

Distribution and New Sightings of Goeldi's Monkey (*Callimico goeldii*) in Amazonian Perú

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Abstract There is a general consensus on the geographic distributions of many primate species; however, the continuity and validity of species range maps are often inaccurate on a local scale. In the case of rare and cryptic species, census methodology is often insufficiently rigorous or specialized, resulting in probable false negatives. *Callimico goeldii* is a rare primate, with most of its geographical range purported to lie in Perú. We evaluate the accuracy of its predicted geographic range within Perú with an assessment of mammal surveys over the last 40 yr and the inclusion of new sightings from three sites. We found that of all 340 study sites, only 10.9 % indicate that this species is present, and only 51 % of these sites receive any government protection. The Sierra del Divisor Reserve Zone and the Rodal Tahuamanu Conservation Concession have the highest estimated densities of *Callimico goeldii*. We suggest using focal follows of sympatric tamarins and vocalization playbacks rather than traditional line transects to improve the likelihood of locating this species. Although the current range maps based on the available data are likely an exaggeration of the species' true range, the inherent imperfections of standard census methodology when applied to rare and cryptic species can lead to underrepresentative range maps as well. For these reasons, it is clear that the current

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distribution map for *Callimico goeldii* is imprecise, and until its distribution is reassessed, its conservation status cannot be confirmed.

Keywords Amazonian Perú · *Callimico goeldii* · Distribution · Conservation

Introduction

Accurate evaluations of the geographic distribution, population abundances, and densities of a species are critical to assessment of its conservation status. Although distribution maps of most mammal species are easily accessible (NatureServe: Patterson *et al.* 2007; IUCN Redlist: Schipper *et al.* 2008), the quantity and quality of the data on which the maps are based cannot be evaluated directly. Species range maps often disregard local habitat variation and other factors that affect actual occurrence of a species (Hurlbert and White 2007; Palminteri *et al.* 2009), and because of their broad scale, these maps often overestimate species' ranges (Schipper *et al.* 2008, supplementary material). There are potential challenges in estimating the geographical range of any species; however, inaccuracies may be more likely when observers are unfamiliar with a species, especially for cryptic or rare taxa. Such species are less likely to be observed in studies using standard survey methods, while reliable sightings may be opportunistic and not formally reported (Hurlbert and White 2007). As a result, distributions of rare or cryptic species are frequently estimated from observations spanning decades, and may not reflect their current ranges, affecting our understanding of their conservation status.

Customary survey methods are generally effective for recording the occurrence of diurnal South American primates, with some possible exceptions. Certain species may have low densities or avoid observers as a direct result of human activities, e.g., *Lagothrix* in response to hunting pressure (Peres 2000). For the pygmy marmoset (*Cebuella pygmaea*) and the callimico or Goeldi's monkey (*Callimico goeldii*), infrequent sightings are likely due to their naturally patchy distributions (Emmons and Feer 1997), habitat specificity (Porter 2004), and cryptic behavior and appearances (Castro *et al.* 1990).

Callimico goeldii is a monotypic taxon in the family Callitrichidae (Groves 2001). Although it shares many characteristics with other callitrichids, such as its small body size and claw-like nails, *Callimico goeldii* retains its third molar, and has singleton births, unlike most other habitually twinning callitrichids (Dettling and Pryce 1999; Hershkovitz 1977). It inhabits the western Amazonian basin of Perú, Brazil, Colombia, and Bolivia (Emmons and Feer 1997). Although there are multiple reports of *Callimico goeldii* in Colombia and Perú (Aquino and Encarnación 1994; Encarnación and Heymann 1998; Leite Pitman *et al.* 2003), it has been the focus of study only at sites in Pando, Bolivia and Acre, Brazil (Porter and Garber 2004; as reviewed in Porter and Garber 2010; Rehg 2007). The occurrence of *Callimico goeldii* throughout this region appears patchy, so assumptions about its presence at particular sites may not be reliable.

Since its description by Emilio Goeldi in 1904, *Callimico goeldii* has been bred successfully and studied in captivity (Altmann *et al.* 1988; Dettling and Pryce 1999; Nuss and Warneke 2010; Power *et al.* 2003; Schradin and Anzenberger 2001). Its

behavior and ecology have been challenging to study in the field because it is cryptic, disappearing quietly into dense undergrowth when disturbed (Castro *et al.* 1990; Christen and Geissmann 1994). Local human populations are often unaware of its existence, and in some regions of Perú it has no common name (Castro *et al.* 1990; Pook and Pook 1981; Soini 1972; M. Watsa *pers. obs.*). Large home ranges (50–150 ha; Porter *et al.* 2007; Rehg 2009), which are discontinuous at some sites, are linked to low population densities, contributing to the difficulty of detecting this species with standard transect surveys.

Hundreds of sites in Perú have been the focus of intensive faunal surveys, as well as rapid biological inventories, which inform determinations of protection levels for various areas within the country. Accurate data on animal populations, in particular taxa that may be rare or endangered at these sites, have practical and important consequences. *Callimico goeldii* is listed on Appendix I of CITES, and classified as Vulnerable on the IUCN Red List owing to its declining numbers (Cornejo 2008; Heymann 2004; INRENA 2004). According to Cornejo (2008), the only government protected area in Perú with a documented population of *Callimico goeldii* is the Manu National Park (Terborgh 1983). A more detailed understanding of its geographic distribution is necessary for local or regional conservation action for this species. A review of surveys conducted at multiple sites, over a long period, can decrease the likelihood that *Callimico goeldii* might go undetected in areas where it does exist, or that population sizes will be overestimated from erroneously assuming a continuous distribution across its range.

We here report on new observations of *Callimico goeldii* at three sites in Perú and summarize records of its occurrence in Perú in published and unpublished mammal surveys. We verify its presence at locations included in its acknowledged range that were based on earlier observations, and evaluate the species range map (Patterson *et al.* 2007; Schipper *et al.* 2008) on a smaller scale. Given this review, we consider the implications of assuming a continuous distribution in assessing conservation status, and the efficacy of standard, mammal transect surveys as a method to detect this species.

Methods

Published Reports of *Callimico goeldii*

We reviewed mammal and primate surveys in Perú for records of *Callimico goeldii*, including the reports of the Rapid Biological Inventories of the Chicago Field Museum of Natural History (RBI 2002), the Rapid Assessment Program of Conservation International (RAP 2011), and articles in international and Peruvian journals. Study sites and survey locations were plotted on a map of Perú, along with protected areas and buffer zones (Josse *et al.* 2007; SINANPE 2011a) and the current projected distribution of *Callimico goeldii* (Patterson *et al.* 2007; Schipper *et al.* 2008) (Fig. 1; Table I). Although studies differed in their methodologies, we extracted the following data whenever possible, whether *Callimico goeldii* was recorded or not: location coordinates; description of site location with respect to landmarks such as nearby water bodies; recorded presence of *C. goeldii*; nature of observation, e.g., capture, focal follow, vocalization, brief sighting of free-ranging individuals, or

