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The Taxonomic Status of Wied's Black-tufted-ear Marmoset, *Callithrix kuhlii* (Callitrichidae, Primates)

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Abstract: In this paper we provide a description of Wied's black tufted-ear marmoset, or the Southern Bahian marmoset, *Callithrix kuhlii* Coimbra-Filho, 1985, from the Atlantic forest of southern Bahia in Brazil. It was first recorded by Prinz Maximilian zu Wied-Neuwied during his travels in 1815–1816. Its validity was questioned by Hershkovitz (1977, *Living New World Monkeys [Platyrrhini]*, Chicago University Press, Chicago), who considered it a hybrid of two closely related marmosets, *C. penicillata* and *C. geoffroyi*. Vivo (1991, *Taxonomia de* Callithrix *Erxleben 1777 [Callitrichidae, Primates]*, Fundação Biodiversitas, Belo Horizonte), on the other hand, while demonstrating it was not a hybrid, argued that it was merely a dark variant of *C. penicillata*. We discuss a number of aspects concerning the taxonomic history of the forms *penicillata*, *jordani*, and *kuhlii* and the validity of the form *kuhlii,* examining the supposition that it may be a hybrid, besides the evidence concerning vocalizations, morphology, pelage, and ecology. We also discuss the use of the taxonomic category of subspecies to classify the different forms of the Atlantic forest marmosets, and the circumstances prevailing for the correct assignation of the authorship of the name *kuhlii.* We conclude that *Callithrix kuhlii* is a distinct and valid taxon, today restricted to the Atlantic forest between the Rio de Contas and Rio Jequitinhonha in southern Bahia, Brazil.

Key Words: Primates, Callitrichidae, *Callithrix kuhlii*, marmoset, Atlantic forest, Brazil

Introduction

The marmosets — small, gum-eating, frugivore-insectivores of the family Callitrichidae — comprise a remarkable radiation of (currently) 14 "Amazonian" species, genus *Mico*, which range south of the Rio Amazonas and east of the Rio Madeira, south through eastern Bolivia to the northeastern chaco in Paraguay, and six "eastern Brazilian" species, genus *Callithrix*, occurring through a large part of the Atlantic forest and central savanna (Cerrado) in Brazil, north from the basin of the Rio Paraíba do Sul in the state of São Paulo to the interfluvium of the Rios Mearim and Itapecurú in the state of Maranhão (Rylands *et al.* 1993, 2000, in press; Silva Jr. 1999).

In his major revision of 1977, Hershkovitz recognized just one species of marmoset in the Atlantic forest, *Callithrix jacchus*, with five subspecies: *jacchus*, *penicillata*, *geoffroyi*, *flaviceps*, and *aurita*. These he referred to as the "Jacchus" group, or tufted-ear marmosets; as opposed to the "Argentata" group, which consists of the bare-ear marmosets, *C. argentata* (with three subspecies), and the tassel-ear marmosets, *C. humeralifer* (also with three subspecies). Seven more Amazonian marmosets have been discovered since then (Ferrari and Lopes 1992; Alperin 1993; Silva Jr. and Noronha 1998; Van Roosmalen *et al*. 1998, 2000), and taxonomic treatments subsequent to Hershkovitz (1977) have opted for the classification of all forms as distinct species (Mittermeier and Coimbra-Filho 1981; Mittermeier *et al*. 1988; Vivo, 1991; Groves 1993, 2001, 2005; Rylands *et al*. 1993, 2000, in press).

Coimbra-Filho (1971) considered that the Atlantic forest marmosets recognized by Hershkovitz (1977) should be treated as full species and not subspecies of *C. jacchus*. He also pointed out that there were two distinct subspecies of the black tufted-ear marmoset, *C. penicillata* (see also Coimbra-Filho and Mittermeier 1973). The nominate subspecies (*penicillata* [Humboldt, 1812]) Coimbra-Filho and Mittermeier (1973) ascribed to the coastal forest of southern Bahia, and the other (*jordani* Thomas, 1904) to the marmosets occurring inland in central and south-east Brazil. Hershkovitz (1975, 1977) discussed the arguments of Coimbra-Filho (1971) and Coimbra-Filho and Mittermeier (1973) at length, and concluded that the form in southern Bahia was first described by Prinz Maximilian zu Wied-Neuweid (1826), as *Hapale penicillatus Kuhlii* [*sic*], but was in fact nothing more than a hybrid between *penicillata* and the white-faced marmoset, *C. j. geoffroyi*, to the south. Mittermeier and Coimbra-Filho (1981) insisted that what they then referred to as *C. penicillata kuhlii* was in fact a valid form and possibly even a valid species. Mittermeier *et al*. (1988) maintained that the marmoset in southern Bahia was distinct, and a "good" species, *C. kuhlii*. Vivo (1991) reviewed the systematics of the marmosets and concluded that they should all be considered species, but that the form *kuhlii*, though not a hybrid, was a junior synonym of *C. penicillata*.

In this paper, we discuss a number of aspects concerning the taxonomic history of the forms *penicillata*, *jordani*, and *kuhlii* and the validity of the form *kuhlii,* examining the supposition that it may be a hybrid, besides the evidence concerning vocalizations, morphology, pelage, and ecology. We also discuss the use of the taxonomic category of subspecies to classify the different forms of the Atlantic forest marmosets, and the circumstances prevailing for the correct assignation of the authorship of the name *kuhlii.*

Simia penicillata Humboldt, 1812 and *Hapale penicillata jordani* Thomas, 1904

Humboldt (1812) described *Simia penicillata*, attributing authorship of the specific name to É. Geoffroy St. Hilaire. Geoffroy St. Hilaire (1812) described *Jacchus penicillata*, but published his monograph a few months after that of Humboldt, who placed it as a junior synonym. The author of the name *penicillata* for this species is, therefore, given to Humboldt, but its source should be sought in É. Geoffroy St. Hilaire (1812) (Hershkovitz and Rode 1947). The type, from "le Brésil," was collected by Alexandre Rodrigues Ferreira between 1783 and 1792, and taken from the Museu Real d'Ajuda, Lisbon, by É. Geoffroy Saint Hilaire in 1808 following Napoleon Bonaparte's conquest of Portugal (Carvalho 1965; Hershkovitz 1977). Although the type no longer exists (Elliot 1913), the possibility that *Simia penicillata* Humboldt was the form from southeast Bahia is denied in the original description by St. Hilaire (taken from Carvalho 1965):

> "2. Pinceau (noir). *Jacchus penicillatus* Geoff., 1812: 119. (Pelage cendré: croupe et queue annelées de brun et de cendré: une tache blanche au front: un pinceau de poils noirs et trés-longs devant les oreilles: la tête et le haut-col noirs.)"

The key features are the black head and neck (collar) and the ash color of the general pelage, not features of the marmosets from southeast Bahia. According to Vivo (1991), Spix (1823) was the first to provide a more precise locality for *Simia penicillata*—forest of low altitude in Minas Gerais. Wied-Neuwied (1826) subsequently reported *Hapale penicillatus* from southeast Bahia, giving the localities of Belmonte, Rio Pardo, and Ilhéus. Ávila-Pires (1969) pointed out that Schlegel (1876) had noted that forms from the coast (eastern Bahia) were different from those inland, but made no further inferences or comments. Hershkovitz (1977) and Vivo (1991) relate the subsequent taxonomic history of *penicillata* during the 19th century, including proposals by some authors for its synonymy, variously with *C. geoffroyi* or *C. jacchus*.

In 1901, Thomas reported on a series of skins, collected from May to July in the same year by Alphonse Robert, from the Rio Jordão, Minas Gerais. Thomas (1901) identified them as *Hapale penicillata*. Based on this material, however, Thomas (1904) subsequently described *Callithrix penicillata jordani*: type locality Araguari, Rio Jordão, Minas Gerais, 700–900 m [Ribeirão Jordão is a left bank (south) affluent of the upper Rio Paranaíba, in its upper reaches, near to the town of Araguari, 18°30′S, 48°08′W]. The holotype, an adult female (1901.11.3.9), and six paratypes, are in the British Museum (Natural History), London (Napier 1976). Thomas (1904) also described *C. p. penicillata* from "Lamarão, near Bahia," based on a series of nine specimens in the British Museum collected by Alphonse Robert in May and June 1903 (see Napier 1976; accession numbers: 9.5.8–15 and 9.5.160). Rode and Hershkovitz (1945) interpreted this as a restriction of the type locality, and this was maintained by recent authors (Cabrera 1958; Hill 1957; Ávila-Pires 1969; Hershkovitz 1975, 1977).

Rode and Hershkovitz (1945) designated as a lectotype for *Jacchus penicillata* a specimen from Goiás in the Paris Museum. They retracted this two years later, however, because the individual selected was not one of the original series examined by É. Geoffroy St Hilaire, and was referable in fact to *C. penicillata jordani* Thomas, and therefore not even available as a neotype (Hershkovitz and Rode 1947).

The exact locality of "Lamarão, near Bahia" is uncertain. In the distribution map of Hershkovitz (1968, p.567), Lamarão is placed in the north-central region of the state of Bahia on the uppermost reaches of the Rio Itapicurú (locality 292 in Hershkovitz [1968, p.567], and listed as locality 292d, "Lamarão, upper Rio Itapicurú, 10°46′S, 40°21′W, 490 meters, *Callithrix penicillata penicillata*, A. Robert, May–June, 1903, at 300 meters" by Hershkovitz [1975, p.168; 1977, p.937]). Napier (1976, p.8) gave the coordinates for the type locality as "10°45′S, 40°20′W, 300 meters", probably read from the map of Hershkovitz (1968). Kinzey (1982) gives the same coordinates as those of Hershkovitz (1977), which place this locality about 320 km northwest as the crow flies from Bahia, today the city of Salvador, capital of the state of Bahia. Vivo (1991) made no reference to the location of Lamarão.

We have been unable to identify, however, any reference to a "Lamarão" on the upper Rio Itapicurú (for example, Brazil, IBGE 1972). A town called Lamarão, however, does exist on the railway line midway between the towns of Água Fria (south) and Serrinha (north), 11°45′S, 38°53′W, northwest of Salvador, about 140 km as the crow flies (Vanzolini and Papávero 1968; Brazil, IBGE 1972). Paynter and Traylor (1991) also give this as the locality that Alphonse Robert visited in 1903: "Lamarão, Bahia, 291 m, on railroad 140 km NW of Salvador, eastern Bahia." An atlas in the British Museum (*Stieler's Hand-Atlas*, Gotha: Justus Perthes, 1905) was used by Oldfield Thomas, and contains numerous annotations in his own hand. He underlined this town of Lamarão, indicating the probability that this is the correct locality where Alphonse Robert collected the series of *C. penicillata* that he studied, although it will be necessary to check whether any field notes or publications of Robert himself might clarify the exact locality and the origin of that designated by Hershkovitz (1968, 1977).

The region immediately north of Salvador is referred to as the Recôncavo da Bahia, and contains populations of *C. jacchus* as well as hybrids between *C. jacchus* and *C. penicillata* along a narrow zone about 50 km wide (see Hershkovitz 1977; Alonso *et al*. 1987). The forests of the entire region north of Salvador well into the state of Sergipe and along the Rio São Francisco suffered widespread destruction even in the early 1500s (Coimbra-Filho and Câmara 1996). The presence of *C. jacchus* south of the Rio São Francisco along the coast as far south as Salvador (south of the Rio São Francisco) was registered even by Wied-Neuwied (1826). This may be part of their original distribution (with the hybrid zone resulting from forest destruction; see Alonso *et al*. 1987), but may also be the result of numerous, repeated introductions of *C. jacchus*. Under any circumstances, the town of Lamarão lies west of the hybrid zone identified by Alonso *et al*. (1987), and within what is considered to be the natural range of *C. penicillata*.

The general appearances of *C. p. penicillata* and *C. p. jordani* are very similar, explaining the fact that Thomas (1901) initially regarded the series of specimens collected by Alphonse Robert from the Rio Jordão as typical *C. penicillata*. Thomas (1904, pp.188–189) provides an excellent, meticulous, and clear description of the differences between the two forms, from "Lamarão, near Bahia," and from the "Rio Jordão, Province Araguay, Minas Geraes," when describing the latter. The differences are easily seen when examining the skins carefully, and his description of *C. p. jordani* is, therefore, quoted verbatim here:

> "Size averaging slightly larger than in *penicillata*. General tone of the light colour of the back buffy whitish instead of pure greyish white. Under surface with less black on the throat, this part being grey, only slightly washed with blackish; the black, however, tends to form a black central line over the sternum. Belly and anterior face of thighs strongly suffused with dull yellowish, the hairs of *penicillata* being blackish tipped with white over the whole under surface. Flank-hairs, where overhanging belly, less vividly coloured, their bases dark slaty instead of black; their next ring dull instead of vivid orange, and their subterminal dark band narrower and less conspicuous. Face less brightly picked out with black and white, the white patches below the eyes almost obsolete, and the centre line between the nostrils pale brownish white instead of pure white. Hands and feet more or less marbled with black and orange instead of clear greyish. Tail-hairs, even near its base, almost or quite without orange rings, the great majority of the hairs being simply black with white tips.
>
> Skull much as in true *penicillata*, but the middle upper incisors show a curious difference in shape; for in *jordani* they are longer, narrower, more parallel-sided, and less strongly convergent towards each other than in *penicillata*, their breadth in the latter about two-thirds their length, while it is about half in the former. [...] The yellowish aspect of the belly and inguinal region, the dulled whiteness of the nasal septum, the general absence of yellow on the tail-hairs, and the long narrow incisors are the most tangible characteristics of this inland race of the well-known *Callithrix penicillata*."

As pointed out by Vivo (1991), Thomas' (1904) arrangement of two *penicillata* subspecies was generally accepted for many years (Elliot 1913; Vieira 1955; Cabrera 1958; Hill 1957; Ávila-Pires 1969; Coimbra-Filho 1971, 1972; Coimbra-Filho and Mittermeier 1973). *Callithrix p. penicillata* was considered to be the form in the north and from the Atlantic forest of southeast and eastern Bahia, and *C. p. jordani* the form inland in the states of Goiás, Minas Gerais, and western Bahia. Auricchio (1995) maintained the division of *C. penicillata* in two subspecies, *jordani* and *penicillata*, but also recognized *C. kuhlii* (well illustrated in Plate 1, following p. 55) from between the Rio de Contas and Rio Jequitinhonha in southeast Bahia and extreme northeast Minas Gerais. *Callithrix p. penicillata*, he indicated, occurred north of the Rio de Contas to the lower and middle Rio San Francisco and along the south (right) bank of the Rio Grande (a western tributary of the Rio São Francisco), and *C. p. jordani* occurred in the states of Goiás, Tocantins, and Minas Gerais.

