1	10.43	9.99	10.72	0.28	5	10.88	10.59	11.12	0.24	5
Width across lower molars	13.62	13.19	14.06	0.36	4	-	-	-	-	-	-	-	-	-	-	13.15	12.62	13.79	0.46	5	12.97	12.77	13.26	0.19	5
Gnathic index	8.94	8.58	9.27	0.34	3	-	-	-	-	-	9.45	-	-	-	1	8.24	7.99	8.5	0.24	5	9.15	8.64	9.57	0.34	5
Width between lateral surfaces of mandibular condyles	27.65	26.68	28.44	0.73	4	-	-	-	-	-	-	-	-	-	-	26.45	26.2	26.74	0.24	5	25.27	24.78	25.76	0.40	5
Width between coronoids	25.36	23.21	27.22	1.85	4	-	-	-	-	-	-	-	-	-	-	24.89	23.64	26.4	1.31	5	24.50	23.56	25.02	0.57	5
Mandibular condyle (width)	4.26	4.16	4.49	0.15	4	-	-	-	-	-	4.27	-	-	-	1	3.88	3.5	4.13	0.24	5	3.79	3.69	3.88	0.07	5
Lower canine (width)	9.20	8.37	10.79	1.14	4	-	-	-	-	-	8.62	-	-	-	1	8.13	7.89	8.33	0.16	5	8.47	8.37	8.57	0.08	5
Width between medial surfaces of mandibular condyles	19.72	18.71	20.24	0.70	4	-	-	-	-	-	-	-	-	-	-	18.99	18.71	19.24	0.26	5	18	17.39	18.28	0.36	5
Nasal-prosthion (NPRa)	14.99	14.25	15.77	0.62	4	-	-	-	-	-	15.68	-	-	-	1	14.14	13.82	14.8	0.40	5	13.89	13.29	15.11	0.80	5
Nasal-prosthion (NPRb)	7.51	7.24	7.72	0.20	4	-	-	-	-	-	8.73	-	-	-	1	7.8	6.85	8.55	0.62	5	7.31	6.84	7.8	0.37	5

Table 4 continued

Characters	<i>Saguinus cruzlimai</i>			<i>Saguinus f. avilapiresi</i>			<i>S. f. primitivus</i>			<i>Saguinus w. weddelli</i>			<i>Saguinus f. mura</i>									
	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.							
Nasal-opisthocranial (NOPa)	42.12	40.34	43.52	1.35	4	-	-	-	-	41.37	-	-	40.14	39.17	40.89	0.83	5	40.15	39.26	40.86	0.64	5
Cranium height	23.62	22.78	24.85	0.95	4	-	-	-	-	23.14	-	-	23.21	22.78	23.8	0.43	5	22.54	21.62	23.34	0.64	5
Nasal width	5.50	5.16	5.93	0.32	4	-	-	-	-	5.45	-	-	5.37	4.91	5.93	0.42	5	5.19	4.91	5.65	0.32	5
Upper canine (length)	5.97	5.82	6.16	0.14	4	-	-	-	-	5.23	-	-	5.92	5.56	6.1	0.22	5	5.57	5.14	5.86	0.29	5
Palate (length a)	11.50	11.38	11.7	0.14	3	-	-	-	-	10.78	-	-	10.51	10.11	10.75	0.26	5	11.11	10.71	11.86	0.47	5
Palate (length b)	15.42	15.09	15.78	0.35	4	-	-	-	-	16.00	-	-	14.14	13.69	14.63	0.38	5	15.44	14.67	15.96	0.51	5
Palate (width)	10.74	10.39	11.18	0.40	4	-	-	-	-	11.68	-	-	10.89	10.44	11.83	0.58	5	10.38	10.02	10.63	0.26	4
Orbit height	10.67	10.06	10.94	0.41	4	-	-	-	-	10.5	-	-	10.41	9.73	10.76	0.40	5	10.23	9.93	10.58	0.36	4
Pterion-pterion distance	22.46	21.25	23.22	0.85	4	-	-	-	-	22.65	-	-	22.32	21.83	22.98	0.42	5	21.54	21.39	21.97	0.25	5

Palate (length a) — total length between the front of the two incisor teeth to the back edge of the palatal spine, at the medial line of palate. Palate (length b) — total length between the incisive foramen to the back edge of the palatal spine, at the medial line of palate

*cruzlimai*. Comparing *L. cruzlimai* with *L. w. melanoleucus*, the distance between the medial surfaces of the mandibular condyles was larger in *L. w. melanoleucus*; otherwise the two tamarins were similar.