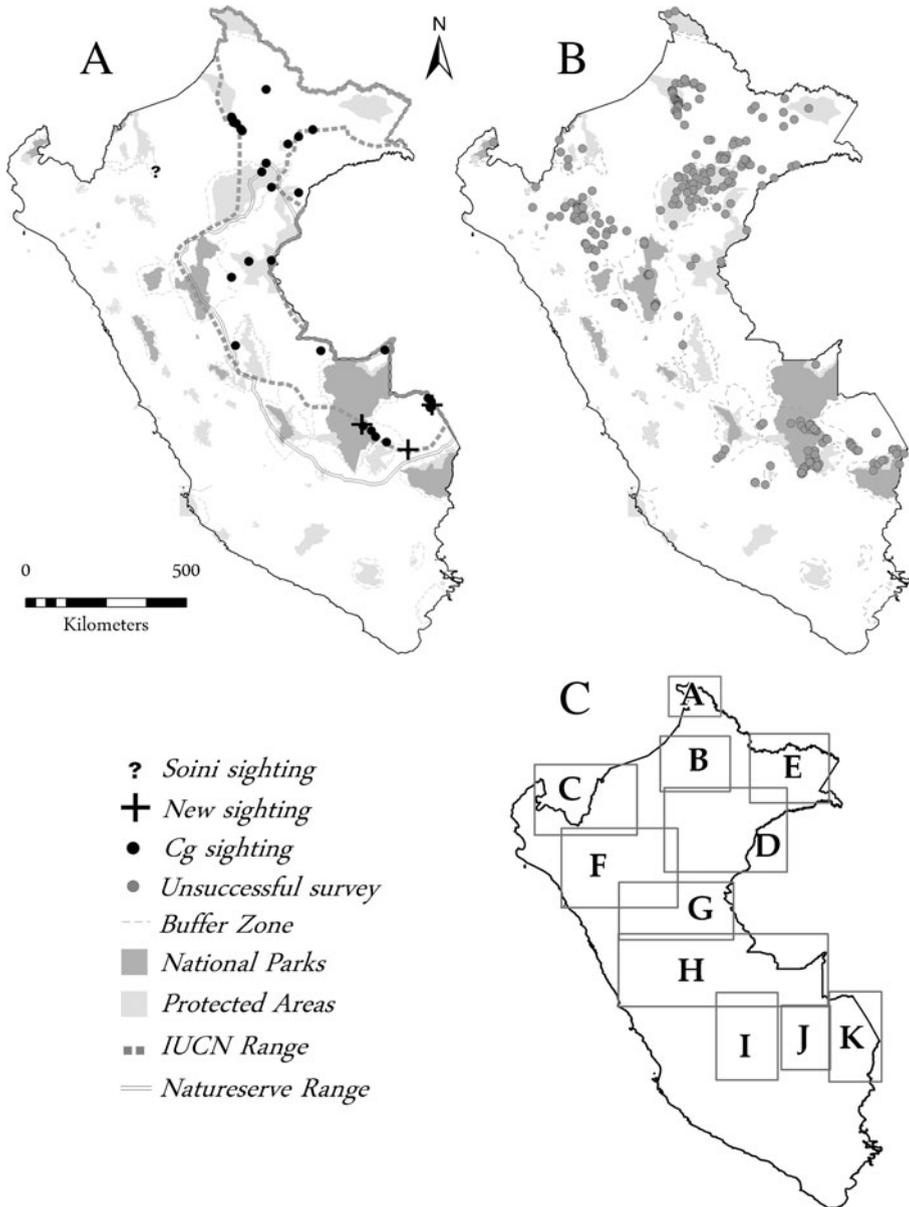


Fig. 1 Map of Perú with distribution of surveyed sites. Map A: Sites with *Callimico goeldii* overlaid with the species distribution polygon of Natureserve (Patterson *et al.* 2007) and the IUCN (Schipper *et al.* 2008), as well as the protected areas of Perú. Map B: Sites without observations of *Callimico goeldii* overlaid with the protected areas of Perú. *SoiRAP*, a reported observation by Pekka Soini in 1972, with published coordinates that appear to be incorrect, is marked with a question mark. Sites reported for the first time in this publication to have *Callimico goeldii* are distinguished from other known sites with *C. goeldii*. Map C: Key to detailed maps represented in Fig. 2.

observation in captivity in local communities; and the duration and intensity of the survey, measured as the number of days surveyed or the survey transect length or

Table 1 Categories of national protected areas in Perú

Type	N ^a	Characteristics	General protection ^b
Private conservation areas	38	Community-managed areas with governmental support	Community permitted to use the land to improve living standards
National reserves	15	Areas for biodiversity conservation and sustainable use of resources	Exploitation of wildlife resources allowed under management plans, except for logging
National parks	13	Representatives of the natural diversity of the country	Receive full protection within core areas
Reserved zones	12	Areas that meet the conditions to qualify for protection, but that have not been granted full protection	Protection level under review
National shrines	9	Natural formations of scientific interest	Minimal or no government intervention
Communal reserves	8	Areas for the conservation of flora and fauna for the benefit of surrounding rural populations	Regulated by management plans of beneficiaries, but no logging or expansion of agriculture permitted
Protected forests	6	Forested areas within watersheds that require protection to prevent erosion	Use of wildlife and wood-based forest products permitted
Wildlife refuges	5	Areas requiring active intervention to ensure the survival of particular species	Used only for tourism, recreation, investigation, and education
Historical sanctuaries	4	Sites of national significance and archaeological history	No government intervention
Hunting reserves	2	Areas for the exploitation of wildlife for sport hunting	Regulated access to wildlife for hunting
Scenic reserves	2	Areas that highlight the harmonious relationship between man and nature	Intervention for use of natural resources allowed
Buffer zones	n/a	Zones adjacent to a protected area that need special consideration to ensure conservation of the protected area	Receives lesser protection than protected area, varies by site

^a Numbers of National Protected Areas from SINANPE (2011c)

^b Characteristics of each type of protected area from SINANPE and the ANP Law (Ley no. 26834, 1997)

both (electronic supplementary material [ESM] Table SI). When the coordinates for survey sites were not specified in a report we estimated them from accompanying maps, if provided, and indicated as such (ESM Table SI). These coordinates are point locations and do not represent the full area surveyed because this was impossible to determine for all surveys. In some cases, several sites were surveyed in close proximity, but they are indistinguishable on a map with the coordinates or scale provided, and are thus represented by a single location (ESM Table SI). A single map point represents sites ≤ 20 km² of each other, surveyed as part of the same study. We also noted which survey sites fell within a protected area (ESM Table SI). Protected areas include national parks, national shrines, historical sanctuaries, wildlife refuges, national reserves, communal reserves, protected forests, hunting reserves, scenic reserves, and reserved zones (Ley de Áreas Naturales Protegidas 1997; SINANPE 2011b) (Table 1). Peruvian law subdivides each protected area according to more specific zoning regulations that determine allowable use and levels of protection for

its subareas. Such zoning implies that these areas do not receive uniform protection, but may include subareas with no policing, subareas that completely prohibit exploitation of natural resources, as well as intermediate conditions (Table I). In all, we reviewed the results of 59 surveys in Perú, totaling 340 sites.

New Sightings

Previously unpublished sightings of *Callimico goeldii* are described for three localities in Madre de Dios, Perú: Cocha Cashu in Manu National Park, the Concesión de Conservación Rodal Semillero Tahuamanu (CCRST), and the Centro de Investigación y Capacitación Río Los Amigos (CICRA). *Callimico goeldii* was reported at Cocha Cashu in the 1980s (Terborgh 1983), and was more recently observed at another site in Manu province near the Manu National Park (Barry 2002). It had also been trapped in the Tahuamanu province near the CCRST in the 1970s (Encarnación and Heymann 1998). Our observations provide recent updates on the occurrence of *Callimico goeldii* in these areas. Although *Callimico goeldii* was believed to occur at CICRA, there are no previously documented observations from this site. We report detailed accounts of these observations with an emphasis on their ecological context.

The Institutional Animal Care and Use Committee of each principal investigator's institution approved research protocols, and the Peruvian government (Ministerio de Agricultura — MINAG) granted research permits for this work.

Study Sites

The Cocha Cashu Biological Station (11°45'S 71°30'W) is located 45 km northwest of the mouth of the Manu River within Manu National Park, and is one of the last completely undisturbed stretches of forest remaining in Perú (Terborgh 1983). The station is on the banks of the Cashu oxbow lake and has been the location of field research for >30 yr (Terborgh 1983). The vegetation is largely tropical evergreen forest, with some naturally disturbed areas caused by treefalls in the wet season creating dense undergrowth in these areas (Emmons 1984). Annual precipitation is *ca.* 2,000–2,100 mm, with a dry season from May to September (Terborgh 1983). Leite Pitman conducted a study on wild dogs (*Atelocynus microtis*) at this station, for which she surveyed a total of 80 km on a single 10-km trail during September 2000. She revisited the site in July 2001, and did not conduct formal surveys, but used the same trail as part of the larger trail system while monitoring the capture of *Atelocynus microtis*.