Hershkovitz (1968, 1975, 1977), however, was discordant in considering *penicillata* (which included the nominate subspecies and *jordani*) to be a subspecies of *Callithrix jacchus*, and the form from southeast Bahia to be merely a hybrid (see below). He regarded the differences between *C. p. penicillata* and *C. p. jordani* as described by Thomas (1904) to be trivial. Emmons and Feer (1990) followed Hershkovitz's classification, and, making no mention of *jordani*, included southeast Bahia and northern Espírito Santo as part of the geographic range of *C. j. penicillata*. Later, Emmons and Feer (1997) recognized *C. jacchus kuhlii*, however, from between the Rio de Contas and the Rio Jequitinhonha, following Rylands *et al*. (1993) in the description of its range, but maintaining Hershkovitz's (1977) classification of all Atlantic forest and central and northeastern Brazilian marmosets as subspecies of

C. jacchus. Vivo (1991), likewise, did not recognize Thomas' (1904) arrangement, considering just one species, *C. penicillata*, with no subspecific forms, and wrote that the form *kuhlii*, although not a hybrid as was argued by Hershkovitz (1975, 1977), was not sufficiently distinct to warrant separation from *C. penicillata*.

"*Hapale penicillata Kuhlii* Wied, 1826"

Hershkovitz (1975, p.142) was the first to indicate that Wied-Neuwied (1826) had referred to the marmoset of southeast Bahia as "*Hapale penicillata Kuhlii*" [*sic*]. According to Hershkovitz this was on the basis of a male collected at the mouth of the Rio Belmonte (= Rio Jequitinhonha), southern Bahia, distinguishable from the form *penicillata* on the basis of a "weisslich-graubraun" crown and whitish cheeks. Wied-Neuwied noted that specimens from the Rio Pardo and Ilhéus farther north were also characterized by their more buffy cheeks and frontal blaze. However, Hershkovitz (1975, 1977) argued at length that *kuhlii* was not a valid taxon, being merely an intergrade between *C. j. penicillata* and *C. j. geoffroyi*: "Their geographic position, buffy crown, pale cheeks, well-defined white median rostral line and large frontal blaze extending over the crown mark them as intergrades between *geoffroyi* and *penicillata*." (1975, p.142). Hershkovitz (1977) also gave the opinion that those from Ilhéus are nearer to *penicillata* (to the west) and those from Belmonte nearer to *geoffroyi*, and indicated that marmosets in adjoining regions to the south into Espírito Santo "belong to the same or similarly mixed stock."

However, Vivo (1991, pp.80–81) argued that Wied-Neuwied (1826) had not intentionally given it this name. According to him: "Wied (1826) systematically placed the name of the author beside the scientific name he used. Unfortunately some of the author's names (as was the case for *penicillata*) were printed in italics, as were the names of the species. In other cases the names of the authors were printed in the typescript of the text, sometimes separated by a comma, or abbreviated, sometimes not." Vivo (1991) gives an example of this, where Wied-Neuwied (1826, p.135) refers to "*H. Leucocephalus* Kuhlii" in meaning merely the *H. leucocephalus* of Kuhl, with no intention of designating a subspecies. Elliot (1913, p.227) reported several specimens of *C. penicillata* in the Paris Museum, the earliest dated 1822, and in all the name *penicillatus* is attributed to H. Kuhl from his publication in 1820 (p.47). It is notable that Thomas (1901) also attributed the authorship of *Hapale penicillata* to Kuhl. This might explain Wied-Neuwied's attachment of "Kuhlii" (rather than É. Geoffroy or Humboldt) to the scientific name. Besides this, Vivo (1991) argued that, contrary to Hershkovitz's (1975, p.142) affirmation, Wied-Neuwied did not compare his material from southeast Bahia with "true *penicillata*," but with the previous species he was discussing, *Hapale leucocephalus* (= *C. geoffroyi*), that he had encountered to the south. Vivo (1991) pointed out that the first person who intentionally used the name *kuhlii* to describe the marmosets from southeast Bahia was Hershkovitz, and gave the opinion that he should, therefore, be attributed authorship if, as we argue here, the form is to be considered a taxon distinct from *penicillata*. However, the fact that Hershkovitz (1975, 1977) argued that the form was not a valid taxonomic entity disqualifies the possibility of him being attributed authorship (see below).

"*Callithrix penicillata kuhlii* Wied, 1826"

Coimbra-Filho (1971, 1972), and Coimbra-Filho and Mittermeier (1973) maintained that the southeast Bahian marmoset was distinct from populations inland in Goiás, western Bahia, and Minas Gerais. In the absence of a contemporary study of the taxonomy and geographic distribution, they followed Thomas (1904) in referring to the marmoset of coastal Bahia as *C. p. penicillata*, even though the description of the pelage of the specimens from Lamarão, Bahia (ascribed to the nominate subspecies by Thomas [1904]), was not consistent with that of the specimens from southeast Bahia. In pointing out that (it would seem erroneously, see above) Wied-Neuwied (1826) had given the name *H. penicillata kuhlii* to the marmosets from southeast Bahia as if he was describing a new subspecies, Hershkovitz (1975) provided the name used subsequently by Coimbra-Filho and Mittermeier (1977; Mittermeier and Coimbra-Filho 1981), even though he argued that the form was merely a hybrid between *C. j. penicillata* and *C. j. geoffroyi*. Mittermeier and Coimbra-Filho (1981), following Hershkovitz's affirmation that Wied-Neuwied had given the subspecific name to this marmoset, suggested that *penicillata* should remain as the subspecific name for all forms inland, subsuming as such the form *jordani* Thomas 1904,

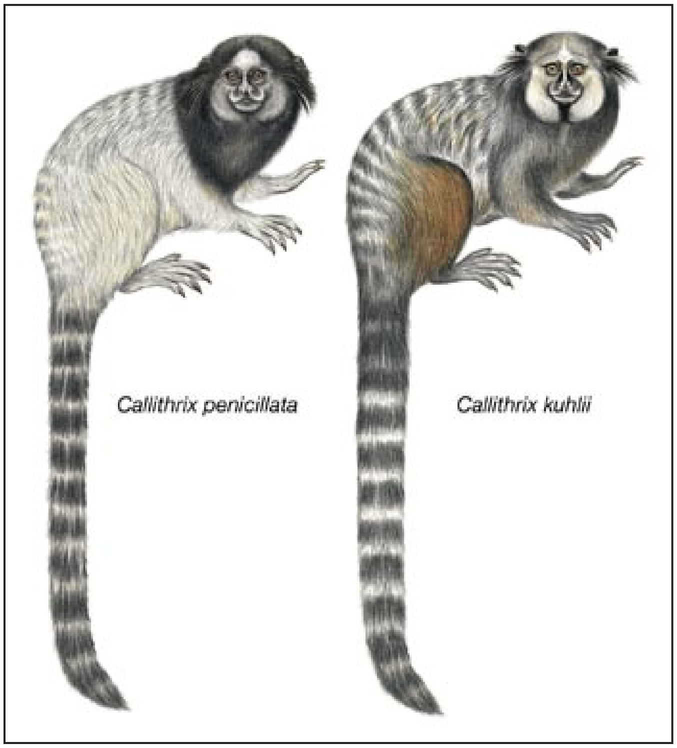


Figure 1. *Callithrix penicillata* and *C. kuhlii.* Illustration by Stephen D. Nash.

while *C. penicillata kuhlii* (Wied-Neuwied, 1826) should be the correct name for the southeast Bahian marmosets (p.35 and footnote). This is reinforced by the fact that the original description of *Jacchus penicillatus* by St. Hilaire does not conform to the southeast Bahian marmosets (see above).

"Jacchus" Group Marmosets — Species or Subspecies?

Mittermeier and Coimbra-Filho (1981) maintained that the marmosets comprising Hershkovitz's (1975) "Jacchus" group should be considered good species rather than subspecies of *C. jacchus*. Fertile hybrids had been produced in captivity (Hill 1957; Coimbra-Filho 1970, 1971, 1973, 1974, 1978; Mallinson 1971; Hampton *et al*. 1971; Coimbra-Filho and Mittermeier 1973; see also Coimbra-Filho *et al*. 1993), and Hershkovitz (1975, 1977) had provided evidence of intergradation in the wild. However, Mittermeier and Coimbra-Filho (1981) argued that the issue was controversial and depended on the resolution of three questions: (1) Do the forms naturally overlap in their ranges without interbreeding? (2) What is the correct taxonomic interpretation of the intergades reported by Hershkovitz (1975, 1977), considering they might be merely individual or ontogenetic variants rather than hybrids? and (3) Presuming natural zones of intergradation do exist, are they regions of broad clinal variation or narrow contact zones? Mittermeier *et al*. (1988, p.21) provided answers to these questions, which reinforced the argument that at least the forms *aurita*, *geoffroyi*, *penicillata*, *jacchus*, and *kuhlii* should be considered valid species (*flaviceps* may be subspecific to *aurita*, see below), even though it would seem that none of the "Jacchus" group marmosets overlap in their geographic distributions without interbreeding. Evidence is now available for a number of natural hybrid zones either at the distributional limits of the various forms or due to introductions (see Table 1). They are reviewed in Coimbra-Filho *et al*. (1993) and Mendes (1997). Coimbra-Filho *et al.* (1993) classified the hybrid localities into three types: (1) at distributional limits and ecotones of ecologically distinct species (*C. penicillata* × *C. geoffroyi*, *C. penicillata* × *C. kuhlii*, and *C. geoffroyi* × *C. flaviceps*); 2) ecologically similar forms at their distributional limits but not involving ecotones (*C. aurita* × *C. flaviceps*) and; (3) ecologically similar species but involving introductions of one or both in areas that may or may not be ecotones (*C. jacchus* × *C. penicillata*). The similarities between *C. flaviceps* and *C. aurita* (pelage patterns such as the ear tufts and the skull-like facial mask, ecological adaptations, ontogeny, vocalizations and clinal variation in overall pelage color) indicate to us that *flaviceps* might well be best considered a subspecies of *aurita* (Coimbra-Filho 1986a, 1986b; Coimbra-Filho *et al*. 1993, 1997). The important feature is that, in all cases, the documented contact zones are narrow or confined and clinal variation is not evident (Vivo 1991; Coimbra-Filho *et al*. 1993; Mendes 1997). Vivo (1991) classified all the "Jacchus" group marmosets (except for *kuhlii*, which he did not recognize as distinct from *C. penicillata*) as species, arguing that allopatry or parapatry alone cannot be used to determine subspecific or specific status, and that there is no evidence for widespread intergradation or clinal variation, and protesting that the use of subspecific classifications merely on the basis of similarity in pelage between forms is inadequate. Examining pelage color and patterns alone, Rosenberger (1984) also argued that they should be considered species rather than subspecies, but qualified that more information is needed from other systems — genetic and morphological.

Table 1. Hybrids born at the Rio de Janeiro Primate Center (CPRJ/FEEMA), Rio de Janeiro.

Registration no.[1]	Birth number	Date of birth	No. of offspring (sex)	Death
***C. kuhlii* (male) × *C. jacchus* (female)**				
- MP 075	First	3 April 1976	2 (0.1.1)	29 June 1976[2] 29 June 1976
MP 122 MP 123	Second	?	2 (2.0)	29 March 1978 29 March 1978
***C. kuhlii* (male) × *C. penicillata* (female)**				
MP 191 MP 197	First	9 December 1978	2 (1.1)	7 February 1980 25 February 1980
***C. kuhlii* (male) × *C. geoffroyi* (female)**				
MP 106	First	19 June 1973	1 (0.1)	13 November 1975
- MP 033	Second	28 November 1973	2 (0.1.1)	5 December 1973[1] 5 May 1976
MP 121	Third	2 May 1974	1 (0.1)	20 March 1978
MP 127	Fourth	17 September 1974	1 (0.1)	22 August 1978
MP 221	Fifth	23 May 1975	1 (1.0)	25 July 1980
***C. geoffroyi* (male) × *C. penicillata* (female)**				
MP 145 MP 152	First	16 November 1977	2 (2.0)	19 January 1979 24 May 1979
MP 181 MP 221	Second	14 September 1979	2 (2.0)	16 January 1980 Alive

[1] MP = Museu de Primatologia (CPRJ).

[2] Material lost, no registration number.

The lack of evidence for the classification of the "Jacchus" group marmosets as subspecies of *C. jacchus* led Groves (1993, 2001, 2005) to list them all as species, explicitly following the Phylogenetic Species Concept. Natori (1986, 1990) and Natori and Shigehara (1992) in their studies of the dental morphology, and Natori (1994) in his craniometrical study, also argued for their ranking as species, on the basis of, however, compliance with the separation of *C. argentata* and *C. humeralifera* as distinct species. Natori (1986) examined six dental characters and tooth size in *Callithrix*. On the basis of molar tooth size alone, he found that the differences among the "Jacchus" group marmosets were greater than between the Amazonian *argentata* and *humeralifera*. He argued that if the latter were to be considered separate species, then so should the "Jacchus" group marmosets. The same conclusion was drawn by Natori (1994) in his study of 19 cranial measures. On the basis of Q-mode correlation of these measures, the distances between the "Jacchus" group members were greater than those between *C. argentata* and *C. humeralifera*, and, excepting *C. jacchus* and *C. penicillata*, were greater than between *Cebuella* and *C. argentata* and between *Cebuella* and *C. humeralifera*.

Mendes (1997) argued for their species status on the basis of a reanalysis of their geographical distributions and pelage variation (agreeing with the conclusions of Mittermeier *et al*. [1988] and Rylands *et al*. [1993] regarding hybrid zones), as well as a detailed study of their vocalizations (see below). Most recently, Marroig *et al*. (2004; see also Marroig 1995) reported on a study of the cranial morphology of the "Jacchus" group marmosets. They concluded that they should be classified as separate species rather than subspecies, based on their finding that "morphological distances among marmosets are similar to or higher than distances found among other related taxa usually accepted as good species, like the tamarins (Moore and Cheverud 1992; Ackermann and Cheverud 2000, 2002)" (p.17). They also failed to find evidence for intergradation along contact zones, but instead "a sharp, steep morphological boundary between taxa with no trend of species being more morphologically similar at contact zones than at other parts of their ranges."