### Vernacular name

In English, Cruz Lima's saddle-back tamarin (as per Herzhkovitz 1977). In Brazil where it occurs, local people refer to it as "sauím" and "sauím-vermelho" or "soim-vermelho."

### Natural history

In 2011, we carried out surveys on 5-km-long, straight paths using the linear transect method of Buckland et al. (1993; also Peres 1999), at three sites on the left bank of the Rio Inauni, Purus National Forest, municipality of Pauini, Amazonas (see Fig. 6). The total distance walked was 120 km. We counted 73 tamarins in 13 groups — 6.08 individuals/10 km. It was the primate we recorded most during the surveys (R. Sampaio, unpubl.). We also saw *L. cruzlimai* on four occasions in other localities. We saw two groups in 2012, in the Purus National Forest, in Vila Céu do Mapiá, and at Igarapé Mapiá (*igarapé* = creek). The third was in 2013, on the left bank of the Rio Teuini, near the Purus National Forest; seen during a brief primate survey in the area. The fourth was in November 2013, during a primate survey in the Arapixi Extractivist Reserve (RESEX Arapixi), on the left bank of the Rio Purus, municipality of Boca do Acre, Amazonas (see Fig. 6; Table 5).

Seventeen groups, totaling 90 individuals, were seen in terra firme forest (*Floresta Ombrófila Densa Submontana* in the management plans of the Purus National Forest and the Arapixi Extractivist Reserve) and just one group, of three individuals, was found in lower (<25 m), inundated forest [*várzea* (white-water inundated forest); *Floresta Ombrófila Densa Aluvial* in the management plan of the Purus National Forest] (Table 5). There are patches of vegetation dominated by bamboo (*Guadua* sp.; known locally as *tabocal*) throughout these two forest types. Although never observed there, it is quite possible that the tamarins use these patches of dense bamboo.

On ten occasions we observed *L. cruzlimai* travelling with the red-cap moustached tamarins, *Saguinus mystax pileatus* (Table 5). The formation of mixed-species groups between saddle-back tamarins and members of the larger moustached tamarins is typical wherever the species' ranges overlap (Heymann and Buchanan-Smith 2000).

*Leontocebus cruzlimai* is evidently the most abundant of the primates in the terra firme forests of the region. The IUCN Red List has this species categorized as Least



**Table 5** Records of *Leontocebus cruzlimai* in the south of the state of Amazonas, Brazil. The number indicates the locality shown on the map (Fig. 3)

Record	No. of individuals	Mixed species group <sup>a</sup>	Forest type	Latitude (S)	Longitude (W)
1	>5	Yes	Terra Firme	8°11'47.9"	67°58'38.9"
2	>10	Yes	Terra Firme	8°11'12.3"	67°58'28.3"
3	>6	Yes	Terra Firme	8°09'45.8"	67°58'07.8"
4	>10	No	Terra Firme	8°11'47.9"	67°58'38.9"
5	1	No	Terra Firme	8°23'35.5"	67°42'07.0"
6	12	Yes	Terra Firme	8°25'18.4"	67°42'43.2"
7	6	Yes	Terra Firme	8°24'49.8"	67°42'31.9"
8	6	No	Terra Firme	8°24'16.0"	67°42'19.4"
9	>6	No	Terra Firme	8°25'42.2"	67°42'54.3"
10	6	No	Terra Firme	8°23'43.9"	67°42'09.5"
11	1	Yes	Terra Firme	8°33'06.3"	67°30'41.0"
12	1	No	Terra Firme	8°33'35.6"	67°31'04.3"
13	3	Yes	Várzea <sup>b</sup>	8°33'29.2"	67°31'00.3"
14	>6	Yes	Terra Firme	8°17'01.2"	67°37'26.7"
15	>5	Yes	Terra Firme	8°24'57"	67°27'37"
16	1	Yes	Terra Firme	8°01'48.9"	67°21'39.9"
17	3	No	Terra Firme	8°52'25.6"	67°49'08.5"