The CCRST (11°15'S 69°24'W) is a 12,772-ha concession located along the border with the Pando Department of Bolivia. The concession area was originally defined in 1999 as part of a national reforestation program principally to protect valuable tree species threatened by logging, but is currently managed by Conservation International. Unlike Cocha Cashu and CICRA, the concession does not border a river and has no oxbow lakes. However, there are numerous streams running through *terra firme* forests of various successional stages, and large stands of bamboo ("pacaes") (Conservation International 2005). The concession is described

as relatively undisturbed by human activity; however, illegal removal of trees has occurred at the site. Annual precipitation is 1,600–1,800 mm, with a dry season May through September (Conservation International 2005). Rehg and Inés Nole made a preliminary visit to this site for ten days in July 2011 to determine if *Callimico goeldii* is present. They did not attempt to conduct systematic linear transect surveys, but searched for primates by walking a main road that grants access to the concession and trails within the concession from 07:00 h to 15:30 h each day. They also used a small hand-held speaker to play long-call vocalizations of *Callimico goeldii* previously recorded during encounters at CICRA in an attempt to elicit responses from or attract *C. goeldii* groups at this site.

CICRA (12°34'S 70°05'W) is a 453-ha site located at the confluence of the Los Amigos and Madre de Dios Rivers and adjacent to the 146,000-ha Los Amigos Conservation Concession, both of which are managed by the Asociación para la Conservación de la Cuenca Amazónica (ACCA) in Perú and U.S.-based Amazon Conservation Association (ACA) (Pitman 2008). The station has been in existence since 2000, and despite selective logging, the forest structure at CICRA has remained relatively intact and can be classified broadly into five major categories: *terra firme* primary forest, bamboo, palm swamp, floodplain, and successional/disturbed forests (Pitman 2008). Annual precipitation is *ca.* 2,900 mm, with the driest months usually May through September (CICRA *unpubl. data*), coinciding with lower fruit availability at this site (M. Watsa *pers obs.*). Observations of *Callimico goeldii* at CICRA resulted opportunistically during research on free-ranging populations of saddleback tamarins (*Saguinus fuscicollis*) and emperor tamarins (*S. imperator*), in October 2009–August 2010 and January–August 2011, and more directed attempts to locate *C. goeldii* in the 2011 field season.

We followed selected groups of *Saguinus* for partial and full days as part of the project, which we hoped would also provide opportunities to encounter *Callimico goeldii* in association with the tamarins. We also monitored provisioned sites as part of a capture-and-release program for *Saguinus* during May–July of 2010 and April–May of 2011. In total, we conducted 1,510 h of focal follows of *Saguinus* and 639 h of trap-site monitoring. We conducted linear transect surveys (Chapman *et al.* 1988; Fashing and Cords 2000; National Research Council 1981) from February to July 2011 using the existing trail system. We initially conducted surveys only on a terrace forest trail that sampled primary forest, secondary forest, treefall disturbances, and bamboo. We selected the trail because it incorporated habitats in which *Callimico goeldii* had previously been observed at the site, and it diagonally bisected the study area. We added a floodplain trail that sampled primary forest, secondary forest, inundated areas, and stream edge subsequent to observations of *Callimico goeldii* near the river. The terrace transect length was 1,525 m and the floodplain transect length was 1,255 m. We conducted surveys January 2011 through June 2011, with 5–10 surveys conducted each month and an additional 2 surveys in July 2011. Average walking speed for all transects was 0.865 km/h. A pair of observers walking together conducted 7 of these surveys, and a single observer conducted 31 surveys. We conducted a total of 38 surveys: 28 of the terrace trail and 10 of the floodplain trail. We collected data on all primate sightings. We always made attempts to obtain accurate counts of group sizes and record all species present, which regularly resulted in 10–20 min of observation of the primates after the initial sighting.

Results

New Sightings of *Callimico goeldii*

At the Cocha Cashu Biological Field Station in Manu National Park, Leite Pitman briefly observed lone individuals of *Callimico goeldii* on two separate occasions, in 2000 and 2001, at a bamboo patch 6 km north of the station. In both cases, the individuals were not associating with any other primate, although a thorough search was not conducted in either instance (Table II). At the CCRST in July 2011, we observed a minimum of two individuals (more may have been out of sight) for *ca.* 15 min. They were spotted when approaching a researcher playing long calls of *Callimico goeldii*. The monkeys were in a patch of mixed secondary forest and bamboo in an area traversed by streams. There were no other primate species in the immediate vicinity at the time of the sighting (Table II).

Table II New sightings of *Callimico goeldii*

Observation	Year	Month	No. of individuals	Habitat	Associated primates	Observation method
Cocha Cashu, Manu National Park, Manu, Madre de Dios						
RenCC1	2000	September	1	B	Unknown	O
RenCC2	2001	July	1	B	Unknown	O
Concession de Conservación, Rodal Semillero TahuaManu, TahuaManu, Madre de Dios						
Rodal	2011	July	2+	B	None	P
CICRA, Madre de Dios						
1	2005	—	2	BT	None	O
2	2009	November	3	T	<i>Sf</i>	F
3	2010	January	1+	T	<i>Sf, Si, C</i>	F
4	2010	January	3	F	<i>Sf</i>	O
5	2010	February	2+	T	<i>Sf, Si</i>	O
6	2010	March	2	BT	<i>Sf*</i> , <i>Si</i>	S
7	2010	March	3	T	<i>Sf, Si</i>	F
8	2011	February	1	ST	None	O
9	2011	March	1	SF	<i>Sf*</i>	O
10	2011 ^a	April–May	1	BT	<i>Sf*</i> , <i>Si*</i>	S
11	2011	April	2	T	<i>Sf*</i> , <i>C</i>	S
12	2011	June	2	BT	<i>Sf, Si</i>	F
13	2011	July	2	SF	<i>Si</i>	F

Survey technique: F = follow; S = monitoring provisioned site; O = opportunistic; P = vocal playbacks

Associating primates: *Sf* = *Saguinus fuscicollis*; *Si* = *Saguinus imperator*; *C* = *Callicebus brunneus*; * = known group identifiable with collars

Forest type: T = terra firme; S = secondary/disturbed; F = floodplain; B = bamboo

^a Six sightings of the same individual are combined

Assessment of *Callimico goeldii* at CICRA

The first reported sighting of *Callimico goeldii* at CICRA was made in 2005, ca. 200 m from the field station, on a well-used trail through bamboo, by a local field assistant who had not previously seen the species in >50 yr of working in the area. During field seasons in 2009–2010, and 2011, our research team encountered *Callimico goeldii* 17 times, in all but one instance in association with one or both species of *Saguinus* (Table II). We observed *Callimico goeldii* with at least four different marked tamarin groups, as well as another seven times with unmarked groups of *Saguinus* during a total of 2,149 h of tamarin group follows and provisioned site monitoring. Of the 17 observations, 6 were sightings of what appeared to be the same lone female *Callimico goeldii* visiting a provisioned site, so we have condensed these observations into a single event; therefore, we have a total of 13 separate observation events. The majority of sightings were of pairs or groups of three individuals (Table II). The observation conditions and length of sightings were sufficient in nearly all cases to make confident complete counts of individuals. Periodically, we used playbacks of long calls of *Callimico goeldii* to assist in locating them, without any success (tamarins did not respond by vocalizations or by approaching either); however, *C. goeldii* approached us on five occasions when we used playbacks of tamarin long calls (both *Saguinus fuscicollis* and *S. imperator*) (Table II). Four of the 13 events were in bamboo-dominated habitats (Table II), 6 were in *terra firme* forests of varying successional stages, and 3 were on the floodplain in secondary or dense undergrowth. No sightings occurred during transect surveys, although some of our opportunistic observations of *Callimico goeldii* during focal follows of groups of *Saguinus* occurred ≤ 10 m of the same transects.

A minimum convex polygon encompassing all sightings produces a range of ca. 200 ha. Given documented home range sizes of 150 ha (Porter *et al.* 2007), and the infrequent encounters with *Callimico goeldii* at CICRA, it is possible that three individuals inhabit the main 200-ha study area at CICRA.

