

Reconsidering mammal extinctions in the Pernambuco Endemism Center of the Brazilian Atlantic Forest: a critique

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Abstract

Reconsidering mammal extinctions in the Pernambuco Endemism Center of the Brazilian Atlantic Forest: a critique. This is a reply to the critique made by Garbino et al. (2018) to our article (Mendes Pontes et al., 2016) in which we revealed an unprecedented mass extinction event in the Pernambuco Endemism Center (CEPE) and with which they disagreed. Here we critically review their arguments, and present incontrovertible evidence that the processes presented in our 2016 paper are real events. Additionally, we discuss the importance of providing up-to-date scientific data to prove the existence of a species, and the critical importance of historical records in formulating a better understanding of the mammalian diversity of the CEPE. We point out that a more rigorous approach towards historical and recent records is needed when producing checklists of CEPE mammals, given that ignoring evidence and allowing personal opinion to prevail may lead to loss of credibility and jeopardize conservation efforts.

Key words: Mass extinction, Pernambuco Endemism Center, Atlantic forest of northeastern Brazil, Medium-sized and large mammals, Conservation

Resumen

Reconsiderando las extinciones de mamíferos en el Centro de Endemismo de Pernambuco del bosque atlántico del Brasil: una crítica. Presentamos la respuesta a la crítica formulada por Garbino et al. (2018) a nuestro artículo (Mendes Pontes et al., 2016), en el que revelamos una extinción en masa en el Centro de Endemismo de Pernambuco (CEPE), de la que discreparon. En este artículo examinamos sus argumentos de forma crítica y exponemos pruebas irrefutables de que los procesos presentados en nuestro artículos de 2016 son acontecimientos reales. Asimismo, analizamos la importancia de aportar datos científicos actualizados para demostrar la existencia de una especie y la trascendencia de mantener registros históricos para comprender mejor la diversidad de mamíferos del CEPE. Señalamos la necesidad de abordar de una manera más rigurosa los registros históricos y recientes a la hora de confeccionar listas de comprobación de los mamíferos del CEPE, ya que pasar por alto las pruebas y dejar que prevalezca la opinión personal puede conllevar una pérdida de credibilidad y poner en peligro las iniciativas de conservación.

Palabras clave: Extinción en masa, Centro de Endemismo de Pernambuco, Bosque atlántico del nordeste del Brasil, Mamíferos de talla mediana y grande, Conservación

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General considerations

In reply to the critique made by Garbino et al. (2018) to our article (Mendes Pontes et al., 2016) we here critically review their arguments regarding three issues. First, Garbino et al. (2018) repeatedly use the word 'locally' to refer to regional species extinctions in the Pernambuco Endemism Center.

They repeatedly use the word 'locally' while simultaneously acknowledging that the species are, in fact, extinct in the entire region, which per se would be characteristic of a 'regional extinction' (linear distance 200–2,000 km; Peterson et al., 2011). In other words, if, for example, jaguars (*Panthera onca*) are confirmedly extinct in the CEPE, this means a total decrease in their former geographic range of ~56,000 km², which was the original size of the CEPE. What's more, if we consider them extinct in both the CEPE (this study) and in the Bahia Endemism Center (CEBA) (Canale et al., 2012), this means a total decrease of almost 90,000 km² in the species' former geographic range. Such figures highlight the critical importance of understanding the true dimension of these regional extinctions for effective species conservation.

On correctly estimating the extent of the anthropogenic destruction of the CEPE: the detrimental use of old figures/references by Garbino et al. (2018) rather than the more recent data used by Mendes Pontes et al. (2016):

Citing Ribeiro et al. (2009), Garbino et al. (2018) says that approximately 12% of the original vegetation currently remains in the CEPE.