<sup>a</sup> Mixed-species group with *Saguinus mystax pileatus*

<sup>b</sup> Várzea = white-water inundated forest

Concern (Rylands and Mittermeier 2008a), but it is considered Data Deficient for the Brazilian Red List (Brazil MMA 2014). It was believed, following Hershkovitz (1977), that it occurred north of the Rio Tapauá, and there the forests of the region are not yet threatened by cattle-farming, industrial agricultural plantations, or dams. These tamarins evidently tolerate disturbed and second-growth forest, and are not hunted. The same is true of the middle Purus south of the Rio Tapauá.

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## References

- Brazil MMA (2014) Portaria No. 444, 445, de 17 de dezembro de 2014. Diário Oficial da União—Seção 1 (245):110–130. Ministério do Meio Ambiente (MMA), Brasília. <http://pesquisa.in.gov.br/imprensa/jsp/visualiza/index.jsp?data=18/12/2014&jornal=1&pagina=110&totalArquivos=144>
- Buckland ST, Anderson DR, Burnham KP, Laake JL (1993) Distance sampling: estimating abundance of biological populations. Chapman and Hall, London
- Buckner JC, Lynch Alfaro J, Rylands AB, Alfaro ME (2015) Biogeography of the marmosets and tamarins (Callitrichidae). *Mol Phylogenet Evol* 82:413–425
- Canavez FC, Moreira MAM, Simon F, Parham P, Seuánez HN (1999) Phylogenetic relationships of the Callitrichinae (Platyrrhini, Primates) based on  $\beta_2$ -microglobulin DNA sequences. *Am J Primatol* 48:225–236
- Cheverud JM, Moore AJ (1990) Subspecific variation in the saddle-back tamarin (*Saguinus fuscicollis*). *Am J Primatol* 21:1–15
- Cropp SJ, Larson A, Cheverud JM (1999) Historical biogeography of tamarins, genus *Saguinus*: the molecular phylogenetic evidence. *Am J Phys Anthropol* 108:65–89