Mammal Surveys and Inventories

Callimico goeldii was reported at only 37 of the 340 sites surveyed across Perú (10.9 %). It is recorded at eight of these based only on captures or observations of captive individuals such as local pets. We have identified every site with an abbreviated name (sites with *Callimico goeldii*) or number (sites without *C. goeldii*) and a single set of coordinates (ESM Table SI, Table III). From these reports we can infer that group sizes ranged from 1 to 12 individuals. Reported observations of infants (sites Ib2 and Ib5, Fig. 2, Table III) were of single carried infants, suggesting single births in those groups (Castro *et al.* 1990; Encarnación and Heymann 1998). Hershkovitz (1977) noted nine independent sight records made by Pekka Soini of *Callimico goeldii* in Perú (coded Soi-X, Table III). However, the IUCN report and our review confirms that one site (coded SoiRAP, Fig. 2c) is located on the Río Marañon but is described incorrectly in the original source (Hershkovitz 1977) as occurring where the Apaga River enters the Putumayo River from the south. Although we have included this point in our list of sites where *Callimico goeldii* occurs, others may not (Aquino and Encarnación 1994; Cornejo 2008).

Table III Sites in Perú with confirmed observations of *Callimico goeldii*

Map code	Map	Site/region	Protection	Record	Year	No. of inds.	Effort
Alt1 ^a	J	Altamira	NP	MS	Unk	1	N/A
Alt2 ^b	J	Altamira	NP	C	1963	1	N/A
CAC ^b	G	Cerro Azul, Contamana	RZ	C	1927	1	N/A
CarC ^c	K	Carretera Carrozable	None	S	1980	1	19.6 km
CC1 ^d	J	Cocha Cashu	NP	S	1973–1985	1+	Multi-year survey
CICRA ^e	K	CICRA	NP-BZ	S, F	2009–2011	3 max	This study
Ib2 ^f	K	Iberia	None	C	1979	12 (2)	Trap capture
Ib5 ^f	K	Iberia	None	C	1987	7 (1)	Trap capture; bred
IntRT ^g	B	Intuto: Río Tigre	None	CT	Unk	2	Unk
MWC ^h	J	Manu Wild. Ctr.	None	S, F	2000–2002	5	6 months tracking
NSJ ⁱ	D	Nuevo San Juan	None	S	1994–1996	Unk	18 mo/ 583 h
Pan ^j	H	Panguana	CR-BZ	S	1968–1985	Unk	Single observer, Long-term study
PCD ^k	B	Pucacuro: Cocha Despensa	NR	LS	2000	Unk	Proportion of 600 km total in study
PCM1 ^k	B	Pucacuro: Cocha Monterrico	NR	LS	2000	Unk	Proportion of 600 km total in study
PCM2 ^k	B	Pucacuro: Cocha Monterrico	NR	LS	2000	Unk	Proportion of 600 km total in study
Pesp ^l	H	Puerto Esperanza	None	CT	1999	2	230 days
Pis ^m	G	Río Pisqui	None	C	1926	1	Unk.
Ppon ^k	B	Pucacuro: Ponal	None	S	2000	Unk	Proportion of 600 km total in study
PSE ^k	B	Pucacuro: Santa Elena	None	LS	2000	Unk	Proportion of 600 km total in study
PSQ ^k	B	Pucacuro: Soldada Quebrada	NR	LS	2000	Unk	Proportion of 600 km total in study
RenCC1 ^c	J	Cocha Cashu	NP	S	2000	1	80 km
RenCC2 ^c	J	Cocha Cashu	NP	S	2001	1	Chance encounter
RNP ⁿ	K	R.Noaya-Putirija	None	S	1980	1+	Chance encounter
RTCC ^o	K	Tahuamanu	None	S	Unk	Unk	Long-term
SoiChi ^b	D	Chiarara	NP	S	1970	Unk	Unk
SoiMis ^b	D	Mishana	NP	S	1970	Unk	Unk
SoiPY ^b	D	Pinto Yaco	None	S	1970	Unk	Unk
SoiQT ^b	D	Quebrada Tocon	NP	S	1970	Unk	Unk
SoiRAP ^b	C	Río Apaga	None	S	1970	Unk	Unk

Table III (continued)

Map code	Map	Site/region	Protection	Record	Year	No. of inds.	Effort
SoiRC ^b	B	Río Curaray	None	S	1970	Unk	Unk
SoiRT ^b	D	Río Tigre	NR-BZ	S	1970	Unk	Unk
SoiSam ^b	D	Río Samiria	NR	S	1970	Unk	Unk
SoiSC ^b	E	Santa Cecilia	None	S	1970	Unk	Unk
Tap1 ^P	G	Tapiche	RZ	LK	2005	4	5 d/111 km
Tap2 ^b	D	Río Tapiche	RZ-BZ	C	1926	1	Unk
YM ^a	H	Río Yurúa	None	S	2005	3–6	Unk
Rodal ^c	K	CCRST	None	S	2011	2	Chance encounter

Sighting type: MS = museum specimen; C = captured specimen; CT = captive animal; S = study sighting; LS = local sighting; LK = local knowledge; F = followed

Protected area type: BZ = buffer zone; NP = national park; NR = national reserve; RZ = reserved zone; CR = communal reserve; None = no government protection

No. of inds. = number of individuals sighted; Unk = Unknown; + = possibly more individuals; () = number of infants. Coordinates and search effort for each site are provided in ESM Table SI

Sources: ^aSolari *et al.* (2006) and Patterson *et al.* (2006); ^bHershkovitz (1977); ^cCastro *et al.* (1990); ^dTerborgh *et al.* (1985); ^ethis study; ^fEncarnación and Heymann (1998); ^gP. Alvarez (*pers. comm.*); ^hBarry (2002); ⁱFleck *et al.* (1999); ^jHutterer *et al.* (1995); ^kSoini (2001); ^lLeite Pitman *et al.* (2003); ^mUtani and Aguado (2009); ⁿValverde *et al.* (1990); ^oSousa and Meneses (2007); ^pVriesendorp *et al.* (2005); ^qEscobedo and Mena (2006)

There is substantial geographic variation in survey effort, with the greatest number of sites located in the north of Perú (Table IV). We conducted the surveys in national parks, communal reserves, national reserves, reserved zones, protected forests, their corresponding buffer zones, and outside protected areas (Table V). We found that 60 % of all sites surveyed and 51 % of sites reported to contain *Callimico goeldii* were within some type of nationally protected area (Tables I and IV). However, >40 private concessions exist in the country, making it possible that some sites with *Callimico goeldii* that lack official government protection might be protected privately. These areas are not considered protected areas here because of the high variability in protection standards.

Distribution of *Callimico goeldii* in Northern Perú

The majority of sites with *Callimico goeldii* in the north are located in the Pucacuro National Reserve along the Tigre River, and the Pacaya Samiria Reserve (ESM Table SI, Fig. 2b, d). Records of its occurrence in Pucacuro (sites PSE, IntRT) are based on reports of observations by local residents and of captive individuals in the area (J. Alvarez, *pers. comm.*; Soini 2001; Vriesendorp *et al.* 2006) (Table III, Fig. 2b). Although not included in our maps because there were no direct sightings, local people recognized *Callimico goeldii* from photos near the Algodón River and referred to it as *chichi* (Gilmore *et al.* 2010), and a pet individual carried with an expedition to the Yaguas area in 1974 was also recognized by local people (Freese *et al.* 1982)