Cytogenetics and molecular genetics have to date been indecisive in their contribution to the debate concerning the taxonomic status of the "Jacchus" group marmosets. Peixoto (1976) and Peixoto and Pedreira (1982) compared the chromosomes of *C. jacchus*, *C. penicillata*, and *C. geoffroyi* and recorded clear differences in G-banding, indicating paracentric inversions not found in later studies by Seuánez *et al.* (1988) and Nagamachi (1995). Nagamachi (1995; Nagamachi *et al*. 1997) carried out a study of the chromosome morphology of *C. kuhlii* and the other "Jacchus" group marmosets except *C. flaviceps.* All of the eastern Brazilian marmosets have a diploid chromosome number of 46, with 30 two-armed and 14 acrocentric autosomes, a conservative submetacentric X chromosome, and a Y chromosome that is highly variable in size and morphology. In *C. kuhlii* the Y chromosome is small and two-armed (metacentric). An analysis of the G-banding patterns demonstrated a lack of any chromosomal rearrangements to differentiate their karyotypes. C-banding, likewise, demonstrated no differences between the species. Heterochromatin was found to occur in small quantities in the centromeric regions of all the chromosomes, in the telomeric region of the short arm of pair 6, and in the telomeric region of the long arm of chromosome 22. Ag-NOR staining marked secondary constrictions of the small arms of the acrocentric chromosomes. Nagamachi (1995; Nagamachi *et al*. 1997) concluded that the five species they studied were extremely homogeneous in their karyotypes (except for the size and morphology of the Y chromosome, which in the case of *C. jacchus* was variable even between populations) and that nothing can be said as a result concerning the taxonomic status of each.

Tagliaro *et al*. (1997) analyzed mitochondrial DNA control region sequences in all the "Jacchus" group marmosets except for *C. flaviceps*. In reconstructing the phylogeny of these marmosets from their findings, they concluded that "Our trees certainly do not come down in strong support of a monophyletic *C. kuhli*, although their paraphyly is also only weakly supported (i.e., a monophyletic *C. kuhli* adds only one substitution to the MP tree)" (p.682), and later (p.683): "our data do not support a clear taxonomic distinction between *C. kuhli*, *C. penicillata*, and possibly *C. jacchus*, which [...] we regard as a tentative proposal but one that needs to be further explored...". They found, on the contrary, strong support that both *C. aurita* and *C. geoffroyi* are "distinct evolutionary entities." Studying electrophoretic patterns in protein systems in four of the "Jacchus" group marmosets (*jacchus*, *penicillata*, *geoffroyi*, and *kuhlii*), Meireles *et al*. (1992, 1998) concluded that Hershkovitz's (1977) use of subspecies was the most appropriate taxonomy based genetic distance values.

Evidence for the Validity of *Callithrix kuhlii*

Intergradation and hybrid zones in the wild

Hershkovitz (1975, 1977) argued that the form *kuhlii* was a natural hybrid of *C. j. penicillata* and *C. j. geoffroyi*. Rylands (1989), however, argued that the consistency of the pelage characteristics of *C. kuhlii* both within social groups and between distant parts of its geographical distribution would militate against them being hybrids. In part, Hershkovitz's argument was based on the misbelief that *C. j. penicillata* extended into the northern part of the state of Espírito Santo. As pointed out by Hershkovitz (1975), there has been considerable confusion over this. Ruschi (1964, see also 1965) stated that the form *penicillata* occurred along coastal Espírito Santo from Conceição da Barra to Barra do Itapemerim, near the state boundary with Rio de Janeiro. Coimbra-Filho (1971; see also Coimbra-Filho and Mittermeier 1973) pointed out that if this was so, it was a recent range extension, the majority of this region (between the Rios Jucu and Itaunas) being the domain of *C. geoffroyi*. Although emphasizing the lack of concrete evidence, Hershkovitz (1975) argued that "...should *penicillata* and *geoffroyi* meet in Espírito Santo, they would almost certainly merge [...]. Offspring of the predicted inter-

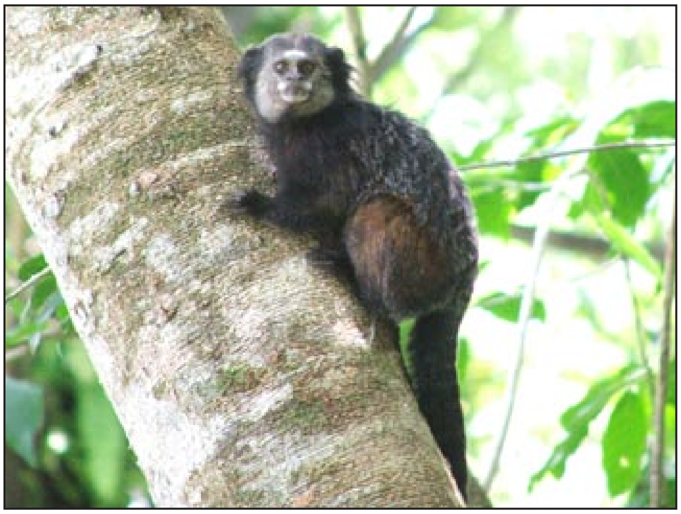


Figure 2. Adult *C. kuhlii* in the Una Biological Reserve, southern Bahia. Note the brownish grey crown, which the species develops as an adult (compare with the juvenile in Figure 6. Photograph by Gustavo Canale.

Figure 3. Adult *C. kuhlii* in the Una Biological Reserve, southern Bahia. Photograph by Gustavo Canale.

gradation would likely be classified as *geoffroyi* or *penicillata*, depending on the degree of phenetic resemblance to either parent." (p.142). Hershkovitz (1975) then argued that intergradation between the two species in southeastern Bahia is evidence for the likelihood of this. Despite the affirmation of Ruschi (1964, 1965), there is no evidence that *penicillata* has ever naturally occurred in Espírito Santo, nor of intergradation between *penicillata* and *geoffroyi* in the northeastern part. The localities listed by Ruschi (1964) are uncorroborated (Hershkovitz 1975, 1977).

The only confirmed outlying locality for *C. j. penicillata*, listed by Hershkovitz (1977), Kinzey (1982) and Vivo (1991), is the Rio Jucurucu, southern Bahia, south of the Rio Jequitinhonha (see Fig. 5). This locality is based on four specimens in the Museum of Zoology, São Paulo (MZSP): Specimens MZSP 3843, 3844, and 3854 (young), collected by Olivério M. O. Pinto in March 1933, are very similar and clearly referable to *Callithrix kuhlii*. MZSP 3843 has a tail ringed off-white on black, the tip grayish-white. There are rusty red brown hairs on outer thighs (from the base of the hair: black, rusty red, black or whitish tips). On the back, the hairs, from the base, are: black, rusty red, and black with a white tip. The grayish-white transverse banding on the lower back becomes less distinct on the middle. Mantle and shoulders black, hairs with white tips (flecking). Flanks reddish brown. Back of head and nape black. Crown brownish gray-beige. Hands and lower arms brownish black with white speckling (tips of some hairs whitish). Hairs of upper arms: from base, black, rusty red, and black with a whitish tip. Pale yellowish-white star between eyes. Cheeks as in crown but paler buffy brown.

The fourth specimen, MZSP 3842, is labeled "R. Jucurucu, Bahia," collected by Camargo (listed by Kinzey 1982, locality 25). It is strikingly paler than the other three, and referable to typical *C. penicillata*, with a black head and nape, off-white cheek patches not extending to the throat, a striated gray/white dorsum, a distinctly striped tail, and a pale orangy-brown showing through on the outer thighs. The back and upper arms are also pale gray whereas in the other three specimens these parts are dark, almost black.

The actual locality of the Rio Jucurucu is not clearly identified. Vivo (1991, locality 26) listed it as "Rio Jucurucu (boca [mouth]) 17°32′S, 39°14′W", which is a little south of the mouth of the Rio Jucurucu, south of the town of Prado. In the place name index "Localidades da Coleção do Museu de Zoologia de São Paulo," a compilation by Paulo Emílio Vanzolini, kept in the museum, the following coordinates are given "Rio Jucurucu (= Cachoeira Grande), Bahia (17°15′S, 39°46′W)", a location on the middle of the southern arm of the Rio Jucurucu, near to the village of Torcida, inland. Kinzey (1982) listed the Rio Jucurucu (locality 25) with the coordinates 17°21′S, 39°13′W. We have been unable to clarify the origin of the name Cachoeira Grande given as a synonym for the Rio Jucurucu by Vanzolini. Today there is a Rio Cachoeira Grande farther north, a little north of the Rio de Contas, south of the town of Valença, where the phenotypes of the Pinto specimens would be expected (see below). The Rio Jucurucu is otherwise the domain of *C. geoffroyi*.

The striking difference between the three specimens collected by Pinto on the one hand and that collected by Camargo on the other (not commented upon by Vivo [1991]), the odd sequence of registration numbers of the four specimens in the MZSP, and the lack of certainty regarding the precise locality where these specimens were collected, means that it is very difficult to arrive at any conclusion about the significance and veracity, or otherwise, of this record. Mendes (1997) concluded that it almost certainly results from introduced animals or possibly mistaken provenance. A survey of the Rio Jucurucu would hopefully resolve the doubts concerning these specimens.

Today, *C. geoffroyi* occurs throughout northern Espírito Santo, extending north as far as the south bank of the Rio Jequitinhonha in southern Bahia and northeastern Minas Gerais, west as far the Rio Araçuaí (Santos *et al*. 1987; Rylands *et al*. 1988; Oliver and Santos 1991; Vivo 1991; Mendes 1997).

There is no evidence of intergradation between the form *kuhlii* on the north bank of the lower Rio Jequitinhonha and *geoffroyi* on the opposite bank. Oliver and Santos (1991) obtained reports of both *kuhlii* and *geoffroyi* occurring in two localities on the south of the Rio Jequitinhonha (Itapebi and Belmonte), but they argued that this probably resulted from small, introduced populations of the former. Hybrids possibly occur along the upper Rio Araçuaí, where the geographic distributions of *penicillata* and *geoffroyi* meet. Likewise, an evidently hybrid group of *kuhlii* and *penicillata* was observed at Almenara, north of the Rio Jequitinhonha, at the interface between the caatinga (dry thorn scrub) of the middle reaches of the river and the humid Atlantic forest of the lower reaches (Rylands *et al*. 1988). During extensive surveys in southern Bahia, Oliver and Santos (1991), and L. P. de S. Pinto (unpubl. data) have confirmed that the *kuhlii* phenotype is consistent from the north bank of the lower Rio Jequitinhonha to the north of Rio de Contas, perhaps as far as Valença, midway between the Rio de Contas and Rio Paraguaçú.

Hybrid groups of *C. penicillata* × *C. geoffroyi* have been found to occur along the eastern slopes of the Serra do Espinhaço in Minas Gerais, at the interface between the cerrado (west) and Atlantic forest (east). Hybrid groups containing animals typical of both species as well as a variable mixes have been observed at the Serra da Piedade (I. B. Santos and C. M. C. Valle, pers. comm.), and in the municipality of Santa Bárbara, both near to Belo Horizonte (Rylands and Costa 1988; Coimbra-Filho *et al*. 1993). Although some of the hybrids had off-white face masks, none have been observed with the appearance of the *C. kuhlii* phenotype.

Experimental hybridization

Besides the lack of evidence for the wide zone of intergradation supposed by Hershkovitz (1975, 1977), experimental hybridization of *geoffroyi* × *penicillata* in captivity has failed to reproduce a phenotype similar to that of *kuhlii* (Coimbra-Filho *et al*. 1993). Hybrids of *C. kuhlii* with other Atlantic forest marmosets have demonstrated that its phenotype is genetically dominant. Hybrids from the following matings *C. kuhlii* × *C. geoffroyi*, *C. kuhlii* × *C. jacchus*, *C. kuhlii* × *C. penicillata*, and *C. geoffroyi* × *C. penicillata* have been obtained at the Rio de Janeiro Primate Center (CPRJ) (Table 1).

As in the wild, the offspring of *C. geoffroyi* × *C. penicillata* are very variable in pelage patterns and color. Newborn *C. geoffroyi* × *C. penicillata* have a phenotype more similar to newborn pure *C. penicillata*, with two pale, oval areas above the eyes. The white mask of *C. geoffroyi* is present to varying degrees and generally dirty white to greyish and extending to the forehead and crown. The whitish hairs on the front of crown can be mixed with dark hairs providing the suggestion only of the typical white interorbital "star" on the forehead of *C. penicillata* and *C. kuhlii*. In general, the mask and head of 30-day-old hybrids are much darker. The dorsum in the hybrid offspring can be quite pale grey, with the the well-defined black of the crown, nape, shoulders, and upper chest typical of *C. penicillata* but not of *C. kuhlii*.

In *C. geoffroyi* the hairs of the back, flanks, and outer thighs have a yellowish-ochre bar instead of the intense reddish brown bar of *C. kuhlii*, but in both this chromatic field is much more intense than in *C. jacchus* and *C. penicillata*, in which it is a very pale yellowish or very light reddish. The intense reddish brown field of the hairs of *C. kuhlii* is evidently a dominant feature, transmitted to its hybrids, and even dominant to the corresponding allele in *C. geoffroyi*. This demonstrates that *C. kuhlii* is not simply a natural hybrid of *C. penicillata* and *C. geoffroyi*, nor a variant of *C. penicillata*. The dominance of its phenotype in hybrid forms would indicate a genetic stability acquired during speciation over some considerable time.

Is C. kuhlii a variant of C. penicillata?