Although we recognize the importance of the study by Ribeiro et al. (2009) and, indeed, referred to this in our 2016 study, the rate of deforestation in the CEPE is both extremely rapid and unceasing (Melo, 2009), and in the intervening near-decade the scenario will without doubt have changed for the worse. In consequence, the data used in our study (Mendes Pontes et al., 2016) were more recent and based on up-to-date satellite images. This more recent evaluation reveals that only 5.6% of the original forest remained at the time of the publication (a total loss of 94.4% of the original ~56,000 km² of pristine forest), a figure that was not considered by Garbino et al. (2018), but that is a bad enough scenario to have an extremely negative effect on conservation initiatives.

On the unquestionable validity of the old literature and paintings of the 16th and 17th century's first colonists of the Atlantic coast of northeastern Brazil, when analysing the composition of the former mammalian fauna in the CEPE (Gandavo, 1980; Salvador, 1975; Marcgraf and Piso, 1942; Falcão, 1964; Brandão, 1980; Vasconcelos, 1981; Marcgraf, 1995):

Garbino et al. (2018) sometimes accept (e.g. the case of the blond capuchin, *Sapajus flavius*), sometimes refute (e.g. the case of the deer, *Mazama* spp.), and sometimes seem not to have had access to these above mentioned invaluable references (e.g. the case of the bush dog, *Speothos venaticus*). Such historical materials are invaluable testimonies of the original

condition that these highly skilled and observant 16th and 17th century colonists/artists/naturalists found in the Atlantic coast of northeastern Brazil, in what are now the states of modern-day Pernambuco, Paraíba, Alagoas, and Rio Grande do Norte.

Such valuable historical documents have been used in various regions to validate the occurrence and/or extinction of species, such as in West Indies, where several species of macaw were reported and depicted, and from which scientists became aware of their extinction (Wiley and Kirwan, 2013). But we do not have to go too far in order to find appropriate examples of the contribution of these colonists to current taxonomy and conservation. Marcgraf and Piso (1648) described what is evidently a curassow of the genus *Crax* with a yellow beak, which has never been recorded in the Atlantic forest of northeastern Brazil. These plates and paintings were considered unambiguous evidence of the disappearance of an undescribed species.

The importance of their works is incommensurable and greatly important for our better understanding of the mammalian fauna originally in the CEPE when they first arrived. In fact, they are the only reference that we have of the occurrence of most large mammals (Jaguars, pumas, *Puma concolor*, tapirs, *Tapirus terrestris*, white-lipped peccaries, *Tayassu pecari*, giant ant-eater, *Myrmecophaga tridactyla*, among others) that were made from direct observation of the species in the wild, since they went extinct before contemporary scientists could record them. All the other references to the CEPE is via extrapolation (see Mendes Pontes et al., 2016).

On the allegedly faux absences

Leopardus wiedii

Garbino et al. (2018) state: "Feijó and Langguth (2013) mention the margay, *Leopardus wiedii*, in two localities in PEC: Roteiro (Alagoas), and Alhandra (Paraíba)." Feijó and Langguth (2013) is, therefore, the reference supposedly to prove the occurrence of the species in the CEPE, but this is a reference entirely based on museum specimens (dead individuals) that have been deposited in the scientific collections and that *per se* does not prove that the species is still extant in the CEPE.

Cabassous unicinctus

Garbino et al. (2018) state: "The naked-tailed armadillo, whose species occurring in CEPE is *Cabassous tatouay*, not *C. unicinctus* as reported by Mendes Pontes et al. (2016), was recorded, based on voucher specimens, in two localities in CEPE (Feijó and Langguth, 2013)." Again, Feijó and Langguth (2013) is, therefore, the reference supposedly to prove the occurrence of the species in the CEPE, but this is a reference entirely based on museum specimens (dead individuals) that have been deposited in the scientific collections and that '*per se*' does not prove that the species is still extant.

The species has not been detected recently through proper surveys/census, or any other method that prove that the species is still extant (e.g. camera trap). Our assertion that *C. unicinctus* is extinct in the CEPE is therefore well supported.

Cyclopes didactylus

Garbino et al. (2018) assert that "There have been several recent records of the pygmy anteater, *Cyclopes didactylus*, for the region (Gardner, 2008; Miranda and Superina, 2010; Feijó and Langguth, 2013)."

