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ORIGINAL ARTICLE

On the occurrence of *Cebus flavius* (Schreber 1774) in the Caatinga, and the use of semi-arid environments by *Cebus* species in the Brazilian state of Rio Grande do Norte

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Abstract *Cebus flavius* is a recently rediscovered species and a candidate for the 25 most endangered primate species list. It was hypothesized that the distribution of *C. flavius* was limited to the Atlantic Forest, while the occurrence of *C. libidinosus* in the Rio Grande do Norte (RN) Caatinga was inferred, given its occurrence in neighboring states. As a result of a survey in ten areas of the RN Caatinga, this paper reports on four *Cebus* populations, including the first occurrence of *C. flavius* in the Caatinga, and an expansion of the northwestern limits of distribution for the species. This *C. flavius* population may be a rare example of a process of geographic distribution retraction, and is probably the most endangered population of this species. New areas of occurrence of *C. libidinosus* are also described. Tool use sites were observed in association with reports of the presence of both capuchin species.

Keywords *Cebus flavius* · Caatinga · Capuchin monkeys · Semi-arid environments · Tool use

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Introduction

Due to its great ecological plasticity, the genus *Cebus* (capuchin monkeys, macacos-prego, and caiararas) is one of the most widely distributed geographically among neotropical primates (Silva Júnior 2001; Fragaszy et al. 2004). Groves (2001) divides *Cebus* into eight species (*C. capucinus*, *C. kaapori*, *C. albifrons*, *C. olivaceus*, *C. apella*, *C. nigritus*, *C. xanthosternos*, *C. libidinosus*), whereas Silva Júnior (2001) considers 11 species for the genus (the aforementioned eight, plus *C. robustus*, *C. cay*, *C. macrocephalus*). Species of the genus are found in virtually all forested habitats of South and Central America, including humid areas, forests on the Atlantic Coast, dry areas, *llanos* in Venezuela and the Brazilian Caatinga (Silva Júnior 2001; Madden et al. 2007). *Cebus libidinosus* occurs in most of northeastern Brazil (Rylands et al. 2000; Silva Júnior 2001), in areas of the Caatinga and in Cerrado biomes (Silva Júnior 2001).

The recent rediscovery of *C. flavius* in areas of coastal Atlantic Forest in northeastern Brazil (Oliveira and Langguth 2006) suggests that the diversity of this genus, as well as the distribution limits and possible hybridization areas of

its species, are not sufficiently known, particularly for the new and rediscovered species (Silva Júnior 2001; Ferreira et al. 2007; Fialho et al. 2007). *C. flavius* has a yellowish fur compared to *C libidinosus* (in fact, local people call *C. flavius* the blond monkey, distinguishing them from the red monkey—*C. libidinosus*). *C. flavius* also have a more homogenous coloration throughout the body while *C. libidinosus* has darker forearms [see Fig. 2 and Silva (in prep) for a thoroughly description of differences between these two species]. Earlier surveys have confirmed the suggestion made by Oliveira and Langguth (2006) that the distribution of *C. flavius* is restricted to the coastal Atlantic Forest, from south Rio Grande do Norte (RN) to the left margin of the São Francisco River in Alagoas state, with the western limit coinciding with the limits of the Atlantic Forest biome (Ferreira et al. 2007). These surveys recorded small populations of *C. flavius* inhabiting isolated patches of Atlantic Forest in northeastern Brazil (Ferreira et al. 2007), suggesting that the species is at risk of extinction. The IUCNs recent evaluation (November 2007) confirmed the critically endangered status of the species (unpublished data).

Rio Grande do Norte state, in the northeast of Brazil, exhibits a diversity of environments such as Atlantic Forest and Caatinga biomes, and transition zones. Currently, Caatinga ecosystems occupy 93.6% of RN territory, while only 6.4% are characterized as Atlantic Forest formations (Brasil 2005). Official and scientific reviews of mammal presence in the RN Caatinga are scarce, and nonexistent for *Cebus*. Reis et al. (2006) report the occurrence of only two mammals (*Tolypeutes metacus* and *Dasyprocta prymnolopha*) in RN, while the official list of the Brazilian Environment Ministry (Brasil/MMA 2003) contains five mammals (*Alouatta belzebul*, *Dasyproctus novemcintus, Euprhactus sexcinctus*, *Tolipeutes tricinctus* in coastal areas, and *Cabassous* sp. in the Caatinga). However, Porpino and Silva (submitted) indicate the presence of 23 non-flying mammals in the RN Caatinga, most of them listed by the IUCN (2007) and the Brazilian Environment Ministry (Brasil/MMA 2003) (see Table 3) as non-threatened.