Although concluding that *C. kuhlii* is probably not an intergrade between *C. penicillata* × *C. geoffroyi*, Vivo (1991) argued that the distinct features of the pelage of southeast Bahian marmosets were not sufficient to warrant its separation from *C. penicillata*, most especially the darker forms recorded in central Minas Gerais (upper Rio São Francisco). He analyzed a number of cranial measurements for *C. penicillata*, and examined their geographic distribution. The measurements included skull length and width, condylo-basal length, width of the zygomatic arch, interorbital width, width of M^1, mandible length, height of the mandibular condyle, length of the lower postcanine tooth row, and width of upper canines. The southeast Bahian marmosets were found to be indistinguishable in these measures from *C. penicillata* from northern and central Minas Gerais. According to Vivo (1991) "The only important difference, although inconsistent, is that the southeast Bahian specimens tend to have a paler face than those of central Minas Gerais" (p.81). He considered, however, that the difference was not sufficient for the recognition of two taxa, and defined *C. penicillata* as the marmoset with black pre-auricular tufts and a brown (*castanho*) to pale gray (*cinza-claro*) face, and corresponding strictly to the *C. jacchus penicillata* of Hershkovitz (1975, 1977). As pointed out by Mendes (1997), Vivo did not take into account two other important and consistent pelage differences — the pale, grayish-beige crown of *C. kuhlii* (black in *C. penicillata* and *C. geoffroyi*), well illustrated in Hershkovitz (1975, p.143–144), and the conspicuous red-brown underlying the otherwise black pelage on the outer thigh and lower back. The reddish-brown bars on the hairs of the back of the lower and outer thigh are much broader than in *C. geoffroyi* and much more evident as a result. Mendes (1997) concluded that this feature and the grayish-beige crown are diagnostic for *C. kuhlii*. Since his publication in 1991, Vivo (pers. comm., December 1997) has come to accept that the distinct pelage coloration of the southeast Bahian marmosets does warrant their classification as separate from *C. penicillata*.

Far from being a variant of *C. penicillata*, a number of studies have indicated that it is in fact phylogenetically closer to *C. geoffroyi*. Rosenberger (1984) pointed this out in considering pelage color patterns. In broad ecological terms, *C. kuhlii* and *C. geoffroyi* are more similar in occupying lowland evergreen forests in eastern Brazil, whereas *C. penicillata* occupies the more intensely seasonal gallery forests and semideciduous forest patches of the *cerrado* and *caatinga* in the interior of Brazil to the west. Natori, examining the morphology of the postcanine dentition (1990) and cranial morphology (1994), and Natori and Shigehara (1992) the lower anterior dentition, concluded in all cases that *C. kuhlii* was distinct and more similar to *C. geoffroyi* than to *C. penicillata*. Marroig *et al*. (2004), on the other hand, also studying cranial morphology, found that *C. penicillata* and *C. geoffroyi* are more similar to each other than either is to *C. kuhlii*. They specifically tested, and refuted, the hypothesis of Vivo (1991) that *C. kuhlii* does not differ to any significant extent from the *C. penicillata* populations in the region of the upper Rio São Francisco in the state of Minas Gerais.

Habitat

Whereas *C. penicillata* is the marmoset typical of seasonal semi-deciduous forest, *cerradão*, and gallery forests of the central savanna (*Cerrado*) of Central Brazil, *C. kuhlii* is restricted to the coastal evergreen humid lowland and mesophytic (farther inland) forests along the Atlantic coast (Mori and Silva 1979; Fonseca and Lacher 1984; Rylands and Faria 1993). The two species meet in the strip of liana forest along the leeward side of the coastal mountain range that extends farther west into caatinga. The type locality of *C. penicillata* ("Lamarão, near Bahia" Thomas, 1904) is to the west of the Atlantic forest domain, whether it is considered to be the upper Rio Itapicurú (Hershkovitz 1968, 1975, 1977; Napier, 1976; Kinzey 1982) or the town of Lamarão, northwest of Salvador (see above).

Dental anatomy

Although Vivo (1991) did not find any difference between *C. penicillata* and *C. kuhlii* in the width of M^1, the length of the lower post-canine tooth row, and the width of the upper canines, a detailed study of the crown shape of the post-canine dentition of *C. kuhlii*, *C. penicillata*, and *C. geoffroyi* by Natori (1990) discriminated *C. kuhlii* clearly from the other two species. Natori also concluded that there was no evidence for intermediacy in *C. kuhlii* in the characters he studied, arguing against them being hybrids of *C. penicillata* and *C. geoffroyi*, and reinforcing their taxonomic position as a distinct species. Natori and Shigehara (1992) came to a similar conclusion when comparing the lower anterior dentition of all the "Jacchus" group marmosets, with *C. jacchus* and *C. penicillata* clearly separated from the remainder in having distinctly larger lower incisors and canines, which they associated with the higher degree of tree-gouging characteristic of the two species.

Cranial anatomy

A detailed study of the craniometry of the "Jacchus" group marmosets was carried out by Natori (1994). On the basis of 19 measures, Natori found "quite large morphological differences between the six forms of the *C. jacchus* group" (p.174)—differences that were greater than those observed between *C. argentata* and *C. humeralifera*, and between each of the two Amazonian species and *Cebuella* (except in the case of *C. jacchus* and *C. penicillata*). *Callithrix kuhlii* was clearly recognized as a separate species in this study. Marroig *et al*. (2004) also studied cranial morphology in five of the six "Jacchus" group marmosets (all but *C. flaviceps*) and concluded that *C. kuhlii* was a good species.

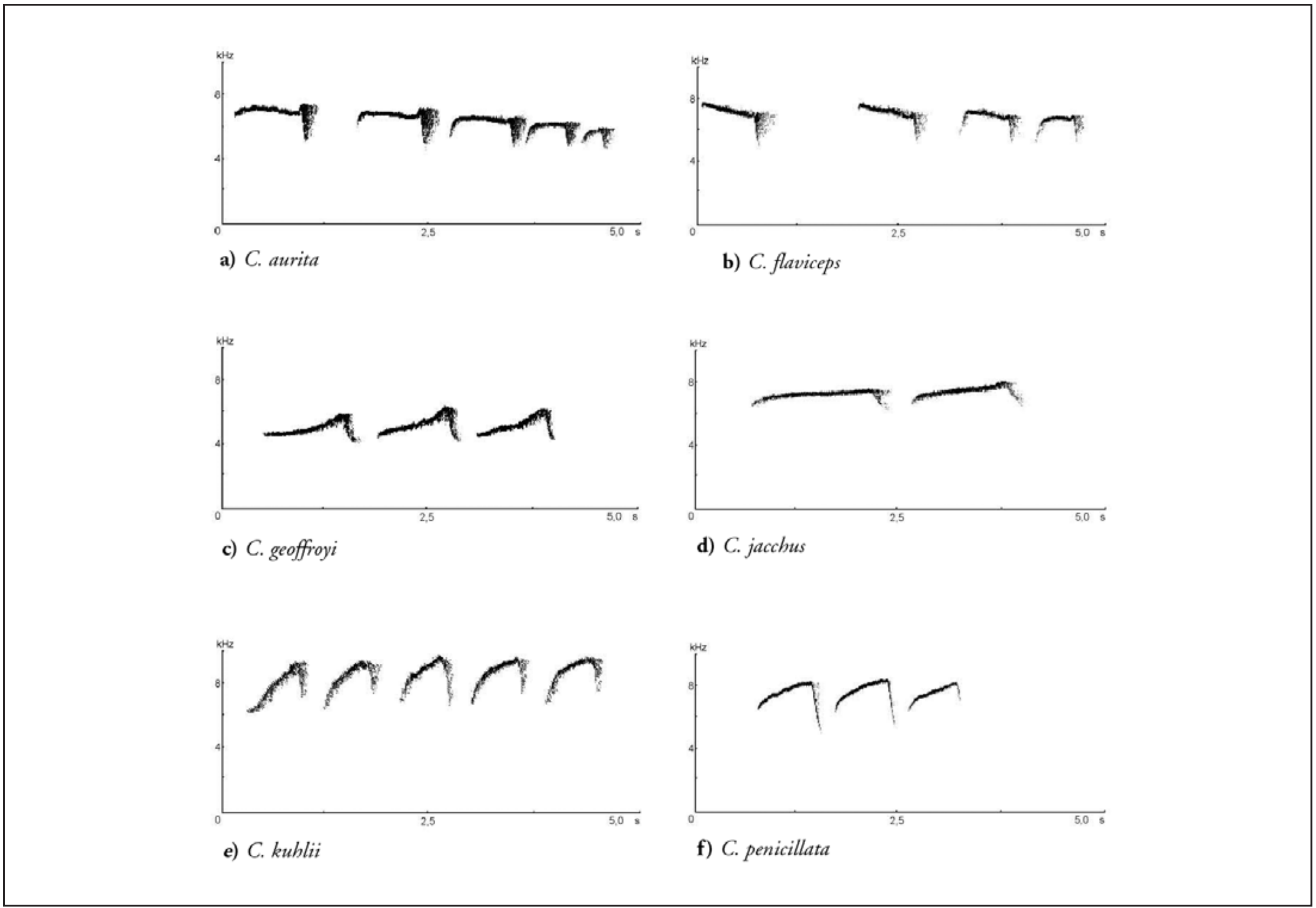
Genetics

As mentioned above, genetic studies have not contributed decisively in the debate concerning the taxonomic status of any of the "Jacchus" group marmosets, and have provided no evidence that would argue for *kuhlii* being anything more than a junior synonym of *penicillata*. Nagamachi *et al*. (1997) found the karyotypes in five of the six species (*C. flaviceps* not studied) except for the Y chromosome, to be extremely homogeneous. Tagliaro *et al*. (1997) analyzed mitochondrial DNA control region sequences in all the 'Jacchus" group marmosets except for *C. flaviceps*. Although they found that *C. geoffroyi* and *C. aurita* were distinct, they failed to find a clear distinction of *C. kuhlii*, *C. jacchus*, and *C. penicillata*. While inconclusive, Tagliaro *et al*. (1997) interpreted their results as not providing any convincing indication that *C. kuhlii* should be regarded as a distinct taxon. Canavez *et al.* (1999) found few differences in nucleotide sequences between species in the each of the *Callithrix* groups ("Argentata" and "Jacchus"), and their phylogenetic resolution was weak. *Callithrix kuhlii* and *C. penicillata* were associated due to a single synapomorphy. Canavez *et al*. (1999) pointed out that the polytomic phylogeny for the "Jacchus" group differed from the paryphyly observed by Tagliaro *et al.* (1997) probably because they shared an ancestral polymorphism.

Meireles *et al.* (1998) also concluded that their results examining electrophoretic polymorphism in blood proteins militated against the validity of *kuhlii* as separate from *penicillata*; "A comparison of the distance values recorded among *geoffroyi*, *kuhli*, and *penicillata* populations […] and the existence of a genetic marker (*LDHA*3*) shared only by *penicillata* (60%) and *kuhli* (47%) also support De Vivo's (1991) view on the status of the latter, based on morphological evidence, i.e., that the *kuhli* form should be synonymized with *penicillata*." (p.238).

Vocalizations

Mendes *et al*. (in press) carried out an analysis of the long calls of the "Jacchus" group marmosets. They measured note (syllable) duration, the interval between notes, minimum and maximum frequencies, and the initial and final frequencies. Recordings of *C. kuhlii* were obtained both from the wild (between the towns of Camacã and Mascote, Bahia [15º32′S, 39º20′W] and the Lemos Maia Experimental Station of the Regional Cocoa Growing Authority – CEPLAC, Una, Bahia [15º15′S, 39º05′W]) and from captive animals at the Rio de Janeiro Primate Center (CPRJ/FEEMA), Rio de Janeiro, and



a) *C. aurita*

b) *C. flaviceps*

c) *C. geoffroyi*

d) *C. jacchus*

e) *C. kuhlii*

f) *C. penicillata*

Figure 4. Sonograms of representative long calls of *Callithrix*. a) *C. aurita*, b) *C. flaviceps*, c) *C. geoffroyi*, d) *C. jacchus*, e) *C. kuhlii*, and f) *C. penicillata*.

the Museu de Biologia Mello Leitão, Santa Teresa, Espírito Santo. The distinctive call (Fig. 4) was found to be consistent between the captive and wild populations, and clear and consistent differences were found between *C. kuhlii* and the remaining "Jacchus" group marmosets. The structure of the long call of *C. kuhlii* was not intermediate between that of *C. penicillata* and *C. geoffroyi*, as might be expected if it were a hybrid. In fact, Mendes *et al.* (in press) found that *C. kuhlii* had the most distinctive call of the species they studied, the notes showed little variation in terms of duration and the interval between them, and were shorter, higher pitched, and more modulated than in all other Atlantic forest species (see Table 2). Mendes *et al*. (in press) concluded that evidence from the study of the long call in the "Jacchus" group marmosets argues clearly for the species' status of the southeast Bahian *C. kuhlii*.

Callithrix kuhlii Coimbra-Filho, 1985

Vivo (1991) pointed out that Wied-Neuwied (1826) did not use the name "Kuhlii" in the sense of a latin name for the species, and he suggested that the name of the southeast Bahian marmoset should be attributed to Hershkovitz (1977), the first person to consciously use the trinomium for the subspecies. In fact, the first time that Hershkovitz discussed this form was in a paper in *Folia Primatologica* in 1975. However, because Hershkovitz (1975, 1977) argued that it was not valid, merely a hybrid of *C. j. penicillata* × *C. j. geoffroyi*, this disqualifies him as the author, despite the fact that he described and illustrated features of its pelage, and the differences from the "parent forms." Other references to *C. p. kuhlii* were made by Coimbra-Filho and Mittermeier in 1977 (in *Biology and Conservation of the Callitrichidae*, ed. D. G. Kleiman, p.107, Smithsonian Institution Press, Washington, DC), and by the same authors in the first volume of *Ecology and Behavior of Neotropical Primates* in 1981 (pp.34–35, 36, Academia Brasileira de Ciências, Rio de Janeiro). Coimbra-Filho (1982, p.93) also mentioned *C. penicillata kuhlii*. In none of these cases, however, was the form described or details given of the characteristics that distinguish it from *C. penicillata* (or *C. p. penicillata*) and *C. geoffroyi*. These publications cannot, therefore, be considered for the purposes of attributing authorship. Likewise, Coimbra-Filho (1984, p.23) discussed the conservation status of *C. kuhlii*, but no description was given. The first publication that gives a description of this marmoset, along with its geographic distribution and some observations on its behavior and conservation status, is that of Coimbra-Filho (1985, *FBCN/Inf.*, Rio de Janeiro 9[4], p.5, out./dez.).