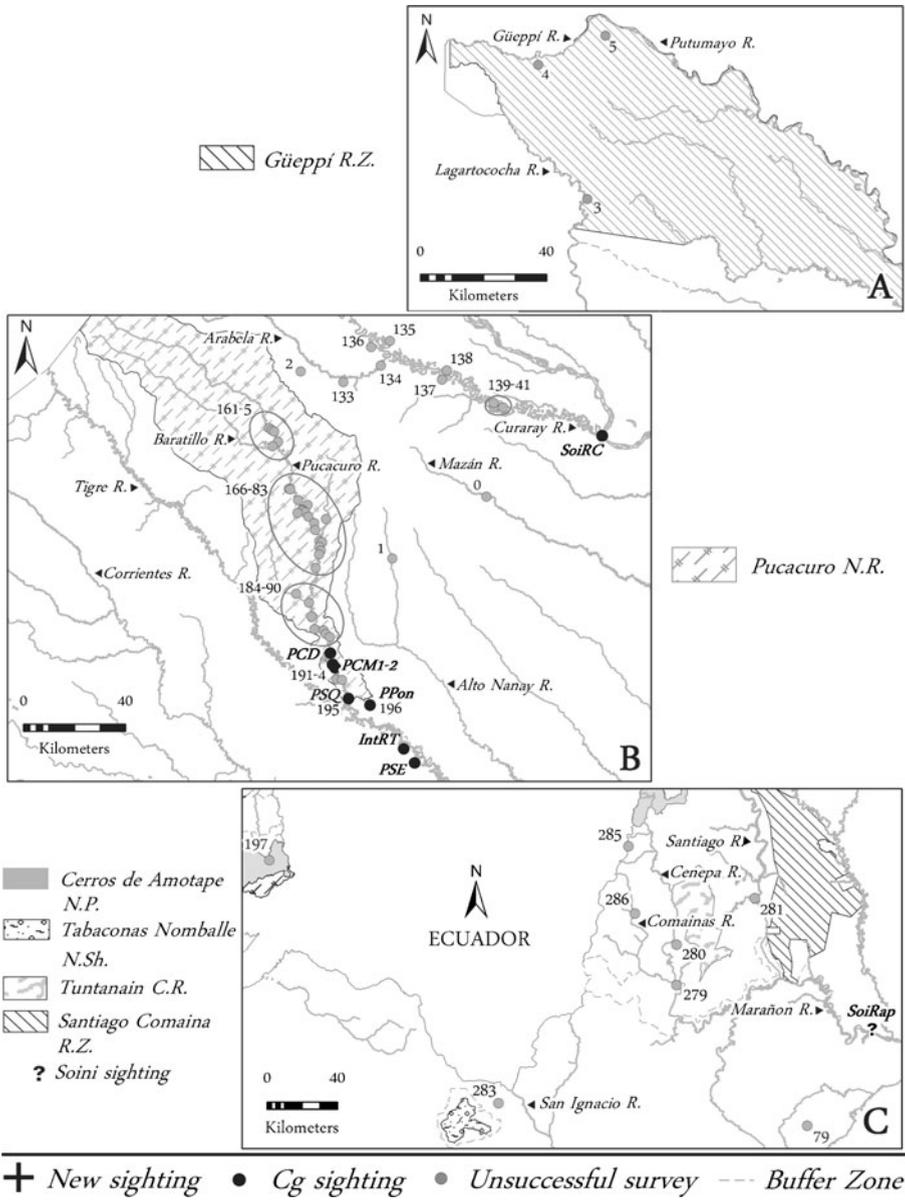
Fig. 2 (a–c) Distribution maps of sites with and without *Callimico goeldii* as per published mammal inventories. **(a, b)** Northern Perú. A key is provided on the page before indicating regions expanded by each map. Numbers are the site code for sites without *Callimico goeldii* and letter codes represent sites with observations of *C. goeldii* (ESM Table S1). Outlines around a series of surveyed sites indicate clusters of sites named by a single label. N.R. = national reserve; R.Z. = reserve zone; N.P. = national park; N.Sh. = national shrine; C.R. = communal reserve. **(d, e)** Distribution maps of sites with and without *Callimico goeldii* as per published mammal inventories. **(d, e)** Northern Perú. See reference map for regions expanded by each map. Numbers are the site code for sites without *Callimico goeldii* and letter codes represent sites with observations of *C. goeldii* (ESM Table S1). Outlines around a series of surveyed sites indicate clusters of sites named by a single label. N.R. = national reserve; R.Z. = reserve zone. **(f–h)** Distribution maps of sites with and without *Callimico goeldii* as per published mammal inventories. **(f, g)** Northern Perú. **(h)** Southern Perú. See reference map for regions expanded by each map. Numbers are the site code for sites without *Callimico goeldii* and letter codes represent sites with observations of *C. goeldii* (ESM Table S1). Outlines around series of surveyed sites indicate clusters of sites named by a single label. R.Z. = reserve zone; N.P. = national park; C.R. = communal reserve; P.F. = protected forest; H.Z. = hunting zone; N.Sh. = national shrine **(i–k)** Distribution maps of sites with and without *Callimico goeldii* as per published mammal inventories. **(i–k)** Southern Perú. See reference map for regions expanded by each map. Numbers are the site code for sites without *Callimico goeldii* and letter codes represent sites with observations of *C. goeldii* (ESM Table S1). Outlines around series of surveyed sites indicate clusters of sites named by a single label. N.P. = national park; C.R. = communal reserve; N.R. = national reserve; H.Sh. = historical shrine.

(Fig. 2e). Other sightings of *Callimico goeldii* by Soini occurred in 1970 at the Pucacuro National Reserve, Santa Cecilia on the Maniti River, the mouth of the Curaray River, near the Nanay River, along the Tigre River, and at the mouth of the Samiria River (Hershkovitz 1977) (Fig. 2b, d, e).

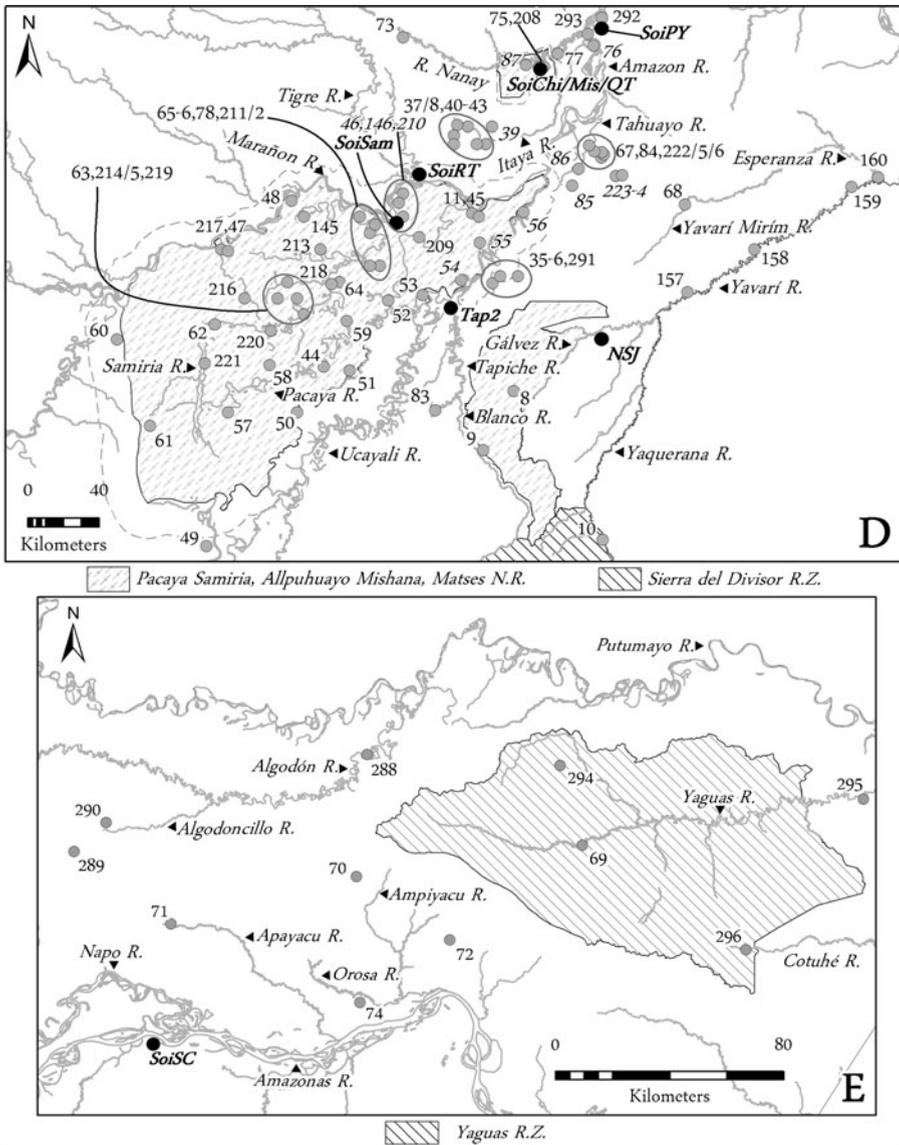
The presence of *C. goeldii*, in groups of up to 4 individuals, was confirmed recently in the Sierra del Divisor Reserve Zone in riverine forest bamboo patches during an RBI survey of the area (Vriesendorp *et al.* 2005) (site Tap1, Fig. 2g). Several other areas, such as the Maraón River, Alto Mayo Protected Forest, and the Huallaga and Huallabamba River areas, have been intensively surveyed recently but with no sightings of *Callimico goeldii* (Table V, Fig. 2f). Although no data are available for the Santiago–Comaina area, the region west of it was intensively studied from 1982 to 1986 (Patton *et al.* 1982), and in 1994 (Schulenberg and Awbrey 1997), with no observations of *Callimico goeldii* (Fig. 2c). Earlier records show a specimen was captured in 1926 on the banks of the River Pisqui (Hershkovitz 1977) (Fig. 2g). The upper altitudinal range of *Callimico goeldii* was investigated in 2000 within the Cordillera Azul National Park, and no individuals were found even as low as 360 masl (Alverson *et al.* 2001) although the upper limit of their range has been reported to be 500 masl (Emmons and Feer 1997) (Fig. 2f, g). Higher altitudes most definitely do not indicate the presence of *Callimico goeldii* based on recent (2007–2010) surveys looking for *Oreonax flavicauda* (Shanee 2011) (Fig. 2f). Near central Perú, a possible sighting was recorded at the Panguana Biological Field Station, situated in the buffer zone of the El Sira Communal Reserve. Maria Koepcke, one of the field station's founders, reportedly observed *Callimico goeldii* at the site, although her observations could not be verified on subsequent visits by herself and her team (Hutterer *et al.* 1995) or a different group of observers (Freese *et al.* 1982) (Fig. 2h).