According to Kinzey (1997), the primate order in RN is represented by three species and three families: *Callithrix jacchus* (Callithrichidae), *Alouatta belzebul* (Atelidae), and *Cebus libidinosus* (Cebidae) (although a question mark indicates the absence of an official record of *Cebus* in RN). In this paper, we present the first official record of two *Cebus* species in RN, *C. libidinosus* and *C. flavius*, and refine the distribution limits for both species.

Methods

Between January 2006 and October 2007, 12 expeditions (of 5 days each) to different regions of the RN Caatinga were conducted to locate remnant *Cebus* groups. Regions were chosen based on habitat conservation status indicated on satellite images. We interviewed local residents (small farmers and hunters) using a semi-structured questionnaire, taking names, time of residence in that area, economic activity, and other socio-economic data (see Table 1). During the interviews, we showed them two plates with pictures *Cebus* (*libidinosus*, *flavius*), *Alouatta*, and *Callithrix* species so they could indicate which of them had been observed in the surroundings, their areas of occurrence,

Table 1 Summary of interviews

Number of interviews	Mean (min–max) family size[a]	Occupation (jobs)[b]	Characteristics of the houses[c]	General Information
35 (27 families, 8 single or divorced)	6.2 (4–11)	7 (20%) retired 18 (51%) local agriculture/pecuarist (corn, manihot, and cattle) 5 (14%) city council employees (environment secretary) 5 (14%) city jobs (hostel owner, snack bar employees, local trail guides for tourists, teacher) Mean salary: R$600.00 (US $400.00) per month[d]	36% own house 50% toilet outside[e] 90% two bedroom, one living room, one kitchen[e]	All families have lived in the area for at least 5 years; 28% of the families have lived in the area for at least 20 years Three men are active hunters; one of them said he "used to" hunt capuchins to consume as meat At Jucurutu, one elderly lady said she has seen capuchins since she was a kid (at least 60 years) Two families have a capuchin as a pet (see electronic material), and another two families reported having had capuchins as pets

[a] Including father, mother, and children

[b] These relative values represent the summary of interviews, not proportion of whole population; we biased our sample to local agriculture/pecuarist due to their vicinity to possible areas of occurrence of capuchins

[c] Private owned and toilets within the house indicate wealth

[d] Considering rate of US $1.00 = RS $1.5 values refers to period of data collection (2006–2007)

[e] Of 28 houses observed, seven interviews were conducted outside houses, so proper assessment of house characteristics could not be conducted

how long these animals had been in this area, and some other information about the habits of animals (e.g., crop raiding, sleeping areas). As a negative control, plates also included pictures of primates that have never occurred in the area (e.g., *C. xanthosternos*, *Brachyteles arachnoides*).

When the presence of *Cebus* was indicated in the interviews we would proceed to conduct active surveys in the areas to observe *Cebus* or remains of their presence (i.e., tool use sites). On these surveys, we followed hunters' trails for 3 days, but the size of the area sampled varied according to weather and terrain conditions and whether or not we found a positive indicator of *Cebus* presence. Based on previous records of tool use by *Cebus* species in Caatinga environments (Fragaszy et al. 2004; Moura and Lee 2004; Visalberghi et al. 2007), we recorded this evidence to infer the presence of capuchins. We considered a tool use site one or some small stones with marks of use (i.e., hammers) on top of larger stones (i.e., anvils) with cracked seeds scattered around. We did not consider sites without broken seeds to be tool use sites, even if there were hammers and anvils with wear-marks This hammer-anvil-cracked seed set is clearly different from the random, scattered distribution of stones on the environment. We considered monkeys to have used these sites because (1) according to the interviews the local inhabitants do not crack nuts in this way, but do report monkeys cracking nuts this way, and (2) the cracked nuts we found were of the same species (*Atallea* and *Siagrus*) cracked by *C. libidinosus* at other locations (Fragaszy et al. 2004; Visalberghi et al. 2007). We also recorded direct observations of other mammals, and proof of their presence, such as feces, tracks, and carcasses.