Table 2. Parameters of the first note and the first three-note sequence of the long call of *C. kuhlii* (from Mendes *et al*. in press).

Parameter	*C. kuhlii*	Other "Jacchus" group marmosets
Note duration	Consistent in the first three notes	Notes progressively shorter after the first note, except in *C. jacchus* (subsequent notes variable).
Duration of 1st note	Short (653 ms)	The shortest of any of the "Jacchus" group marmosets.
Interval between notes	Consistent in first three notes	Interval progressively shorter in *C. aurita* and *C. flaviceps*), but no difference in other species.
Interval between 1st and 2nd notes	Short (253 ms)	The shortest of any of the "Jacchus" group marmosets, but not significantly different from *C. penicillata, C. geoffroyi*, and *C. jacchus.*
Initial frequency	No change along the call sequence	Same, except for *C. flaviceps* and *C. aurita* in which 2nd and 3rd notes are lower in frequency.
Initial frequency of 1st note	High (7.19 kHz)	No different to *C. aurita* and *C. jacchus*, but higher than in *C. geoffroyi* and *C. penicillata*, and lower than in *C. flaviceps.*
Mean frequency	Variable but tendency to increase from 1st to 3rd note	Same, except in *C. flaviceps* and *C. aurita* (mean frequency falls from 1st to 3rd note).
Mean frequency of 1st note	High (7.69 kHz)	Higher than in *C. geoffroyi, C. penicillata,* and *C. aurita,* but similar to *C. jacchus* and *C. flaviceps*.
Frequency modulation	No significant difference between 1st and 3rd notes	Same in *C. aurita*. In *C. flaviceps* modulation progressively less, in others 3rd note tends to be more modulated.
Frequency modulation of 1st note	Ascending (1.53 kHz/ms)	Significantly higher modulation than in any of the other "Jacchus" group marmosets. Descending in *C. flaviceps* and *C. aurita* ascending in remaining species.

Adelmar F. Coimbra-Filho (1985) is, therefore, considered to be the author of *Callithrix kuhlii*.

It is evident that Wied-Neuwied (1826) latinized the name of Heinrich Kuhl to Kuhlius prior to using the genitive, hence Kuhlii, with a double "i". Article 33(d) of the Zoological Code of Nomenclature determines that "The use of a termination *-i* in a subsequent spelling of a species group name that is a genitive based upon a personal name in which the correct original spelling terminates with *-ii*, or vice-versa, constitutes an incorrect subsequent spelling, even if the change in spelling is deliberate..." The use of the specific name "kuhli" with one "i" would, therefore, be incorrect. Coimbra-Filho (1985) referred to the species as *Callithrix kuhlii*.

Type. Of *H[apale] penicillatus Kuhlii* Wied-Neuwied, 1826, designated by Hershkovitz (1975) as a male collected by Prince Maximilian zu Wied-Neuwied near the mouth of the Rio Belmonte, Bahia (1975, p.142; 1977, p.502). According to Hershkovitz (1977) it is part of the collection of Prince Maximilian zu Wied-Neuwied.

According to Ávila-Pires (1965), this collection was purchased by D. G. Elliot in 1869 to stock the American Museum of Natural History, New York. Ávila-Pires (1965) did not include it in his descriptions of the type specimens collected by Wied, because it was only 10 years later that Hershkovitz argued that Wied had described it (as a subspecies). Robert S. Voss, Division of Vertebrate Zoology, American Museum of Natural History, informed us that the type of *Hapale penicillatus kuhlii* has unfortunately been lost (*in litt*. 10 May 2006). Hershkovitz (1975, 1997) evidently did not see the type he designated, mentioning only that the three specimens from Ilhéus he did examine — two in the Field Museum of Natural History (FMNH), Chicago, and one in the Museum of Comparative Zoology, Harvard University, Cambridge (MCZ) — agreed with Wied's (1826) description of the male from Belmonte. On the suggestion of Voss (*in litt*. 10 May 2006) one of the three Ilhéus specimens mentioned by Hershkovitz (1975) could be designated a neotype, but further investigation would be appropriate to determine whether the Belmonte type can still be located. Alternatively, but less satisfactorily, a specimen in the Museu Nacional, Rio de Janeiro "MNRJ 23794. Passuí, Belmonte, Bahia. Male. Col. Unknown. 16 July 1949. Skin M29732(33). SEPSFA, Rockefeller Foundation. Wt. 350 g" could be designated as a topotype.

Type locality. Given by Hershkovitz (1975, pp.142 and 168) as near the mouth of the Rio Belmonte, Bahia [cf. Rio Jequitinhonha], 15°45′S, 38°53′W. (Locality 306 on the map, Figure 1, of Hershkovitz [1975]). Hershkovitz (1977, p.502) also lists Serra do Mundo Novo, Rio Pardo, Rio Ilhéus, southeast of the state of Bahia, Brazil.

Description. Black pre-auricular tufts, white patch in the middle of the forehead, cheeks and throat pale greyish-beige to pale brown, back striped, hands and feet black, outer thighs reddish brown, tail ringed. The following is a translation from Portuguese of the description given in Coimbra-Filho (1985).

> "Species slightly larger than the common marmoset (*C. jacchus*). Its most evident characteristics are the small, white, frontal mark (*estrela*) [*] and the generally dark coloration, noting in certain zones of the hairs, a beautiful reddish-brown coloration, principally on the external parts of the thighs. The hands, arms, feet and legs are very dark, almost black. The head shows a distinct chromogeny, where the grayish-beige tone appears on the sides of the face and the front part of the head. The auricular pencil-like tufts are black, long, and the tufts are less dense than those of *C. penicillata*. The young differ visibly from those of *C. penicillata*,

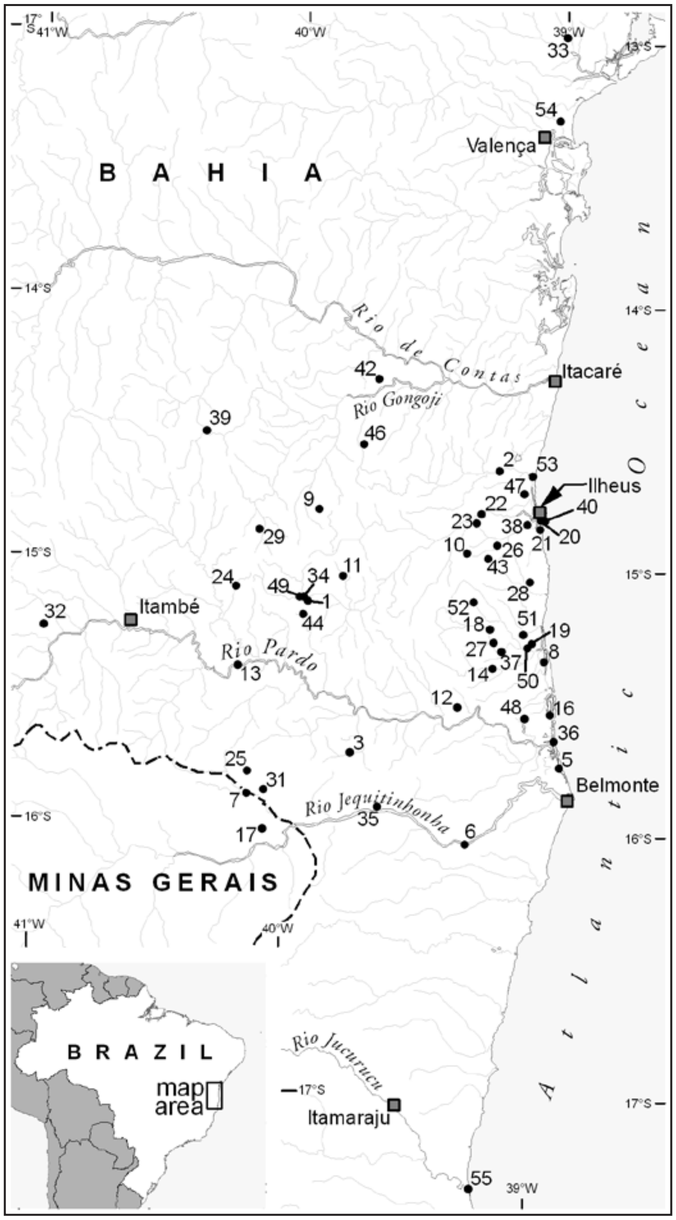


Figure 5. Locality records for *C. kuhlii*. Note that the known distribution is between the Rio de Contas and the Rio Jequitinhonha, extending inland about 200 km, delimited by the transition from forest formations (dry forest and liana forest) to the caatinga and scrub of the interior of the state of Bahia (see Mori 1989; Pinto and Rylands 1997). Localities 33 and 54 are both records of sightings of marmosets attributed to *C. kuhlii* by Oliver and Santos (1991). Locality 55 at the mouth of the Rio Jucurucu is an anomaly and is very probably erroneous. See gazetteer, Appendix 1. Map kindly drawn by Mark Denil, Center for Applied Biodiversity Science, Conservation International, Washington, DC.

Figure 6. A juvenile *C. kuhlii* in Una, Bahia. Note the typical reddish-brown showing through on the flanks and outer thighs. The black crown becomes brownish grey when adult (see Figs. 2 and 3). Photograph by Russell A. Mittermeier, 1980.

> being much darker, and only people who have never seen them could confuse them." [**estrela* = star].

Cranial dimensions. Natori (1994) carried out a detailed craniometrical study of *C. kuhlii*, involving 19 measures of the skull and mandible. Four of the principal measures are as follows: Mean skull length (nasion to lambda) 40.71 ±1.01 mm, n = 43; mean cranial width (euryon to euryon) 22.92 ±0.80 mm, n = 44; mean mandible width (bicondylar breadth) 25.6 ±0.76 mm, n = 43; mean length of upper post-incisor tooth row (mesial surface of left C^1 to distal surface of left M^2) 11.89 ±0.37 mm, n = 33.

Distribution. The known distribution is in the humid lowland forests and higher elevation mesophytic forests between the Rio Jequitinhonha (in the south) and the Rio de Contas (in the north), in the south of the state of Bahia, Brasil (Coimbra-Filho 1985, 1990) (Fig. 5). It is possible that its range extended north along the coast to the Rio Paraguaçu, or even the Rio São Francisco, in the past, but the degradation and destruction of the region's forests (Coimbra-Filho *et al*. 1991, 1991/1992; Coimbra-Filho and Câmara, 1996) and the widespread mixing of populations with *C. jacchus* and *C. penicillata* through introductions makes this difficult or impossible to ascertain today. Likewise, it is possible that in the recent past the range extended south of the Rio Jequitinhonha to the Rio Jucurucu, Bahia, but again this is now difficult to establish. Today, *C. geoffroyi* occurs along the south bank of the Rio Jequitinhonha, west as far as the right bank of the Rio Araçuaí (Rylands *et al*. 1988).

Comparisons with other species. Differs from *C. jacchus* in being darker overall, with consipicuous reddish brown showing through the blackish (variously white-flecked) pelage of the thighs and flanks. The ear tufts are black and pencil-like as in *C. penicillata* and *C. geoffroyi*; those of *Callithrix* *jacchus* are white and fan-like. *C. jacchus* has a dark crown; adult *C. kuhlii* have pale grey/brown crown. The dark neck and nape of *C. jacchus* contrast with the paler grey dorsum and flanks. Differs from *C. penicillata* in having thinner ear-tufts and is also much darker, with the characteristic red-brown showing through the ruffled pelage of the thighs and, to a lesser extent, the flanks. *C. penicillata* has a black crown, but adult *C. kuhlii* have a pale grey/brown crown. Infant *C. kuhlii* differ from infant *C. penicillata* in being much darker. The cheek fur of *C. kuhlii* is a distinct pale grey/brown, that of *C. penicillata* is darker grey. *C. geoffroyi* has a distinctly white and more expansive face-mask overall. The forehead and throat of *C. geoffroyi* are white, whereas *C. kuhli* has the white patch forming a small fan above and between the eyes as in *C. penicillata*. The dark back and flanks (flecked with white) of *C. geoffroyi* are more strongly suffused with reddish brown, the thighs less so.

Vocalizations. Mendes (1997; Mendes *et al.* in press) analyzed the long call in a comparative study of the "Jacchus" group marmosets. He found that the long calls of *C. kuhlii* are characterized by a variable number of notes or syllables, but about 70% of its long calls include three or four notes, differing, for example, from *C. geoffroyi* and *C. penicillata,* whose long calls tend to have a smaller number of notes. The notes are high pitched, with a minimal frequency around 6 kHz or more. Although in most marmosets the first note of the long call is the longest, with the other notes getting progressively shorter, in *C. kuhlii* the notes did not differ significantly in duration. The note duration is about 650 ms, shorter than in other marmosets. Mendes *et al*. (in press) concluded that *C. kuhlii* has the most distinctive call of the six species, that the long calls show little variation in terms of duration and frequency parameters, and that the notes are more modulated than in all other Atlantic forest species (Fig. 4).

Chromosome morphology. Nagamachi (1995; Nagamachi *et al*., 1997) carried out a study of the chromosome morphology of *C. kuhli* and the other "Jacchus" group marmosets, except *C. flaviceps.* All of the eastern Brazilian marmosets have a diploid chromosome number of 46, with 30 two-armed and 14 acrocentric autosomes, a conservative submetacentric X chromosome, and a Y chromosome that is highly variable in size and morphology. In *C. kuhlii* the Y chromosome is small and two-armed (metacentric).

Vernacular name. Wied's black tufted-ear marmoset or Wied's marmoset, Southern Bahian marmoset, sagüi-de-Wied (Portuguese).

Specimens examined: Museu de Zoologia, Universidade de São Paulo (MZSP); Departamento de Zoologia, Secretaria de Agricultura do Estado de São Paulo (DZ); Museu Nacional, Rio de Janeiro (MNRJ); British Museum (Natural History) (BM).

Callithrix penicillata

MZSP 2155. Ponte do Ipê, Arcado, Goiás. 7 May 1904. Female. Coll. Otto Dreher. [Labeled *C. p. jordani*]

MZSP 2588. Vila Nova, Bahia. [= Senhor do Bonfim]. 1908. Coll. E. Garbe.

MZSP 3842. Rio Jucurucu, Bahia. Coll. Camargo.

MZSP 4137. Jaraguá, 29 August 1934. Male. Coll. José Lima.