Distribution of *Callimico goeldii* in Southern Perú

Southern Perú contains several large national parks, including the Alto Purus, Manu and Bahuaja-Sonene National Parks (Fig. 2h–k). *Callimico goeldii* was observed in

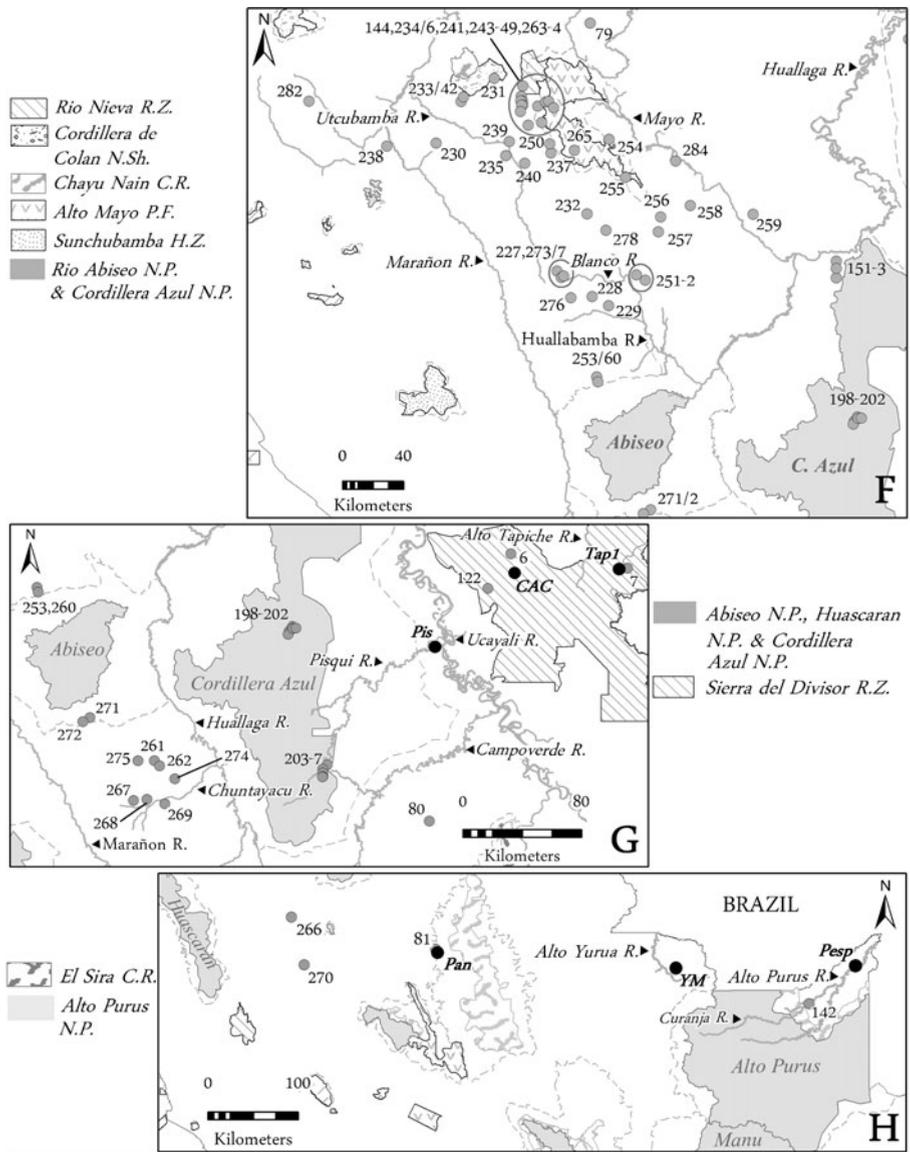


captivity in Puerto Esperanza, a community in the small sequestered area between Brazil and the Alto Purus National Park (Leite Pitman *et al.* 2003) (Fig. 2h). Intensive surveys by Voss and Emmons in 1966, 1968, and 1971 within the Alto Purus National Park did not locate *Callimico goeldii* (1996) (Table V). West of this area on the northeastern bank of the Yurua (or Jurua) River, the WWF and the Ashaninka people reported three sightings of *Callimico goeldii*, in association with *Saguinus imperator* and *S. fuscicollis* in 2005 (Escobedo and Mena 2006) (Fig. 2h). Group counts varied from