However, the use of records in Feijó and Langguth (2013) is problematic for *Cyclopes didactylus* since, as with previous examples, the records in the CEPE, are based solely on museum specimens, that is to say, dead individuals. Regarding the "Several recent records of the pygmy anteater" mentioned by Garbino et al. (2018), the most recent of these records is Miranda and Superina (2010), who collected their information through interviews and questionnaires in the five years prior to the publication of their study, that is to say, between 2005 and 2009 (11 years before our study (Mendes Pontes et al., 2016), in which we surveyed old and recent literature, and also carried out recent field surveys).

Thus, there is more than a ten-year delay between the last opportunistic records of *Cyclopes didactylus* in the CEPE and the systematic line transect surveys carried out by our group. In a highly devastated scenario such as the CEPE, where deforestation and hunting is rampant and uninterrupted –while simultaneously being almost totally ignored by authorities– this is more than enough to have caused the species to have gone extinct. Our results are merely the confirmation of what should be expected in such a neglected hotspot.

Alouatta belzebul

Garbino et al. (2018) says: "The red-handed howler monkey, *Alouatta belzebul*, which is considered Vulnerable by the IUCN Red List, is still widespread at CEPE (Fialho et al., 2014)."

Fialho et al. (2014) carried out literature surveys, questionnaires, and also field inventories, and could confirm the presence of *Alouatta belzebul* in five localities in the CEPE. Their inventories, nevertheless, took place between 2006 and 2009, around 12 years ago, which *per se* do not prove that the species is still extant.

Recent field surveys, nevertheless, revealed a remnant population in the State of Pernambuco, which has been systematically studied (Campelo et al., 2015; Silva, 2015; Silva et al. 2015a, 2015b), which is a valid evidence of the existence of the species in the wild. This species, therefore, should be removed from the list of extinct species of the CEPE.

Lontra longicaudis

Garbino et al. (2018) affirm that: "Nevertheless, the Neotropical otter, *L. longicaudis*, was recently recorded in nine localities in CEPE by Astúa et al. (2010), Feijó and Langguth (2013) and Toledo et al. (2014)."

Although we recognize the importance of the sightings of *Lontra longicaudis* that have been made over the last three decades in the CEPE (Percequillo et al., 2007; Astúa et al., 2010), it is almost a decade since that the last record was made (Astúa et al., 2010), and, as previously stated, they do not prove that the species is still present. Thus, until further extensive field surveys are carried out and direct evidence of the existence of the species is made (e.g. direct sightings; camera-trap), it is reasonable to think that the species is extinct.

On the allegedly faux presences

Tolypeutes tricinctus

Garbino et al. (2018) state: "The open-area dweller three-banded armadillo, *Tolypeutes tricinctus*, do not occur naturally in the CEPE. The distribution of the genus *Tolypeutes* was recently revised based on interviews, direct observations, fossil, historical and recent records up to 2013 (Feijó et al., 2015), and all 168 records of *Tolypeutes tricinctus* were restricted to the Caatinga scrubland (Brazilian ecosystem adjacent to PEC) and Cerrado savanna of northeastern Brazil."

Feijó et al. (2015), on which their arguments are based, nevertheless, recognize that:

"Until now there has been no systematic mapping of the known localities, nor any reliable analysis of possible zoogeographic barriers.";

"The distributional areas of *T. tricinctus* have been poorly surveyed, and this problem is exacerbated by the ongoing extinctions of local populations.";

"Excluding the indirect records and the fossils, only 27 (16%) localities have been recorded reliably over the past 104 years.";

"The geographic distribution of *T. tricinctus* is even less well defined than that of *T. matacus*... ..with extensive lacunas in peripheral areas, impeding a more conclusive interpretation of possible barriers to dispersal.";

"Known localities are predominantly within the domain of the Caatinga scrub, adjacent Cerrado savanna, which suggests a preference for open and / or semi-arid habitats.";

Thus, the fact that the distributional range of *T. tricinctus*, as given by Feijó et al. (2015), is currently limited to the east by the Atlantic forest biome could well be a sampling issue, one which is exacerbated by the ongoing and historical mass extinction processes within the CEPE (Mendes Pontes et al., 2016).