MZSP 10638-39. Goiánia, Goiás. 27 August 1963. Male. Coll. J. Hidasi.

MZSP 11283-85. Cabeceiras, Lagoa Formosa, Minas Gerais. 25 October 1964. Coll. Exp. DZ.

MZSP 11286, 11288-89. Rio Urucuia, Cachoeira, municipality of Buritis, Minas Gerais. 3 November 1964. Coll. Exp. DZ.

MZSP 28534. Itabirito, Minas Gerais. Male. 21 February 1988. Coll. C. J. M. Araújo.

BM 1903.9.5.8-15, 1903.9.5.160. Lamarão, near Bahia. May–June 1903. Alt. 300 m. Coll. Alphonse Robert. [See Thomas (1904), Napier (1976), type locality of *C. j. penicillata*, restricted by Hershkovitz (1977)].

BM 1901. 11.3.6-8. Rio Jordão, near Araguary, Minas Gerais. May/June 1901. Coll. Alphonse Robert. [See Thomas (1904), Napier (1976), paratypes of *C. p. jordani.*]

BM 1901. 11.3.9. Rio Jordão, near Araguary, Minas Gerais. May/June 1901. Coll. Alphonse Robert. [See Thomas (1904), Napier (1976), holotype of *C. p. jordani.*]

BM 1901. 11.3.10-12. Rio Jordão, near Araguary, Minas Gerais. May–July 1901. Coll. Alphonse Robert. [See Thomas (1904), Napier (1976), paratypes of *C. p. jordani.*]

Callithrix kuhlii [See Laemmert *et al.* 1946; Vaz 2005]

MZSP 3498. Fazenda Pontal, Ilhéus, Bahia. August 1919. Male. Coll. E. Garbe.

MZSP 3500. Itabuna, Bahia. 1919. Male. Coll. E. Garbe 16.

MZSP 3843. Rio Jucurucu, Bahia. March 1993, Coll. Pinto.

MZSP 3844. Rio Jucurucu, Bahia. March 1993, Coll. Pinto.

MZSP 3854. Rio Jucurucu, Bahia. March 1993, Coll. Pinto.

MZSP 7048. Rio do Braço, Ilhéus, Bahia. 24 February 1944. Female. Coll. Serviço de Estudos e Pesquisas sôbre a Febre Amarela (SEPSFA), J. Moojen. Ex. MNRJ 17403.

MNRJ 7898. Fazenda Ribeirao da Fortuna, municipality of Ilhéus. Cacao plantation. 10 January 1944. Adult female. HBL 230 mm, tail 315 mm. Labeled *Callithrix penicillata*. Coll. Galdino Pereira.

MNRJ 8524. Fazenda Retiro, Aritaguá, muncipality of Ilhéus. 1 November 1944. Adult female. HBL 230 mm, tail 305 mm, weight 370 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8525. Sambaituba, Aritagua, muncipality of Ilhéus. Secondary growth scrub. 21 October 1944. Adult male. HBL 210 mm, tail 315 mm, weight 300 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8526. Fazenda Provisão, Rio do Braço, muncipality of Ilhéus. Cacao plantation. 6 February 1945. Adult male. HBL 210 mm, tail 330 mm, weight 360 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8527. Fazenda Provisão, Rio do Braço, muncipality of Ilhéus. Cacao plantation. 6 February 1945. Adult male. HBL 210 mm, tail 325 mm, weight 320 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8528. Fazenda Itinga, Pontal, muncipality of Ilhéus. Secondary growrth scrub. 16 December 1944. Adult male. HBL 215 mm, tail 340 mm, weight 340 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8529. Fazenda Bonfim, Rio do Braço, muncipality of Ilhéus. Cacao plantation. 4 February 1945. Adult female. HBL 220 mm, tail 240 mm, weight 400 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8530. Fazenda Almada, Rio do Braço, muncipality of Ilhéus. Cacao plantation. 7 November 1944. Adult female. HBL 210 mm, tail 315 mm, weight 370 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8531. Urucutuba, Aritagua, muncipality of Ilhéus. Secondary growth scrub. 2 October 1944. Adult. HBL 250 mm, tail 305 mm, weight 400 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8532. Fazenda Bonfim, Rio do Braço, muncipality of Ilhéus. Cacao plantation. 23 October 1944. Adult female. HBL 230 mm, tail 320 mm, weight 310 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8533. Fazenda Bonfim, Rio do Braço, muncipality of Ilhéus. Cacao plantation. 27 September 1944. Adult male. HBL 190 mm, tail 310 mm, weight 250 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8534. Fazenda Santa Luzia, Rio do Braço, muncipality of Ilhéus. Secondary growth scrub. 19 October 1944. Adult male. HBL 200 mm, tail 330 mm, weight 280 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8535. Fazenda Bonfim, Rio do Braço, muncipality of Ilhéus. Secondary growth scrub. 29 September 1944. Subadult male. HBL 190 mm, tail 300 mm, weight 250 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8536. Fazenda Quixada, Rio do Braço, muncipality of Ilhéus. Cacao plantation. 9 October 1944. Adult female. HBL 215 mm, tail 330 mm, weight 380 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8537. Fazenda Bonfim, municipality of Ilhéus. 23 October 1944. Adult male. Labeled *Callithrix penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8538. Fazenda Bonfim, Rio do Braço, muncipality of Ilhéus. Cacao plantation. 11 October 1944. Adult female. HBL 200 mm, tail 312 mm, weight 350 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8539. Fazenda Bonsucesso, Castelo Novo, muncipality of Ilhéus. Secondary growth scrub. 19 December 1944. Adult male. HBL 215 mm, tail 325 mm, weight 270 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8540. Sambaituba, Aritagua, muncipality of Ilhéus. Forest. 11 November 1944. Adult male. HBL 220 mm, tail 315 mm, weight 450 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8541. Sambaituba, Aritagua, municipality of Ilhéus. Banana plantation. 1 November 1944. Adult female. HBL 220 mm, tail 305 mm, weight 340 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8542. Fazenda Santa Luiza, Rio do Braço, municipality of Ilhéus. Secondary growth scrub. 22 October 1944. Adult female. HBL 225 mm, tail 320 mm, weight 400 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8543. Fazenda Corumba, Rio do Braço, municipality of Ilhéus. Cacao plantation. 29 October 1944. Adult female. HBL 225 mm, tail 325 mm, weight 320 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8544. Sambaituba, Aritagua, municipality of Ilhéus. Banana plantation. 7 November 1944. Adult male. HBL 223 mm, tail 336 mm, weight 320 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8545. Fazenda Novo Horizonte, Castelo Novo, municipality of Ilhéus. Cacao plantation. 27 October 1944. Adult female (old). HBL 210 mm, tail 270 mm, weight 380 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8546. Fazenda Viçosa, Castelo Novo, municipality of Ilhéus. Cacao plantation. 11 November 1944. Adult male. HBL 205 mm, tail 310 mm, weight 380 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8547. Fazenda Baleia, Rio do Braço, municipality of Ilhéus. Cacao plantation. 14 October 1944. Adult male. HBL 225 mm, tail 330 mm, weight 400 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8548. Fazenda Almada, Rio do Braço, municipality of Ilhéus. Secondary growth scrub. 16 December 1944. Adult male. HBL 220 mm, tail 310 mm, weight 400 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8549. Fazenda Almada, Rio do Braço, municipality of Ilhéus. Cacao plantation. 7 November 1944. Adult male. HBL 215 mm, tail 300 mm, weight 370 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8550. Fazenda Provisão, Rio do Braço, municipality of Ilhéus. Cacao plantation. 6 February 1945. Adult female. HBL 220 mm, tail 350 mm, weight 310 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8558. Repartimento, Pontal, municipality of Ilhéus. Forest. 19 October 1944. Adult male. HBL 245 mm, tail 390 mm, weight 400 g. Labeled *Callithrix p. penicillata*. Coll. Galdino Pereira.

MNRJ 8559. Japu, Repartimento, municipality of Ilhéus. Forest. 24 December 1944. Adult female. HBL 526 mm, tail 300 mm. Labeled *Callithrix penicillata*. Coll. Pedro M. Britto.

MNRJ 8562. Banco da Vitória, Banco da Vitória, municipality of Ilhéus. Secondary growth scrub. 19 October 1944. Adult male. HBL 215 mm, tail 340 mm, weight 350 g. Labeled *Callithrix penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8565. Fazenda Promissão, Banco da Vitória, municipality of Ilhéus. Cacao plantation. 9 March 1945. Adult female. HBL 185 mm, tail 320 mm, weight 260 g. Labeled *Callithrix penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8569. Ribeirão da Fortuna, Buerarema, municipality of Ilhéus. Forest. 10 January 1944. Adult male. HBL 210 mm, tail 320 mm. Labeled *Callithrix penicillata*. Coll. GIP.

MNRJ 8571. Fazenda Ipiranga, Rio do Braço, municipality of Ilhéus. Cacao plantation. 14 March 1945. Juvenile female. HBL 95 mm, tail 140 mm, weight 40 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8574. Fazenda Primavera, Banco da Vitória, municipality of Ilhéus. Secondary growth scrub. 24 January 1945. Adult male. HBL 210 mm, tail 310 mm, weight 330 g. Labeled *Callithrix p. penicillata*. Coll. Hugo W. Laemmert.

MNRJ 8577. Ribeirão da Fortuna, Buerarema, municipality of Ilhéus. Closed forest. 15 March 1945. Adult female. HBL 205 mm, tail 298 mm, weight 335 g. Labeled *Callithrix p. penicillata*. Coll. GIP.

MNRJ 23790. Ilhéus. Maintained in a zoo. 26 April 1945. Adult female. HBL 534 mm, tail 300 mm, weight 335 g. Labeled *Callithrix p. penicillata*. Coll. Pedro M. Britto.

MNRJ 23794. Passui, Belmonte. 16 August 1949. Adult male. HBL 195 mm, tail 340 mm, weight 350 g. Labeled *Callithrix p. penicillata*.

MNRJ 43933. A sul da Boca do Corrego, Bahia. Juvenile. Labeled *Callithrix kuhlii*. Coll. Lucia Lorini.

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Appendix 1

Gazetteer — Localities for *Callithrix kuhlii* (Fig. 5)

MNRJ = Museu Nacional do Rio de Janeiro, Brazil
MZUSP = Museu de Zoologia, Universidade de São Paulo, Brazil
USNM = National Museum of Natural History, Washington, DC
DZ = Departamento de Zoologia, Secretaria de Agricultura do Estado de São Paulo

1. Alegre (Fazenda), região do Barro Branco, sudeste de Rio do Meio, Itororó, Bahia, 15º09′S, 39º56′W. Observation by Pinto (1994).
2. Almada (Fazenda), Rio Almada, 14°38′S, 39°12′W. Serviço de Estudos e Pesquisa sobre a Febre Amarela (SEPSFA). Attributed to *C. jacchus penicillata* by Hershkovitz (1977, p.938, locality 299). Vaz (2005) lists a series of collecting localities under the general name of "Almada, municipality of Ilhéus, district of Rio do Braço (14°39′S, 39°11′W)". Attributed to *C. j. geoffroyi* by Ávila-Pires (1969).
3. Angelim and Salinada, streams in the region of, 19 km to the southeast of Potiraguá, Potiraguá, Bahia, 15º43′S, 39º45′W. Observation by Pinto (1994).
4. Banco da Vitória, Ilhéus, Bahia. Attributed to *C. penicillata* by Vivo (1991; locality 21), who listed eight skins and eight skulls in the MNRJ. Cited by Mendes (1997; locality K7) and attributed to *C. kuhlii*. Not mapped.
5. Belmonte, Rio (c.f. Rio Jequitinhonha) 15°45′S, 38°55′W. Wied-Neuwied 1815–1817. Attributed to *C. jacchus penicillata* (= *C. j. penicillata* × *C. j. geoffroyi*) by Hershkovitz (1975, p.142; 1977, p.938, locality 306). Also cited by Kinzey (1982; locality 24). Vivo (1991; locality 25) lists a specimen (skin) from Belmonte, Passui in the MNRJ. Type locality of *C. kuhlii*.
6. Boa Vista (Fazenda), Belmonte, right bank of lower Rio Jequitinhonha, Bahia, 16°03′S, 39°17′W. Lima (1990, locality 80), attributed to *C. kuhlii*. Cited by Mendes (1997, locality K17), attributed to *C. kuhlii*.
7. Boa Vista (Fazenda), Itarantim, Bahia, 15°53′S, 40°09′W. Rylands *et al*. (1988, locality 41), attributed to *C. kuhlii*.
8. Bolandeira (Fazenda), 10 km to the south of Una, BA-001 (Ilhéus-Canavieiras road), Una, Bahia, 15º21′S, 39º00′W. Observation by Pinto (1994).
9. Buenos Aires (Fazenda), Ribeirão dos Índios, between Ibicuí and Água Doce, Ibicuí, Bahia, 14º48′S, 39º54′W. Observation by Pinto (1994).
10. Buerarema, Ribeirão da Fortuna. Estação da Mata do Cacau, 14°57′S, 39°19′W. Serviço de Estudos e Pesquisa sobre a Febre Amarela (SEPSFA). 17 October 1949. Attributed to *C. jacchus penicillata* by Hershkovitz (1977, p.938, locality 299). Also cited by Kinzey (1982; locality 18). Vivo (1991) lists three skins and two skulls in the MNRJ. Cited by Mendes (1997; locality K2) and attributed to *C. kuhlii*. See Vaz (2005).
11. Café sem Troco (Fazenda), km 11, Santa Cruz da Vitória-Itajú do Colônia road, Santa Cruz da Vitória, Bahia, 15º03′S, 39º48′W. Observation by Pinto (1994).
12. Camacá and Mascote (between), Bahia, 15°32′S, 39°20′W. Mendes (1997, locality K18), attributed to *C. kuhlii*.
13. Camponesa (Fazenda), Rio Pardo ferry road to the south of Itapetinga, Itapetinga, Bahia, 15º24′S, 40º12′W. Observation by Pinto (1994).
14. Canavieiras, Estação Experimental (CEPLAC), 16 km to the southwest of Una, Rio São Pedro, Canavieiras, Bahia, 15º23′S, 39º12′W. Observation by Pinto (1994).