Results

Local inhabitants indicated the presence of capuchins in ten out of 17 areas visited (Table 2). In four of these we recorded evidence of their presence (tool use sites), and in two we were able to observe and count the number of animals in the group (see Fig. 1).

In Martins (Fig. 1, Table 2), we counted a group of 53 *Cebus libidinous* on October 15, 2006, including adult males and females and several immature individuals. On December 3, 2006, the group was resighted and a juvenile was followed for 10 min. *C. jacchus* is a sympatric primate species in this area.

The animals were observed ranging on a privately owned hill at approximately 750 m a.s.l. At this altitude, temperature varies between 16 and 25°C, with a mean yearly rainfall of 1,100 mm. Local vegetation is classified as arboreal Caatinga (i.e., trees between 3 and 6 m in height), but large fruit trees are rare, except for two introduced mango trees. The lower slope of the hill is surrounded by maize fields which, according to interviews with the local people, are regularly invaded by capuchins during harvest time. There is an abundance of stones and pebbles of all sizes and weights due to the granitic nature of the region, which hinders access to the area where the monkeys were observed.

In Jucurutu (Fig. 1, Table 2), we observed a group of at least 45 *Cebus flavius* on August 28, 2006, and September 7, and 16, 2007. The group was composed of adult males, adult females, and several immatures (Fig. 2). Stone tool sites were also recorded (Ferreira et al. in prep.). Interestingly, *C. jacchus* was not observed at this site in any of the visits or reported in the interviews.

Table 2 Surveyed localities and type of evidence obtained for the occurrence of *Cebus* species

No./id.	Municipality	Coordinates (SAD 69 Fuse 24)	Type of evidence
1	Jucurutu	9314281.085962S 717612.15150683W	OBS[a], TUS
2	Martins	9329300.1289646S 621729.31200182W	OBS[b], TUS
3	Portalegre	9327464.8066295S 618036.48735789W	TUS
4	Luiz Gomes	9294375.1598416S 570041.77622764W	TUS
5	Serrinha dos Pintos	9316419.4471446S 612481.97802551W	REP
6	Major Sales	9292525.5636023S 575569.19183413W	REP
7	José da Penha	9301730.6873532S 581111.99072978W	REP
8	Marcelino Vieira	9305399.2235842S 592179.31957447W	REP
9	João Dias	9307158.9854213S 634591.36806459W	REP
10	Frutuoso Gomes	9320070.9064568S 629087.85615082W	REP
11	Caicó		No occurrence
12	Assu		No occurrence
13	Currais Novos		No occurrence
14	Parelhas		No occurrence
15	Carnauba dos Dantas		No occurrence
16	Serra do Mel		No occurrence
17	Mossoró		No occurrence