We assumed that *T. tricinctus* once occurred in the Atlantic forest of the CEPE in Mendes Pontes et al. (2016) because it is referred and also depicted by Marcgraf in 1648, in pg. 33 of *Libri Principis* (Marcgraf and Piso, 1942) (fig. 1). Marcgraf says: "These are armored animals and they are able to pull in the head and paws, doubling themselves into a ball", and the only armadillos capable of rolling into a ball are those of the genus *Tolypeutes* (Eisenberg and Redford, 1999). Marcgraf worked specifically on the Atlantic coast of Pernambuco, describing and illustrating the

local fauna, and producing an undeniably unique contribution to the knowledge of the former mammalian fauna of the CEPE.

We believe that *T. tricinctus* may have been extirpated from the Atlantic forest of the CEPE before contemporary scientists could detect them, but point to the evidence in the illustrations of earlier authors. To ignore the reference and plate that Marcgraf provided of *T. tricinctus* in the CEPE and simply state that there is a 'lack of evidence' (Garbino et al., 2018) regarding their occurrence in the region is to ignore this key evidence and let personal opinion and hypothesis prevail over evidence.

Conepatus semistriatus

Although included by Mendes Pontes et al. (2016), Garbino et al. (2018) removed the striped hog-nosed skunk, *Conepatus semistriatus* (listed as *Conepatus amazonicus*) from their CEPE check list, citing lack of evidence.

We contest this removal. Both Emmons and Feer (1997) and Kipp (1965) believe the species (whether treated as *C. semistriatus* or *C. amazonicus*) occurs in the CEPE region, and that it is not restricted to dry, arid environments. Emmons and Feer (1997) reported that they occur in tropical rainforests, secondary and disturbed forests, clearings, and even gardens. Thus, given their absence in our surveys, we assume that *C. semistriatus* (*C. amazonicus*) once occurred in the PEC, but has now been wiped out from the region.

Speothos venaticus

In addition to the *Conepatus*, Garbino et al. (2018) also consider that the bush bog, *Speothos venaticus*, has no records within the CEPE. This assertion is made despite the evidence presented by Mendes Pontes et al. (2016) that the species was mentioned in historical documents from the 16th and 17th centuries.

While it is true that there are no known recent historical or extant records of *S. venaticus* for CEPE (see Feijó and Langguth, 2013; Fernandes-Ferreira, 2014), earlier records certainly exist. In the third paragraph of page 223, book IV, of History of Quadrupeds and Serpents, in *Historiae Naturalis Brasiliae* (Marcgraf and Piso, 1942), a detailed description is made of a *cachorro-do-mato* (bush-dog). In this case, Garbino et al. (2018) seems to have overlooked this historical record. But based on this evidence, the bush dog once occurred in the CEPE and has subsequently become extinct.

As Garbino et al. (2018) themselves point out, the potential occurrence of the bush dog in CEPE has been suggested by a study that inferred the habitat suitability for the species through ecological niche modelling (DeMatteo and Loiselle, 2008).

Dasyopus septemcinctus

Garbino et al. (2018) also challenge the proposal by Mendes Pontes et al. (2016), that the lesser long-nosed armadillo, *Dasyopus septemcinctus*, once

occurred in the CEPE. They point out that occurrence records of the lesser long-nosed armadillo are very scarce for northeastern Brazil, and that of the states that comprise the PEC, the species has only been recorded for the Caatinga of Pernambuco (Feijó and Langguth, 2013).

However, the mammal fauna of the CEPE remained virtually unknown for more than 500 years, and therefore, rarity and lack of records cannot be used as a reliable surrogate for absence. Accordingly, we follow Eisenberg and Redford (1999) and consider the species as one that was (at least originally) present in the CEPE. That all records from Feijó and Langguth (2013) are concentrated in the dry scrub Caatinga of Pernambuco is, we consider, likely to be a mere reflection of collection efforts.