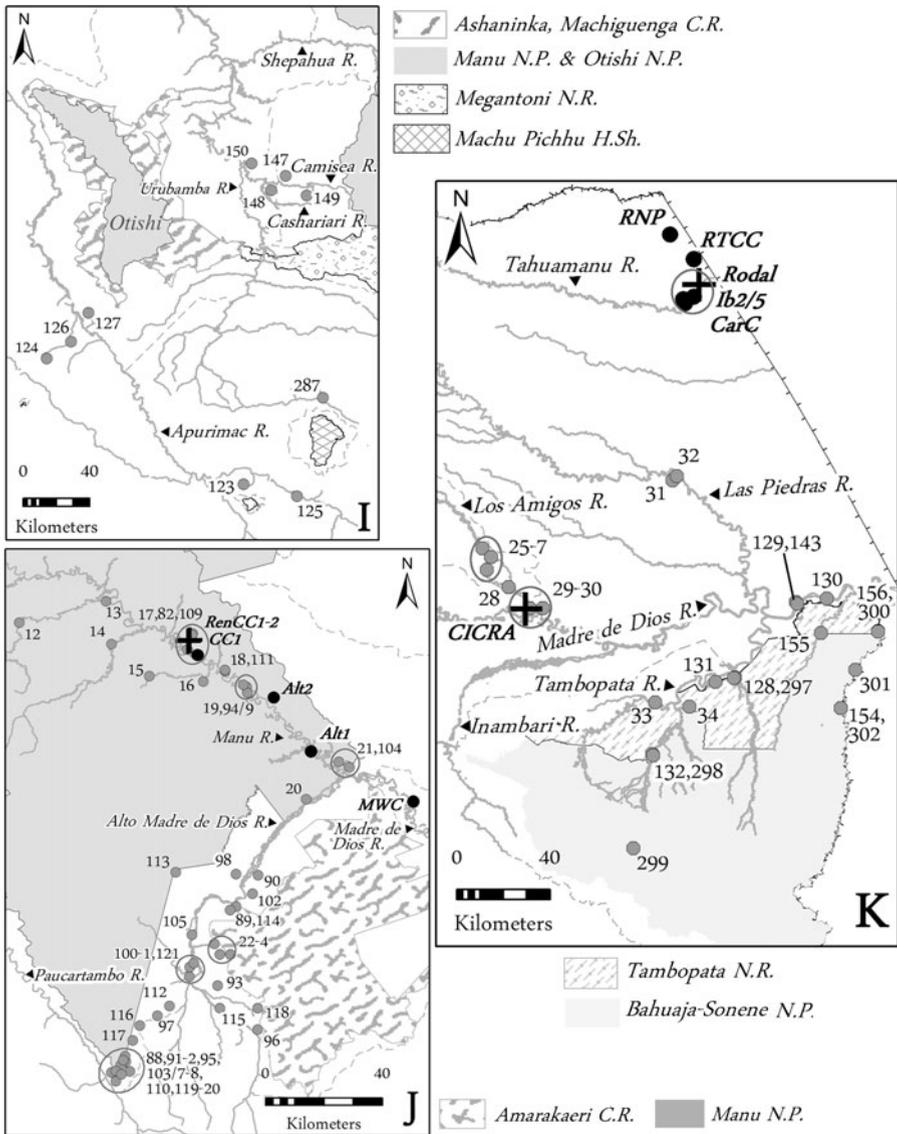
+ New sighting
 ● Cg sighting
 ● Unsuccessful survey
 - - - Buffer Zone
 Fig. 2 (continued).

three to six individuals, and all sightings of monkeys were in bamboo. A pair of unpublished studies conducted in 2000 and 2002 at the Manu Wilderness Center indicates a population of *Callimico goeldii* at this site (Fig. 2j). In 2000, a group of three individuals was observed in the presence of *Saguinus fuscicollis* on 7 occasions and in 2002, a group of 5 individuals was followed for a total of 3 h and 10 min over 11 occasions spanning 49 d (Barry 2002). All observations occurred in the same bamboo area, and the author noted that the monkeys routinely fled at the sight of observers.



+ New sighting ● *Cg* sighting ○ Unsuccessful survey --- Buffer Zone
 Fig. 2 (continued).

Manu National Park is one of the most intensely surveyed areas in the Amazon (Endo *et al.* 2010; Palminteri *et al.* 2009; Solari *et al.* 2006; Terborgh *et al.* 1985). Terborgh has reported the presence of *Callimico goeldii* at Cocha Cashu (1983; Terborgh *et al.* 1985) based on two sightings made by separate observers of one individual at a bamboo stand *ca.* 6 km north of the biological station (Terborgh *pers. comm.*) Despite intensively searching for the monkeys within the area for a week, there were no subsequent sightings of *Callimico goeldii* (Terborgh *pers. comm.*). In 2000 and 2001,



⊕ New sighting • Cg sighting ● Unsuccessful survey --- Buffer Zone
 Fig. 2 (continued).

>15 yr later, Leite Pitman made observations of *Callimico goeldii* in exactly the same bamboo stand (Table II, Fig. 2j). This is the only national park in which *Callimico goeldii* is thought to exist within Perú (Cornejo 2008), but the sightings have been rare in >40 yr of research at Cocha Cashu. The two sites named Altamira, separately reported by Solari *et al.* (2006) and Hershkovitz (1977), within this park are probably reporting the same individual that was captured and designated as a museum specimen.

Table IV Occurrence of *Callimico goeldii* in protected areas within Perú

Protected areas	Northern Perú		Southern Perú	
	Total sites surveyed	<i>C. goeldii</i> reported	Total sites surveyed	<i>C. goeldii</i> reported
National park	11	0	30	5
National park buffer zone	5	0	27	1
Communal reserve	0	0	1	0
Communal reserve buffer zone	0	0	13	1
National reserve	83	8	7	0
National reserve buffer zone	5	2	0	0
National shrine	1	0	0	0
Reserved zone	15	2	0	0
Reserved zone buffer zone	1	0	0	0
Protected forest	4	0	0	0
Protected forest buffer zone	3	0	0	0
No government protection	109	9	25	9
Total number of sites	237	21	103	16

East of Manu National Park is the elongated buffer zone that envelops the Los Amigos Conservation Concession, where CICRA is located (Fig. 2k). Although there was no observation of *Callimico goeldii* during several years of mammal transects conducted by park guards (ACA unpubl. data), we can now confirm its presence at CICRA (Table II). Other than CICRA and Manu, the only location in southern Perú with *Callimico goeldii* is north of the Tahuamanu River, where several confirmed sightings have been made (Tables II and V). The most important records come from a trapping program of a large number of primates that occurred in this area in the 1970s (Castro *et al.* 1990; Encarnación and Heymann 1998) (Fig. 2k). In 1979, during a census of *Saguinus labiatus*, a group of 12 individuals of *Callimico goeldii* was captured ca. 2 km northeast of Iberia, while in 1987 a group of 7 individuals was captured and used for breeding at the Centro de Conservación y Reproducción de Primates in Iquitos (Encarnación and Heymann 1998) (Fig. 2k). In addition to the observations by Rehg and Nole at the CCRST, local residents and site administrators report seeing it frequently within a corridor of bamboo and stream edge along the border of the concession (D. Souza *pers. comm.*).

Recent Status of *Callimico goeldii* in Perú

The presence of *Callimico goeldii* has been verified at six locations in Perú within the last decade: The CCRST, Yurua River, Sierra del Divisor, Manu National Park, Manu Wilderness Center and CICRA. At all of these sites, group sizes range from 3 to 12 individuals except at CICRA, where groups of ≤ 3 have been observed. The low numbers and pattern of sightings at CICRA suggest a low population density such as at some sites in Pando, Bolivia (Porter 2007). Likewise, Cocha Cashu also appears to have a low density of *Callimico goeldii*. All individuals observed at Manu National

Table V Summary of all local regions in Perú with sites surveyed for *Callimico goeldii*

Site name	Map	<i>Y</i>	<i>N</i>
Northern Perú	A–G	21	216
Güepí RZ	A	0	3
Pucacuro NR	B	4	35
Pucacuro River bank	B	3	1
Curaray and Arabela Rivers	B	1	12
Santiago Comaina RZ BZ	C	0	1
Area west and south of Santiago Comaina RZ	C	1	4
Outside Tabaconas Nomballe N. Sh.	C	0	1
Cerros de Amotape NP	C	0	1
Pacaya Samiria NR	D	1	36
Pacaya Samiria NR BZ	D	2	6
Allphuyo-Mishana NR	D	3	3
Rio Nanay	D	1	5
Matsés NR	D	0	2
Sierra del Divisor RZ	D, G	2	4
Javari/Javari Mirim Rivers	D	1	5
Region between Pacaya Samiria and Allphuyo-Mishana NRs	D	0	7
East of Pacaya Samiria Reserves	D	0	9
Region between Pacaya Samiria and Matsés NRs	D	0	2
South of Pacaya Samiria NR	D	0	1
Algodón River	E	0	3
Yaguas RZ	E	0	3
South of Yaguas RZ including Amazonas River	E	1	4
East of Yaguas RZ	E	0	1
Alto Mayo PF	F	0	4
Alto Mayo PF BZ	F	0	2
Cordillera de Colán N. Sh.	F	0	1
Region between Marañon River and Alto Mayo PF	F	0	16
Area between Marañon and Huallaga Rivers, including the Huallabamba watershed	F	0	17
Between Tabaconas Nomballe NS and Marañon River	F	0	2
Rio Nieva RZ	F	0	1
North of Alto Mayo PF	C, F	0	1
Cordillera Azul NP	F, G	0	9
Cordillera Azul NPBZ	F, G	0	4
Rio Abiseo NP BZ	F, G	0	2
Between Marañon River and Cordillera Azul NP	G	0	7
Region between Sierra de Divisor RZ and Cordillera Azul NP	G	1	1
Southern Perú	H - K	16	87
El Sira CR BZ	H	1	1
Alto Purus River	H	1	1
Alto Yurua River	H	1	0