15. Castelo Novo, Ilhéus, Bahia. Attributed by Vivo (1991) to *C. penicillata*, listing one skin in the USNM, and six skins and skulls in the MNRJ. Not mapped.
16. Cotovelo (Fazenda), 14 km to the north of Canavieiras, Bahia, 15º33′S, 38º58′W. Observation by Pinto (1994).
17. Cristal (Fazenda), Jacinto and Jordania, Minas Gerais, 16°01′S, 40°05′W. Rylands *et al*. (1988, locality 40), attributed to *C. kuhlii*. Cited by Mendes (1997, locality K14), attributed to *C. kuhlii*.
18. Dendhevea, Fazenda 20 km to the east of Una, Una-Arataca road, Una, Bahia, 15º14′S, 39º13′W. Observation by Pinto (1994).
19. Djalma Bahia, Estação Experimental (CEPLAC), Una, Bahia, 15º17′S, 39º03′W. Observation by Pinto (1994).
20. Ilhéus, 14°49′S, 39°02′W, sea level. Wied-Neuwied 1815–1817. Serviço de Estudos e Pesquisa sobre a Febre Amarela (SEPSFA). September 1944. E. Garbe, August 1919. Attributed to *C. jacchus penicillata* (*C. j. penicillata* × *C. j. geoffroyi*) by Hershkovitz (1977, p.938, locality 299). Attributed to *C. j. penicillata* by Ávila-Pires (1969). Also cited by Kinzey (1982; locality 18), Vivo (1991; locality 22) lists two specimens (1 skin and 1 skull) in the USNM, 2 skulls in the MZUSP, and one skin in the MNRJ. See Vaz (2005).
21. Ilhéus, 7 km south of, Bahia, 14°51′S, 39°02′W. Oliver and Santos (1991, locality 61), attributed to *C. kuhlii.* Cited by Mendes (1997, locality K12), attributed to *C. kuhlii*.
22. Itabuna, Rio Ilhéus, 14°48′S, 39°16′W. Attributed to *C. jacchus penicillata* by Hershkovitz (1977, p.938, locality 300). Also cited by Vivo (1991; locality 23), who listed one skin and one skull in the MUZSP, attributed to *C. penicillata*.
23. Itabuna, vicinity of, Bahia, 14°50′S, 39°17′W. Oliver and Santos (1991, locality 60), attributed to *C. kuhlii.* Cited by Mendes (1997, locality K11), attributed to *C. kuhlii*.
24. Itajubá (Fazenda), Rio Piabanha, 16 km to the north of Itapetinga, Itambé, Bahia, 15º06′S, 40º13′W. Observation by Pinto (1994).
25. Itapetinga (Fazenda), Serra do Felícimo, south of Itarantim, Bahia, 15º48′S, 40º09′W. Observation by Pinto (1994).
26. Japu, Repartimento, Ilhéus, Bahia, 14°55′S, 39°12′W. One specimen in the MNRJ, listed by Mendes (1997) and attributed to *C. kuhlii*. Listed under the general heading of Fortuna (Vaz, 2005).
27. José Deodato Araújo (Fazenda de), 14 km west of Una Una-Arataca road, Una, Bahia, 15º17′S, 39º12′W.
28. Limeira (Fazenda), Sapucaieira, region of the Rio Aguípe, Ilhéus, Bahia, 15º03′S, 39º04′W.
29. Limoeiro, Fazenda, 10 km from the Nova Canaã-Itajaí road, Nova Canaã, Bahia, 14º53′S, 40º08′W. Observation by Pinto (1994).
30. Morro das Pedras (Fazenda), Ilhéus, 14°49′S, 39°02′W. Serviço de Estudos e Pesquisa sobre a Febre Amarela (SEPSFA). September 1944. Attributed to *C. jacchus penicillata* (*C. j. penicillata* × *C. j. geoffroyi*) by Hershkovitz (1977, p.938, locality 299). See location 20 (Fig. 5).
31. Morro Grande (Fazenda do), Salto de Divisa, Minas Gerais, 15°52′S, 40°05′W. Rylands *et al*. (1988, locality 40), attributed to *C. kuhlii*. Cited by Mendes (1997, locality K15), attributed to *C. kuhlii*.
32. Mundo Novo, Rio Pardo, 15°16′S, 40°58′W. Wied-Neuwied 1815–1817. Attributed to *C. jacchus penicillata* by Hershkovitz (1977, p.938, locality 298). Also cited by Kinzey (1982; locality 21).
33. Nazaré, vicinity of, Bahia, 12°59′S, 39°00′W; Oliver and Santos (1991, locality 24), attributed to *C. kuhlii.* Cited by Mendes (1997, locality K9), attributed to *C. kuhlii*.
34. Nova Guaiaquil (Fazenda), vicinity of Rio do Meio, Itororó, Bahia, 15º08′S, 39º57′W. Observation by Pinto (1994).
35. Palmeira (Fazenda), Palmeira, Serra das Guaribas, left bank of the Rio Jequitinhonha, Itapebi, Bahia, 15º55′S, 39º37′W. Observation by Pinto (1994).
36. Pardo, Rio, 15°39′S, 38°57′W. Wied-Neuwied 1815–1817. Attributed to *C. jacchus penicillata* by Hershkovitz (1977, p.938, locality 304). Also cited by Kinzey (1982; locality 23).
37. Pindorama (Fazenda), 10 km to the southwest of Una, right bank of the Rio Aliança, Una, Bahia, 15º19′S, 39º10′W. Observation by Pinto (1994).
38. Pirataquisse (Fazenda), 14°50′S, 39°05′W. Serviço de Estudos e Pesquisa sobre a Febre Amarela (SEPSFA). Attributed to *C. jacchus penicillata* (*C. j. penicillata* × *C. j. geoffroyi*) by Hershkovitz (1977, p.938, locality 299). Also cited by Kinzey (1982; locality 18). Vivo (1991) lists one skull and one skin in the USNM, and 25 skins, 21 skulls in the MNRJ. Cited by Mendes (1997; locality K4) and attributed to *C. kuhlii*. Attributed to *C. j. penicillata* by Ávila-Pires (1969). Vaz (2005) lists a number of localities under the general heading of "Pirataquissé, municipality of Ilhéus. District of Banco da Vitória (14°48′S, 39°07′W).
39. Poções, 14°31′S, 40°21′W. Attributed to *C. jacchus penicillata* by Hershkovitz (1977, p.490, locality 301).
40. Pontal dos Ilhéus, 14°49′S, 39°01′W. Attributed to *C. jacchus penicillata* by Kinzey (1982; locality 18). Vivo (1991) listed Fazenda Pontal, Repartimento, Ilhéus, with one skin and one skull in the MZUSP, seven skins and five skulls in the MNRJ, attributed to *C. penicillata*. Cited by Mendes (1997; locality K8) and attributed to *C. kuhlii*.
41. Retiro (Fazenda), Aritaguá, Ilhéus, Bahia. Attributed to *C. penicillata* by Vivo (1991; locality 21), who listed six skins and six skulls in the MNRJ. MNRJ 8524, female. See Vaz (2005). Not mapped.
42. Riacho Filó (Fazenda), region of Piancó, left bank of the Rio Gongoji, Gongoji, Bahia, 14º18′S, 39º41′ W. Observation by Pinto (1994).
43. Ribeirão da Fortuna (Fazenda), Ilhéus, Bahia, MN7898, Skin and skull. Serviço de Estudos e Pesquisa sobre a Febre Amarela (SEPSFA), The Rockefeller Foundation. Collector Galdino Pereira, 10 January 1944. Vaz (2005) lists "Fazenda Ribeirão da Fortuna (mata D, G, P., mata da lagoa, est da mata do cacau); Repartimento; Santa Rita, Japu, rodovia Buerarema km 5" under the general heading of "Fortuna, municipality of Buerarema (14°58′S, 39°14′W)".
44. Ribeirão das Minhocas, Rio Ilhéus 15°12′S, 39°57′W. Attributed to *C. jacchus penicillata* by Hershkovitz (1977, p.490, locality 302).
45. Rio do Braço, Ilhéus, Bahia. Attributed to *C. penicillata* by Vivo (1991; locality 24), who listed one skin in the MZUSP, three skins and three skulls in the USNM, and 43 skins and 40 skulls in the MNRJ. Cited by Mendes (1997; locality K1) and attributed to *C. kuhlii*. See Vaz (2005). Not mapped.
46. Rio do Ouro, headwaters of, southeast of Ibitupã, Ibicuí, Bahia, 14º33′S, 39º44′W. Observation by Pinto (1994).
47. Sambaituba, Aritagauá, Ilhéus, Bahia, 14°43′S, 39°06′W. Attributed to *C. penicillata* by Vivo (1991; locality 21) who listed 11 skins and 10 skulls in the MNRJ. Cited by Mendes (1997; locality K6) and attributed to *C. kuhlii*. See Vaz (2005).
48. Santa Clara (Fazenda), km 9 km of BA-270 (Canavieiras-Santa Luzia road), Canavieiras, Bahia, 15º34′S, 39º04′W. Observation by Pinto (1994).
49. Santa Terezinha (Fazenda), region of Barro Branco, southeast of the Rio do Meio, Itororó, Bahia, 15º08′S, 39º58′W. Observation by Pinto (1994).
50. Una, 15°18′S, 39°04′W. Attributed to *C. jacchus penicillata* by Hershkovitz (1977, p.490, locality 303). *C. kuhlii* has also been

recorded from Una by Rylands (1982, 1989), Santos *et al*. (1987), Mittermeier *et al*. (1981, 1982), Pinto (1994), Raboy (1998).

51. Una, Estação Experimental de Lemos Maia (CEPLAC/CEPEC), Bahia, 15°15′S, 39°05′W. Rylands (1982, 1984, 1989), Stevenson and Rylands (1988), Rylands *et al*. (1991/1992) attributed to *C. kuhlii*. Also Oliver and Santos (1991, locality 67), attributed to *C. kuhlii.* Cited by Mendes (1997, locality K13), attributed to *C. kuhlii*.
52. Unacau (Fazenda), Bahia, 15°08′S, 39°17′W. Lima (1990, locality 36), attributed to *C. kuhlii*. Cited by Mendes (1997, locality K16), attributed to *C. kuhlii*.
53. Urucutuca, Aritaguá, Ilhéus, Bahia, 14°39′S, 39°04′W. Serviço de Estudos e Pesquisa sobre a Febre Amarela (SEPSFA). Attributed to *C. jacchus penicillata* by Hershkovitz (1977, p.938, locality 299). Attributed to *C. penicillata* by Vivo (1991; locality 21). Cited by Mendes (1997; locality K3) and attributed to *C. kuhlii*. Vaz (2005) includes the localities of Fazenda Retiro, Sambaituba, and Cajucatinga under the general heading of "Urucutuca, municipality of Ilhéus, district of Aritaguá (14°39′S, 39°07′W)".
54. Valença, vicinity of, Bahia, 13°18′S, 39°01′W. Oliver and Santos (1991, locality 36), attributed to *C. kuhlii*. Cited by Mendes (1997, locality K10), attributed to *C. kuhlii*.
55. [Fazenda Jucurucu, Rio 17°21′S, 39°13′W. Attributed C. jacchus penicillata by Hershkovitz (1977, p.938 and p.490, locality 307a). Ávila-Pires (1969) listed a specimen from Rio Jucurucu [sic] in the DZ, attributed to *C. p. penicillata*. Also cited by Kinzey (1982, locality 25). Vivo (1991; locality 26) cites four specimens (skins) in the MZUSP. This is outside the recognized geographic distribution of *C. kuhlii* and *C. penicillata*, and may well refer to an introduced specimen of the latter.]

Appendix 2

Specimens of *Callithrix kuhlii* in the Museu Nacional, Rio de Janeiro, Brazil. List compiled by Sérgio Maia Vaz, Secão de Mamíferos, Museu Nacional, Rio de Janeiro. See Vaz (2005).

MNRJ = Museu Nacional, Ro de Janeiro

SEPSFA = *Serviço de Estudos e Pesquisa sobre a Febre Amarela*, a program in collaboration with the International Health Divsion of the Rockefeller Foundation, in the municipalities of Ilhéus and Buerarema, state of Bahia, Brazil, December 1943–April 1945 (Laemmert *et al*. 1946).

H.W.L. = H. W. Laemmert, collector.

MNRJ 7898. Fazenda Ribeirão da Fortuna, Buerarema, Bahia, Female. Col. Galdino Pereira, 10 January, 1944. Skin and skull. M17068, SEPSFA, Rockefeller Foundation.

MNRJ 8524. Fazenda Retiro, Aritaguá, Ilhéus, Bahia. Female. Col. H. W.L., 1 November, 1944. Skin and skull M22107, SEPSFA, Rockefeller Foundation. Wt. 370 g.

MNRJ 8525. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H. W. L., 21 October, 1944. In *capoeira*. Skin and skull M21941, SEPSFA, Rockefeller Foundation. Wt. 300 g.

MNRJ 8526. Fazenda Provisão, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 6 February 1945. In a cocoa plantation. Skin and skull M22807. SEPSFA, Rockefeller Foundation. Wt. 360 g.

MNRJ 8527. Fazenda Provisão, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 6 February 1945. In a cocoa plantation. Skin and skull M22808. SEPSFA, Rockefeller Foundation. Wt. 320 g.

MNRJ 8528. Fazenda Itinga, Pontal, Ilhéus, Bahia. Female. Col. H.W.L., 16 December 1944. In *capoeira*. Skin and skull M22670. SEPSFA, Rockefeller Foundation. Wt. 320 g.

MNRJ 8529. Fazenda Bonfim, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 4 February 1945. In a cocoa plantation. Skin and skull M22799. SEPSFA, Rockefeller Foundation. Wt. 400 g.

MNRJ 8530. Fazenda Almada, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 7 November 1944. In a cocoa plantation. Skin and skull M22196. SEPSFA, Rockefeller Foundation. Wt. 370 g.

MNRJ 8531. Urucutuca, Aritaguá, Ilhéus, Bahia. Unsexed. Col. H.W.L., 2 October 1944. In *capoeira*. Skin and skull M19776. SEPSFA, Rockefeller Foundation. Wt. 400 g.

MNRJ 8532. Fazenda Bonfim, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 23 October 1944. In a cocoa plantation. Skin and skull M21955. SEPSFA, Rockefeller Foundation. Wt. 310 g.