Mazama spp. EX BK (extinct before known) (Mendes Pontes et al., 2016).

Garbino et al. (2018) state: "Mendes Pontes et al. (2016) reported two supposedly undescribed species of *Mazama* for CEPE. However, there is neither historical nor current evidence that there existed another species of *Mazama* in the CEPE besides *Mazama guazoubira* (Feijó and Langguth, 2013), although it is currently extinct there."

As stated by Lees and Pimm (2015), the 1648 *Historia Naturalis Brasiliae* by Georg Marcgrave and Willem Piso (Marcgraf and Piso, 1942), represented a pioneering attempt to catalogue the vast biodiversity of the Atlantic coast of northeastern Brazil. Its pages contain compelling evidence for historical extinctions. The same can be said of the works of Zacharias Wagener, who also worked in the CEPE between 1634 and 1641, when the Dutch ruled Pernambuco (Falcão, 1964). Both books described and depicted two different species of deer from the CEPE that have never been seen by contemporary scientists. As no material was collected, these texts and plates become the only evidence of the existence of these two species.

It is important to note that these two deer species had features distinguishing them very clearly from any extant species. The plate in Marcgraf and Piso (1942: see fig. 2) depicts an adult deer with a gray head and neck, and red body. The other, although the plate is in black and white, shows an adult deer with conspicuous white spots along the belly (Falcão, 1964: see fig. 3).

Thus, we conclude that these two deer species went extinct without being recorded by contemporary scientists. We proposed the category EX BK 'Extinct Before Known' in Mendes Pontes et al. (2016) to distinguish it from other IUCN categories and criteria, which do not include species that went extinct before becoming known to recent scientists and being scientifically described by them.

Ateles sp. EX BK

Garbino et al. (2018) state: "The authors based the presence of a spider monkey (*Ateles* sp.) in northeastern Brazil in a Portuguese translation of the work of

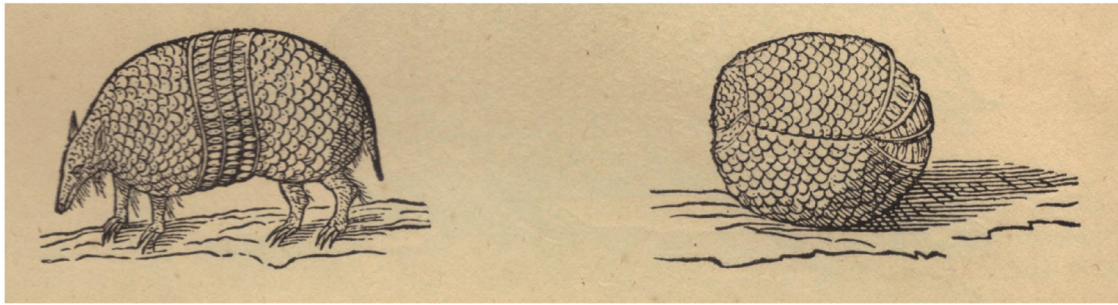


Fig. 1. *Tolypeutes tricinctus* from Marcgraf and Piso (1942), plate 680.

Fig. 1. *Tolypeutes tricinctus* de Marcgraf y Piso (1942), ilustración 680.

Caspar van Baarle, (latinized as Caspar Barlaeus in publications), about the Dutch possessions in Brazil, made by Claudio Brandão (Barlaeus, 1940). Brandão stated in a translation note that the name Cajatayae, used by Barlaeus to describe a long-tailed reddish monkey, was similar to the word Coatá, the name commonly used for the spider monkeys, genus *Ateles*."