- Cruz Lima E da (1945) Mammals of Amazonia. Volume 1. General introduction and primates. Museu Paraense Emílio Goeldi de História Natural e Etnografia, Rio de Janeiro
- Drummond AJ, Rambaut A (2007) BEAST: Bayesian evolutionary analysis by sampling trees. *BMC Evol Biol* 7:214
- Goeldi EA (1907) On some new and insufficiently known species of marmoset monkeys from the Amazonian region. *Proc Zool Soc Lond* 77(1):88–99
- Goodman M, Porter CA, Czelusniak J, Page SL, Schneider H, Shoshani J, Gunnell G, Groves CP (1998) Toward a phylogenetic classification of primates based on DNA evidence complemented by fossil evidence. *Mol Phylogenet Evol* 9:585–598
- Groves CP (2001) Primate taxonomy. Smithsonian Institution Press, Washington
- Groves CP (2005) Order primates. In: Wilson DE, Reeder DM (eds) *Mammal species of the world: a taxonomic and geographic reference*, 3rd edn. The Johns Hopkins University Press, Baltimore
- Hershkovitz P (1949) Mammals of northern Colombia. Preliminary report No. 4: Monkeys (Primates), with taxonomic revisions of some forms. *Proc US Nat Mus* 98:323–427
- Hershkovitz P (1957) The systematic position of the marmoset, *Simia leonina* Humboldt (Primates). *Proc Biol Soc Wash* 70:17–20
- Hershkovitz P (1966) Taxonomic notes on tamarins, genus *Saguinus* (Callitrichidae, Primates), with descriptions of four new forms. *Folia Primatol* 4:381–395
- Hershkovitz P (1968) Metachromism or the principle of evolutionary change in mammalian tegumentary colors. *Evolution* 22:556–575
- Hershkovitz P (1977) Living New World monkeys, with an introduction to primates, vol 1. Chicago University Press, Chicago
- Hershkovitz P (1982) Subspecies and geographic distribution of black-mantle tamarins *Saguinus nigricollis* Spix (Primates: Callitrichidae). *Proc Biol Soc Wash* 95:647–656
- Heymann EW, Buchanan-Smith HM (2000) The behavioural ecology of mixed-species troops of callitrichine primates. *Biol Rev* 75:169–190
- Matauschek C (2010) Taxonomy, phylogeny and distribution of tamarins (genus *Saguinus* Hoffmannsegg, 1807). Doctoral dissertation, Georg-August Universität, Göttingen
- Matauschek C, Roos C, Heymann EW (2011) Mitochondrial phylogeny of tamarins (*Saguinus* Hoffmannsegg, 1807) with taxonomic and biogeographic implications for the *S. nigricollis* species group. *Am J Phys Anthropol* 144:564–574
- Peres CA (1999) General guidelines for standardizing line-transect surveys of Tropical Forest Primates. *Neotrop Primates* 7:11–16
- Peres CA, Patton JL, da Silva MNF (1996) Riverine barriers and gene flow in Amazonian saddle-back tamarins. *Folia Primatol* 67:113–124
- Röhe F, Silva-Júnior JS, Sampaio R, Rylands AB (2009) A new subspecies of *Saguinus fuscicollis* (Primates, Callitrichidae). *Int J Primatol* 30:533–551
- Rylands AB, Mittermeier RA (2008a) *Saguinus fuscicollis* ssp. *cruzlimai*. In: IUCN 2013. IUCN red list of threatened species. Version 2013.2. URL: <<http://www.iucnredlist.org>>. Downloaded on 10 May 2014
- Rylands AB, Mittermeier RA (2008b) The diversity of the New World primates: 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, New York, pp 23–54
- Rylands AB, Mittermeier RA (2013) Family Callitrichidae (marmosets and tamarins). In: Mittermeier RA, Rylands AB, Wilson DE (eds) *Handbook of the mammals of the world*, vol 3., *Primates* Lynx Edicions, Barcelona, pp 262–346
- Rylands AB, Schneider H, Langguth A, Mittermeier RA, Groves CP, Rodríguez-Luna E (2000) An assessment of the diversity of New World primates. *Neotrop Primates* 8:61–93
- Rylands AB, Matauschek C, Aquino R, Encarnación F, Heymann EW, de la Torre S, Mittermeier RA (2011) The range of the golden-mantle tamarin, *Saguinus tripartitus* (Milne Edwards, 1878): distributions and sympatry of four tamarins in Colombia, Ecuador, and northern Peru. *Primates* 52:25–39
- Rylands AB, Mittermeier RA, Silva-Júnior JS (2012) Neotropical primates: taxonomy and recently described species and subspecies. *Int Zoo Yearb* 46:11–24
- Sambrook J, Fritsch EF, Maniatis T (1989) *Molecular cloning: a laboratory manual*, vol. I, 2nd edn. Cold Spring Harbor Laboratory Press
- Tagliaro CH, Schneider H, Sampaio I, Schneider MPC, Vallinoto M, Stanhope M (2005) Molecular phylogeny of the genus *Saguinus* (Platyrrhini, Primates) based on the ND1 mitochondrial gene and implications for conservation. *Genet Mol Biol* 28:46–53
- Thompson JD, Higgins DG, Gibson TJ (1994) CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. *Nucl Acids Res* 22:4673–4680
- Thorington RW Jr (1988) Taxonomic status of *Saguinus tripartitus* (Milne-Edwards, 1878). *Am J Primatol* 15:367–371
- Van Roosmalen T, van Roosmalen, MGM (2003) Note on *Saguinus (fuscicollis) cruzlimai* (Callitrichinae)—Cruz Lima's saddleback tamarin. Website: New species from Amazonia. URL: <<http://www.amazonnewspecies.com>>. Dated 16 August 2003. Accessed 26 September 2003
- Van Roosmalen MGM, Nash SD, Gozzaglio P (undated) *Distributions and phylogeography of Neotropical primates: a pictorial guide to all known New-World monkeys*. E-book. Published privately. p 69