No GPS points collected on localities with negative occurrence of *Cebus*

OBS direct observation; *TUS* tool use site; *REP* reported by inhabitants

[a] *Cebus flavius*

[b] *Cebus libidinosus*

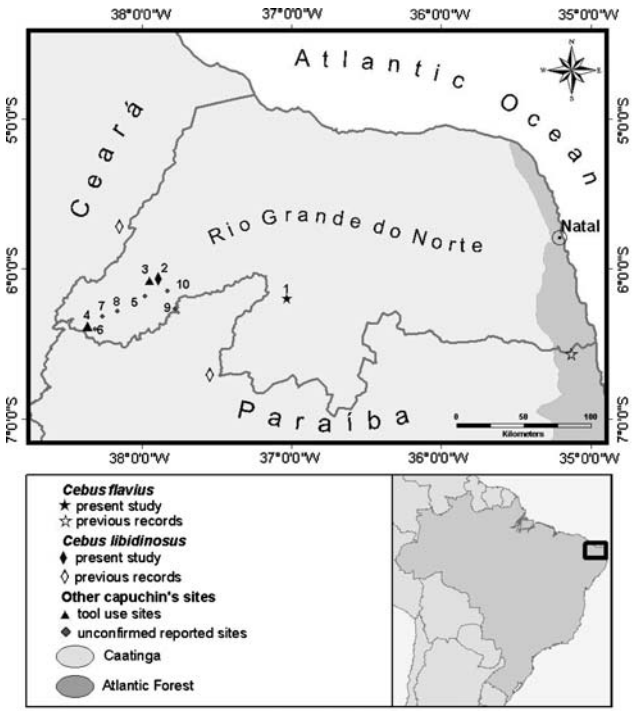

Fig. 1 Occurrence sites of *Cebus* in the RN Caatinga. Sites are identified as in Table 2

Fig. 2 Group of *C. flavius* at arbustive Caatinga (Jucurutu, RN, Brazil) (photo by A. Roque)

These *Cebus flavius* were observed on a private property of 750 ha (maximum height of 680 m), which has been protected by the owners for at least 30 years, and which was officially registered as a Private Ecological Sanctuary (Reserva Particular do Patrimônio Natural "Stoessel de Brito") in 1986. The area is located in a difficult-to-access range of hills (Serra do Estreito) and vegetation is classified as arbustive (bush) Caatinga (i.e., trees 1–3 m height and deciduous leaves).

Evidence of the presence of seven additional non-flying mammal species was found in the visited areas. Furthermore, the occurrence of seven other mammals was reported by local people, including four previously unrecorded in the RN Caatinga (*Monodelphis domestica*, *Gracilinanus agilis*, *Leopardus pardalis*, *Leopardus wiedii*) and the vulnerable (Brasil/MMA 2003) *Puma concolor* (Table 3).

Discussion

Up to the present time, *Cebus libidinosus* has been considered to be the only *Cebus* species occurring in Rio Grande do Norte, given its presence in the Caatingas of the neighboring states of Paraíba and Ceará (Silva Júnior 2001). However, museums contain no *Cebus* specimens collected in RN, nor are there up-to-date reports of capuchins in this state. Therefore, the present record of *C. flavius* not only broadens the diversity of known primates in RN but also records the first primate species at critical risk of extinction in the state.

The Stoessel de Brito ecological sanctuary is now the northernmost and westernmost area of occurrence of *Cebus flavius*. The previous northern limit of *C. flavius* was a forest fragment in the Associação dos Plantadores de Cana-de-Açúcar—Asplan (6°31′12.7″; 35°8′29.32″W), municipality of Camaratuba, in the coastal forest of Paraíba, and the former westernmost limit was Passo de Camaragibe (9°14′S; 35°30′W), in the coastal forest of Alagoas (Oliveira and Langguth 2006), areas far from Caatinga formations.

All the regions where *Cebus* (or evidence of their existence) were sought or were indicated to occur belong to a series of mountains which, before human encroachment, were covered with arboreal caatinga and Atlantic Forest remnants in interior areas after the Pleistocene retraction of the Amazonian forest. More recently, vegetation composition has been changing to more xerophytic arbustive Caatinga formation and some near-desert areas after 200 years of human influence (Oliveira et al. 2005).

Currently, these areas have similar characteristics: they are rocky vertical hills difficult to access by both humans and other large mammals (i.e., cattle and sheep), but near maize fields, from which capuchins (*Cebus libidinosus* but not *C. flavius*) are said to steal food frequently. This indicates capuchins may have been forced into these regions due to increased human occupation of nearby areas and therefore may be adopting alternative habits to ensure survival, including tool use behavior. The area where *C. libidinosus* was found still contains patches of arboreal caatinga while that occupied by *C. flavius* is exclusively arbustive caatinga. The size of the observed groups is also larger than that described for other areas occupied by

Table 3 List of non-primate mammals recorded in the RN Caatinga during the present study and type of evidence obtained for their occurrence