"Marcgrave (1648), however, described a monkey called Caitaia, a name that resembles Barleus's Cajatayae. The animal described by Marcgrave as Caitaia has been considered as *Sapajus flavius*, a capuchin monkey still extant in PEC, especially due to the reference to the yellowish color of its pelage (Oliveira and Langguth, 2006). Moreover, *cay* or *cai*, as in caitaia, is the name of capuchin monkeys in the indigenous language Tupi-Guarani."

"Recent re-discovery of animal drawings made by the artist Frans Post in the Dutch Brazil area revealed an *Ateles*-like monkey among the depicted fauna (De Bruin, 2016). It is very improbable that naturalists such as Georg Marcgrave or Wilhelm Piso would have failed to detect a population of large-bodied spider monkeys in northeastern Brazil (Marcgrave, 1648)."

"A more probable explanation is that the animal illustrated was obtained elsewhere, as transportation of primates was common in the colonial Americas (Browne, 1789; Teixeira and Papavero, 2010)."

Scientific evidence from Marcgrave (1648), Barlaeus (1940), and De Bruin (2016), nevertheless, reveals that Barlaeus and Frans Post are undeniably referring to a spider monkey, genus *Ateles*, in the CEPE, whereas Marcgraf, in turn, is referring to a capuchin monkey, genus *Sapajus*. Personal opinions and interpretations should only add confusion and jeopardize the efforts to unveil the true biological diversity of this unique region. The discovery of Frans Post's spider monkey (fig. 4) is the confirmation that spider monkeys may once have lived in the CEPE, but were extinct, as was the case also with so many other species known and unknown.

Furthermore, we do not believe that "the animal illustrated was obtained elsewhere, as transportation of primates was common in the colonial Americas

(Browne, 1789; Teixeira and Papavero, 2010) (Garbino et al., 2018)", because in the referred works it was very common that whenever a described/depicted animal was from elsewhere, that they mentioned its origin, such as is the case in many plates by Marcgraf and Wagener, in which they refer to them as from Angola, Mozambique, and Guinea (Marcgraf and Piso, 1648; Falcão, 1964).

Saimiri sp. EX BK

Garbino et al. (2018) say that: "According to Mendes Pontes et al. (2016), Pero de Magalhães Gandavo (Gandavo, 1924) and the Franciscan friar Vicente do Salvador (Do Salvador, 1889) mentioned the presence of squirrel monkeys, *Saimiri* sp., in the CEPE. In both works, there is no reference to animals morphologically similar to squirrel monkeys, and, more importantly, according to Capistrano de Abreu (in Gandavo, 1924), Gandavo never visited Pernambuco."

"We believe that Mendes Pontes et al. (2016) assigned some monkeys described in Gandavo (1924) and in do Salvador (1889) to *Saimiri* due to the characteristic odor, mentioned by the two Portuguese authors. Probably, Mendes Pontes et al. (2016) associated the presence of odoriferous glands with the common name of *Saimiri* in Portuguese, 'mico-de-cheiro', which means 'monkey with odor'. However, the presence of scent glands is widely distributed in New World monkeys (Perkins, 1975; Heymann, 2006). Marcgrave (1648, p. 227), for example mentions a 'musky odor' for *Sapajus flavius*. The genus *Saimiri* is endemic from the Amazon basin and Central America (Groves, 2001), and therefore squirrel monkeys were not historically present in the PEC."

We referred to *Saimiri* as occurring in the CEPE because, according to Barlaeus (Brandão, 1980), the not-so-large squirrel monkey that Gandavo (1980) and Salvador (1975) refer to is, in fact, a *Saimiri sciureus* (called by them *jurupixuma*, or *Saimiris sciurea*), which has yellow-olive fur and a very long tail. Thus, we believe that this is an unequivocal reference to squirrel monkeys in the CEPE.



Fig. 2. A species of cf *Mazama* sp. depicted by Marcgraf (Marcgraf and Piso, 1942) in the CEPE.

Fig. 2. Una especie de *Mazama* sp. dibujada por Marcgraf (Marcgraf y Piso, 1942) en el CEPE.