Table V (continued)

Site name	Map	Y	N
Between Huascarán NP and El Sira Communal Reserve	H	0	2
Apurimac BZ	I	0	1
Apurimac River	I	0	4
Urubamba River	I	0	2
Manu NP	J	5	18
Manu NP BZ	J	1	27
Amarakaeri CR	J	0	1
Amarakaeri CRBZ	J	0	10
Between Manu NP BZ and Amarakaeri CR BZ	J	1	0
Tambopata NR	K	0	8
Bahuaja-Sonene NP	K	0	4
Bahuaja-Tambopata BZ	K	0	2
Tahuamanu Area	K	6	0
Río de las Piedras	K	0	2
North of the Madre de Dios River	K	0	3
Mouth of Los Amigos River	K	0	1

Protected area type: BZ = buffer zone; NP = national park; NR = national reserve; RZ = reserved zone; CR = communal reserve; None = no government protection

N = Number of sites without *C. goeldii*; Y = number of sites with *C. goeldii*

Data on sites with *C. goeldii* are taken from sources as per Table I. Data on sites without *C. goeldii* are taken from the following sources: Alverson *et al.* (2001, 2008); Aquino (1990); Aquino and Calle (2003); Aquino *et al.* (2001, 2005, 2007); Barry (2002); Bennett *et al.* (2001); Boddicker *et al.* (2001); CDC-UNALM (1992); Deluycker (2006, 2007); Encarnación *et al.* (1990); Encarnación and Cook (1998); Foster *et al.* (1994); Freese *et al.* (1982); Gilmore *et al.* (2010); Heymann and Aquino (1994); Heymann *et al.* (2002); Kinzey *et al.* (1977); Kirkby *et al.* (2000); Mateo and Arana (2006); Montambault (2003); Neville *et al.* (1976); Oldfield (1920); Oversluijs (2003); Pacheco *et al.* (2007); Palminteri *et al.* (2009); Patterson *et al.* (2006); Patton *et al.* (1982); Pitman *et al.* (2003, 2004, 2011); Puertas *et al.* (1995); Sánchez and Vásquez (2007); Schulenberg and Awbrey (1997); Soini (1986, 2001); Soini and Moya (1987); Soini *et al.* (1996); Solari *et al.* (2006); Utani and Aguado (2009); Valquí (2001); Voss and Emmons (1996); Vriesendorp *et al.* (2005, 2006, 2007)

Park have been in a single location, despite decades of research by people familiar with this species (Goldizen *et al.* 1996; Pitman *et al.* 2009), although there have been recent sightings of *Callimico goeldii* outside the park proper (Barry 2002). The captive individual at Puerto Esperanza confirms its presence within the Alto Purus National Park, but densities remain unconfirmed. Few sightings of *Callimico goeldii* in Perú are attributable to local residents, and in those cases (at Pucacuro, the Algodón River, Yaguas, the Yurua River, and Matsés Reserve), people recognize the monkey but not many have seen it first hand.

Discussion

Our review of sightings records for *Callimico goeldii* across Perú indicates complexity underlying its reported geographic distribution, relating to local patchiness in its

occurrence and also possible changes in population sizes over time. Judging from the many studies conducted in areas where *Callimico goeldii* is known by local populations, but is not recorded during formal surveys, it seems that standard survey methodology is unreliable and often unsuccessful in recording its presence. Transect surveys, the most common method used to estimate primate densities, have been shown to be less accurate than long-term monitoring using focal follows of primates (Fashing and Cords 2000). However, long-term monitoring requires a greater investment of time and money, and eventually the habituation of groups for accurate population counts, which is not always feasible, especially for cryptic species. Nevertheless, there are patterns in successful observation conditions from previous studies, which are supported by our sightings that may prove useful in designing survey methodology for this primate.

No observations of *Callimico goeldii* at CICRA had been made since it was established in 2000, including during >2,500 h of large vertebrate surveys at 10 sites in the Amigos watershed since 2005 (ACA unpubl. data; Palminteri *et al.* 2009). At CICRA, we had greater success locating *Callimico goeldii* while following tamarins, with which it is known to associate, than with transect surveys. Several techniques that have been successfully used in other studies to locate and observe *Callimico goeldii* include provisioning of stationary sites (Masataka 1981) and playbacks of long calls and mimicking of vocalizations (Christen 1999; Porter 2007). We noted *Callimico goeldii* behaved less warily in response to humans at provisioned sites where other tamarin species were accustomed to feeding. It appears that *Callimico goeldii* at CICRA acquired knowledge of these sites, and was habituated to them, via associations with the tamarins (M. Watsa and G. A. Erkenwick *pers. obs.*). Masataka (1981) had successfully used provisioning to study *Callimico goeldii* at a site in Pando, Bolivia, independent of habituation of other tamarin species.

We sparingly used playbacks of vocalizations of *Callimico goeldii* recorded from a captive colony and from an individual at CICRA, but with no success in attracting *C. goeldii* individuals at CICRA. Vocalizations of *Callimico goeldii* recorded at CICRA, however, appeared effective at eliciting a response from a resident pair or group at CCRST. Playbacks of tamarin vocalizations never resulted in a vocal response by *Callimico goeldii* at CICRA, although *C. goeldii* is known to vocally respond to tamarins at other sites, and at CICRA, it approached observers upon hearing tamarin playbacks (Porter 2007; Rehg 2006).

Assessing the conservation status of *Callimico goeldii*, and devising appropriate conservation strategies is challenging for several reasons. Areas in which *Callimico goeldii* is recently confirmed to occur and that may contain the most viable populations are not contiguous, and are not currently granted National Park status by Perú. The Sierra del Divisor Reserved Zone of Perú adjoins the Sierra do Divisor National Park in Acre, Brazil, where *Callimico goeldii* has been reported (Azevedo Lopes and Rehg 2003). It appears to be the only area in central Perú with a verified current population of *Callimico goeldii* that receives protection to some extent. This finding may provide more justification for the Peruvian government to grant the zone full National Park standing. The CCRST is a less well known area, but *Callimico goeldii* may be present in larger numbers here, as this site borders the Pando Department in Bolivia and is near Acre in Brazil, where *C. goeldii* has been observed at higher densities (Porter 2007; Rehg 2007).

However, as the CCRST is also a private conservation area, it has no government protection, and is more susceptible to illegal poaching and logging given its location along the newly completed Interoceanic Highway.

Callimico goeldii is cryptic and prefers habitats that are slightly disturbed and more likely to include bamboo, which is not the priority choice for tropical forest habitat conservation (Porter 2004). The reported distribution of *Callimico goeldii* in Perú, although apparently extensive based on the IUCN (Schipper *et al.* 2008) and NatureServe (Patterson *et al.* 2007) species range polygons (Fig. 1), is largely based on sightings from several decades ago. *Callimico goeldii* does not appear to exist at most sites in Perú in the same higher densities as the few well surveyed sites in Brazil and Bolivia, which is not discernible from the homogeneous appearance of the species range polygon. Although these polygons for *Callimico goeldii* in Perú may convey an overly optimistic impression regarding the status of the population, it is also likely that typical surveys are not always detecting *C. goeldii* when it is present. These factors suggest that the current species range map is locally inaccurate, but it is not yet possible to determine if it is an exaggeration or constriction of the species' true distribution without species-specific searches of more sites. Even though this information is currently lacking, we hope that conservation associations, researchers, and the Peruvian government will see the urgency for a thorough reassessment of the range map and conservation status of this species.

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