Order	Family	Species	Common name (Portuguese/English)	Type of evidence
Didelphimorphia	Didelphidae	*Monodelphis domestica*	Rato-cachorro/Gray Short-tailed Opossum	REP
Didelphimorphia	Didelphidae	*Gracilinanus agilis*	Cuíca-pequena/Agile Gracile Opossum	REP
Cingulata	Dasypodidae	*Euphractus sexcinctus*[a]	Tatu/Yellow Armadillo	OBS
Cingulata	Dasypodidae	*Tolypeutes tricinctus*[a]	Tatu-bola/Brazilian Three-banded Armadillo	CRC
Pilosa	Myrmecophagidae	*Tamandua tetradactyla*[a]	Tamanduá-mirim/Southern Tamandua	TRK
Artiodactyla	Cervidae	*Mazama* sp.[a]	Veado/Brocket Deer	REP
Carnivora	Canidae	*Cerdocyon thous*[a]	Raposa/Crab-eating Fox	REP
Carnivora	Procyonidae	*Procyon cancrivorus*[a]	Guaxinim/Crab-eating Raccoon	TRK
Carnivora	Felidae	*Leopardus pardalis*	Jaguatirica/Ocelot	REP
Carnivora	Felidae	*Leopardus wiedii*	Maracajaçu/Margay	REP
Carnivora	Felidae	*Puma concolor*[a]	Onça-parda/Cougar	REP
Rodentia	Caviidae	*Kerodon rupestris*[a]	Mocó/Rock Cavy	FCS
Rodentia	Caviidae	*Galea spixii*[a]	Preá/Spix's Yellow-toothed Cavy	FCS
Rodentia	Dasyproctidae	*Dasyprocta prymnolopha*[a]	Cutia/Black-rumped Agouti	FCS

OBS direct observation, *CRC* carcass, *FCS* feces, *TRK* tracks, *REP* reported by inhabitants

[a] Also cited by Porpino and Silva (submitted)

Cebus libidinosus and *C. flavius* and larger than that of subgenus *Sapajus* groups in general (Ferreira 2003 for review of size and social dynamics of *Cebus*).

Considering this is the first record of *C. flavius* in the Caatinga, one hypothesis is that the presence of the monkeys in the area could be the result of the release of exogenous animals in this area. However, interviews with local people and with environmental agencies indicate there were no official releases in these areas. Additionally, elderly local inhabitants reported that these capuchins have been present for at least 40 years.

Hitherto, it was thought that *Cebus flavius* followed a parapatry pattern in relation to *Cebus libidinosus* similar to that observed in other northeastern Brazilian primates. Titi monkeys (*Callicebus coimbrai* and *Callicebus melanochir*) have distributions restricted to the Atlantic Forest, whereas *Callicebus barbarabrownae* is typical of the Caatinga, distribution being parapatric in both of these areas (Jerusalinsky et al. 2006). The present record of *C. flavius* refutes what was proposed by Oliveira and Langguth (2006) that this species was restricted to the Atlantic Forest and indicates that this species can also occupy environments in the Caatinga biome.

There are a number of populations of another critically endangered capuchin, *Cebus xanthosternos*, in the Atlantic Forest of eastern Bahia and Sergipe states, and several populations are also known in Caatinga-like environments in western Bahia (Kierulff et al. 2005). However, contact with other *Cebus* species is limited by rivers, unlike what is seen for *C. flavius* and *C. libidinosus*. This highlights the importance of investigating the factors that are limiting the distribution of *Cebus flavius* and *C. libidinosus*, since they are neither restricted to a particular biome nor limited by any apparent physical barriers.

This *C. flavius* population may be a rare example of a process of geographic distribution retraction, similar to that proposed for *Alouatta belzebul*. The restricted distributions of *C. flavius* and *A. belzebul* are associated to an overall retraction of the Atlantic Forest in northeastern Brazil, due to natural and anthropogenic events (Oliveira et al. 2005). The present records demonstrate that *C. flavius* distribution is less restricted than previously thought, and broadens our knowledge of the diversity of habitats that the species is able to occupy. Remarkably, these data reveal the co-relation between Caatinga (savannah like) environments and tool use behavior by another *Cebus* species. This finding indicates the importance of further studies of the species in the Caatinga, and suggests that this biome be included in management scenarios for species conservation as well as for more detailed studies regarding tool use capabilities in *Cebus*.

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