Sapajus (Cebus) apella

Garbino et al. (2018) say: "The equivocal inclusion of '*Cebus apella*' (a species that is now classified in the genus *Sapajus*) in CEPE fauna by Mendes Pontes et al. (2016) apparently has a simpler solution. Using a now-outdated taxonomy of capuchin monkeys, Hershkovitz (1987, p. 23) mentions '*Cebus apella libidinosus*' among the mammals described by Marcgrave in CEPE."

In fact, as stated in Mendes Pontes et al. (2016), we included *Sapajus apella* among the species referred to the CEPE because they occur in the contiguous dry-scrub caatinga forests, and there are no physical barriers to their occurrence in the CEPE. Thus, we hypothesized that the species might once have been sympatric with *Sapajus flavius*. We, nevertheless, acknowledge that it is a reference based solely on a theory, and as such is prone to criticism.

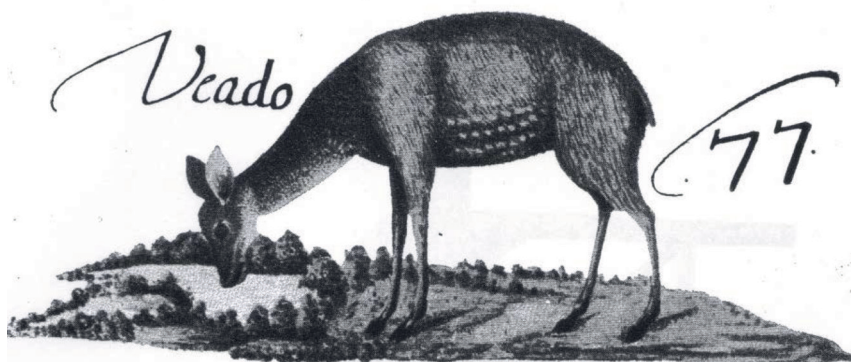


Fig. 3. A species of cf *Mazama* sp. depicted by Wagner (Falcão, 1964) in the CEPE.

Fig. 3. Una especie de *Mazama* sp. dibujada por Wagner (Falcão, 1964) en el CEPE.



Fig. 4. Franz Post's spider monkey, *Ateles* sp. EX BK from the Pernambuco Endemism Center, Atlantic forest of northeastern Brazil.

Fig. 4. Mono araña de Frans Post, *Ateles* sp. (extinto antes de conocerse) del Centro de Endemismo de Pernambuco, bosque atlántico del nordeste del Brasil.

Final considerations

This paper shows that the species list in Mendes Pontes et al. (2016) is not an overestimation, as argued by Garbino et al. (2018), but rather accurately reflects the status of the mammalian fauna of the CEPE in the 21st century. Our study was the first systematic field survey of the CEPE (besides a thorough systematic literature survey) to provide robust scientific data based solely on species presence, recorded through direct sighting of the individuals. Although museum specimens are an important source of biological information (e.g. Feijó and Langguth, 2013), they cannot be used as proxy for the current and continued occurrence of a species in an area, since the species may have been long extinct at that collection site.

We entirely agree with Garbino et al. (2018) on the pervasive consequences of taxonomic errors, false assumptions, and unreliable records for conservation and species management. That is why we based our identification of an *Ateles* sp. in the CEPE on the available evidence. And that is also why we never made assumptions that could not be validated from the literature, such as "It is very improbable that naturalists such as Georg Marcgrave or Wilhelm Piso would have failed to detect a population of large-bodied spider monkeys in northeastern Brazil" (Garbino et al., 2018), or use museum specimens to show that a species is still locally extant (Feijó and

Langguth, 2013; Garbino et al., 2018). A crucial point that seems to have escaped Garbino et al. (2018) is that a species may be present in a museum drawer, yet no longer exist in the wild.

Finally, the mass extinction process that has swept the CEPE does not benefit anyone, and it would be of incommensurable value to conservation that these extinct species were, in fact, re-discovered. In order to achieve that, however, scientists have to rely on efficient methods, such as line transects and camera traps, and not on past publications, or museum specimens.

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