MNRJ 8533. Fazenda Bonfim, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 27 September 1944. In a cocoa plantation. Skin and skull M19744. SEPSFA, Rockefeller Foundation. Wt. 250 g.

MNRJ 8534. Fazenda Santa Luzia, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 19 October 1944. In *capoeira*. Skin and skull M21918. SEPSFA, Rockefeller Foundation. Wt. 280 g.

MNRJ 8535. Fazenda Bonfim, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 29 September 1944. In a cocoa plantation. Skin and skull M19752. SEPSFA, Rockefeller Foundation. Wt. 250 g.

MNRJ 8536. Fazenda Quixadá, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 9 October 1944. In a cocoa plantation. Skin and skull M21887. SEPSFA, Rockefeller Foundation. Wt. 380 g.

MNRJ 8537. Fazenda Bonfim, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 23 October 1944. In a cocoa plantation. Skin and skull M21956. SEPSFA, Rockefeller Foundation. Wt. 300 g.

MNRJ 8538. Fazenda Bonfim, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 11 October 1944. In a cocoa plantation. Skin and skull M21860. SEPSFA, Rockefeller Foundation. Wt. 350 g.

MNRJ 8539. Fazenda Bom Sucesso, Castelo Novo, Ilhéus, Bahia. Male. Col. H.W.L., 19 December 1944. In *capoeira*. Skin and skull M22682. SEPSFA, Rockefeller Foundation. Wt. 270 g.

MNRJ 8540. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., Col. 11 November 1944. In tall forest. Skin and skull M22230. SEPSFA, Rockefeller Foundation. Wt. 450 g.

MNRJ 8541. Sambaituba, Aritaguá, Ilhéus, Bahia. Female. Col. H.W.L., 1 November 1944. In banana plantation. Skin and skull M22123. SEPSFA, Rockefeller Foundation. Wt. 340 g.

MNRJ 8542. Fazenda Santa Luzia, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 22 October 1944. In *capoeira*. Skin and skull M21948. SEPSFA, Rockefeller Foundation. Wt. 400 g.

MNRJ 8543. Fazenda Corumbá, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 29 October 1944. In cocoa plantation. Skin and skull M22082. SEPSFA, Rockefeller Foundation. Wt. 320 g.

MNRJ 8544. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 7 November 1944. In banana plantation. Skin and skull M22205. SEPSFA, Rockefeller Foundation. Wt. 320 g.

MNRJ 8545. Fazenda Novo Horizonte, Castelo Novo, Ilhéus, Bahia. Female. Col. H.W.L., 27 October 1944. In cocoa plantation. Skin and skull M22049. SEPSFA, Rockefeller Foundation. Wt. 380 g.

MNRJ 8546. Fazenda Viçosa, Castelo Novo, Ilhéus, Bahia. Male. H.W.L. Col. 11 November 1944. In cocoa plantation. Skin and skull M22226. SEPSFA, Rockefeller Foundation. Wt. 380 g.

MNRJ 8547. Fazenda Baleia, Rio do Braço, Ilhéus, Bahia. Male. H.W.L. Col. 14 October 1944. In a cocoa plantation. Skin and skull M21876. SEPSFA, Rockefeller Foundation. Wt. 400 g.

MNRJ 8548. Fazenda Almada, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 16 December 1944. In *capoeira*. Skin and skull M22671. SEPSFA, Rockefeller Foundation. Wt. 400 g.

MNRJ 8549. Fazenda Almada, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 7 November 1944. In a cocoa plantation. Skin and skull M22195. SEPSFA, Rockefeller Foundation. Wt. 370 g.

MNRJ 8550. Fazenda Provisão, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 6 February 1945. In a cocoa plantation. Skin and skull M22806. SEPSFA, Rockefeller Foundation. Wt. 310 g.

MNRJ 8551. Fazenda Pedra Branca, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 15 October 1944. In a cocoa plantation. Skin and skull M21888. SEPSFA, Rockefeller Foundation. Wt. 280 g.

MNRJ 8552. Fazenda Novo Horizonte, Castelo Novo, Ilhéus, Bahia. Female. Col. H.W.L., 8 November 1944. In a cocoa plantation. Skin and skull M22203. SEPSFA, Rockefeller Foundation. Wt. 400 g.

MNRJ 8553. Fazenda Quixadá, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 9 October 1944. In a cocoa plantation. Skin and skull M21884. SEPSFA, Rockefeller Foundation. Wt. 290 g.

MNRJ 8554. Fazenda Novo Horizonte, Castelo Novo, Ilhéus, Bahia. Female. Col. H.W.L., 8 November 1944. In a cocoa plantation. Skin and skull M22201. SEPSFA, Rockefeller Foundation. Wt. 420 g.

MNRJ 8555. Fazenda Santa Rita, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 15 December 1944. In a cocoa plantation. Skin and skull M22673. SEPSFA, Rockefeller Foundation. Wt. 280 g.

MNRJ 8556. Fazenda Almada, Mirante, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 19 September 1944. In a cocoa plantation. Skin and skull M19686. SEPSFA, Rockefeller Foundation. Wt. 380 g.

MNRJ 8557, Fazenda Progresso, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 30 March 1944. In a cocoa plantation. Skin and skull M17716. SEPSFA, Rockefeller Foundation. Wt. 350 g.

MNRJ 8558. Repartimento, Pontal, Ilhéus, Bahia. Male. Col. Galdino Pereira, 19 October 1944. In forest. Skin and skull M21967. SEPSFA, Rockefeller Foundation. Wt. 400 g.

MNRJ 8559. Repartimento, Mata do Japú, Ilhéus, Bahia. Female. Col. Pedro M. Britto, 24 December 1943. In forest. Skin and skull. M170003. SEPSFA, Rockefeller Foundation.

MNRJ 8560. Fazenda Bonfim, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 14 December 1944. In a cocoa plantation. Skin and skull M22667. SEPSFA, Rockefeller Foundation. Wt. 370 g.

MNRJ 8561. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 8 November 1944. In *capoeira*. Skin and skull M22215, SEPSFA, Rockefeller Foundation. Wt. 370 g.

MNRJ 8562. Banco da Vitória, Banco da Vitória, Ilhéus, Bahia. Male. Col. H.W.L., 19 October 1944. In *capoeira*. Skin and skull M21930, SEPSFA, Rockefeller Foundation. Wt. 350 g.

MNRJ 8563. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 8 November 1944. In *capoeira*. Skin and skull M22214. SEPSFA, Rockefeller Foundation. Wt. 390 g.

MNRJ 8564. Urucutuca, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 13 December 1944. In *capoeira*. Skin and skull M22666. SEPSFA, Rockefeller Foundation. Wt. 250 g.

MNRJ 8565. Fazenda Promissão, Banco da Vitória, Ilhéus, Bahia. Female. Col. H.W.L., 9 March 1945. In a cocoa plantation. Skin and skull M22884. SEPSFA, Rockefeller Foundation. Wt. 260 g.

MNRJ 8566. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 11 November 1944. In forest. Skin and skull M22231. SEPSFA, Rockefeller Foundation. Wt. 350 g.

MNRJ 8567. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 6 November 1944. In *capoeira*. Skin and skull M22190. SEPSFA, Rockefeller Foundation. Wt. 280 g.

MNRJ 8568. Fazenda Provisão, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 10 February 1945. In a cocoa plantation. Skin and skull M22817. SEPSFA, Rockefeller Foundation. Wt. 450 g.

MNRJ 8569. Ribeirão da Fortuna, Buerarema, Bahia. Male. Col. G.I.D., 10 January 1944. In forest. Skin and skull M17067. SEPSFA, Rockefeller Foundation.

MNRJ 8570. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 7 November 1944. In a coffee plantation. Skin and skull M22209. SEPSFA, Rockefeller Foundation. Wt. 360 g.

MNRJ 8571. Fazenda Ipiranga, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 14 March 1945. In a cocoa plantation. Skin and skull M22895. SEPSFA, Rockefeller Foundation. Wt. 40 g.

MNRJ 8572. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 7 November 1944. In a coffee plantation. Skin and skull M22208. SEPSFA, Rockefeller Foundation. Wt. 320 g.

MNRJ 8573. Fazenda Baleia, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 28 September 1944. In a cocoa plantation. Skin and skull M19746. SEPSFA, Rockefeller Foundation. Wt. 340 g.

MNRJ 8574. Fazenda Primavera, Banco da Vitória, Ilhéus, Bahia. Female. Col. H.W.L., 24 January 1945. In *capoeira*. Skin and skull M22768, SEPSFA, Rockefeller Foundation. Wt. 330 g.

MNRJ 8575. Urucutuca, Aritaguá, Ilhéus, Bahia. Male. Col. G.I.P., 10 October 1944. In *capoeira*. Skin and skull M21600. SEPSFA, Rockefeller Foundation.

MNRJ 8576. Fazenda Bonfim, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 14 December 1944. In a cocoa plantation. Skin and skull M22668. SEPSFA, Rockefeller Foundation. Wt. 330 g.

MNRJ 8577. Ribeirão da Fortuna, Buerarema, Bahia. Female. Col. G.I.P., 15 March 1945. In forest. Skin and skull M23756. SEPSFA, Rockefeller Foundation. Wt. 335 g.

MNRJ 8578. Fazenda Almada, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 11 November 1944. In a cocoa plantation. Skin and skull M22299. SEPSFA, Rockefeller Foundation. Wt. 350 g.

MNRJ 8579. Fazenda Tamburi, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 11 November 1944. In a cocoa plantation. Skin and skull M22228. SEPSFA, Rockefeller Foundation. Wt. 310 g.

MNRJ 8580. Sambaituba, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 21 October 1944. In *capoeira*. Skin and skull M21940. SEPSFA, Rockefeller Foundation. Wt. 320 g. (Missing).

MNRJ 8581. Fazenda Bonfim, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 24 September 1944. In a cocoa plantation. Skin and skull M19728. SEPSFA, Rockefeller Foundation. Wt. 310 g.

MNRJ 8582. Fazenda Triunfo, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 6 March 1945. In forest. Skin and skull M22874. SEPSFA, Rockefeller Foundation. Wt. 500 g. (Pregnant, gave birth to twins on 8 March 1945).

MNRJ 8583. Urucutuca, Aritaguá, Ilhéus, Bahia. Male. Col. H.W.L., 13 December 1944. In *capoeira*. Skin and skull M22665. SEPSFA, Rockefeller Foundation. Wt. 370 g.

MNRJ 8584. Fazenda Lavapés, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 15 October 1944. In *capoeira*. Skin and skull M21903. SEPSFA, Rockefeller Foundation. Wt. 390 g.

MNRJ 8585. Ponto da Baleia, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 10 October 1944. In a cocoa plantation. Skin and skull M21859. SEPSFA, Rockefeller Foundation. Wt. 360 g.

MNRJ 8586. Sambaituba, Aritaguá, Ilhéus, Bahia. Female. Col. H.W.L., 23 October 1944. In *capoeira*. Skin and skull M21997. SEPSFA, Rockefeller Foundation. Wt. 370 g.

MNRJ 8587. Fazenda Santa Luzia, Banco da Vitória, Ilhéus, Bahia. Male. Col. H.W.L., 4 February 1945. In a cocoa plantation. Skin and skull M22801. SEPSFA, Rockefeller Foundation. Wt. 365 g.

MNRJ 8588. Fazenda Santo Antônio, Pontal, Ilhéus, Bahia. Female. Col. H.W.L., 9 March 1945. In a banana plantation. Skin and skull M22887. SEPSFA, Rockefeller Foundation. Wt. 270 g.

MNRJ 8589. Urucutuca, Aritaguá, Ilhéus, Bahia. Female. Col. H.W.L., 13 December 1944. In *capoeira*. Skin and skull M22664. SEPSFA, Rockefeller Foundation. Wt. 390 g.

MNRJ 8590. Fazenda Saudade, Banco da Vitória, Ilhéus, Bahia. Male. Col. H.W.L., 1 February 1945. In a cocoa plantation. Skin and skull M22786. SEPSFA, Rockefeller Foundation. Wt. 400 g.

MNRJ 8591. Fazenda Santa Luzia, Banco da Vitória, Ilhéus, Bahia. Male. Col. H.W.L., 7 February 1945. In a cocoa plantation. Skin and skull M22812. SEPSFA, Rockefeller Foundation. Wt. 430 g.

MNRJ 8592. Fazenda São Francisco, Castelo Novo, Ilhéus, Bahia. Female. Col. H.W.L., 27 February 1945. In *capoeira*. Skin and skull M22864. SEPSFA, Rockefeller Foundation. Wt. 360 g.

MNRJ 8593. Fazenda Saudade, Banco da Vitória, Ilhéus, Bahia. Female. Col. H.W.L., 11 February 1945. In *capoeira*. Skin and skull M22819. SEPSFA, Rockefeller Foundation. Wt. 310 g.

MNRJ 8594. Repartimento, Pontal, Ilhéus, Bahia. Male. Col. G.D., 19 October 1944. In forest. Skin and skull M21971. SEPSFA, Rockefeller Foundation. Wt. 400 g.

MNRJ 8595. Repartimento, Pontal, Ilhéus, Bahia. Male. Col. G.D., 19 October 1944. In forest. Skin and skull M21968. SEPSFA, Rockefeller Foundation. Wt. 275 g.

MNRJ 8596. Fazenda Almada, Rio do Braço, Ilhéus, Bahia. Female. Col. G.I.P., 15 November 1944. In *capoeirão*. Skin and skull M22393. SEPSFA, Rockefeller Foundation. Wt. 333 g.

MNRJ 8597. Fazenda Pirataquissé, Primavera, Ilhéus, Bahia. Male. Col. G.I.P., 29 January 1944. In *capoeirão*. Skin and skull M17188. SEPSFA, Rockefeller Foundation.

MNRJ 8598. Fazenda Santa Rita, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 28 September 1944. In a cocoa plantation. Skin and skull M19742. SEPSFA, Rockefeller Foundation. Wt. 260 g.

MNRJ 10998. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Pedro M. Britto, 19 January 1944. Skin M17219. SEPSFA, Rockefeller Foundation.

MNRJ 10999. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 6 February 1944. Skin M17108. SEPSFA, Rockefeller Foundation.

MNRJ 11001. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 4 February 1944. Skin and skull M17208. SEPSFA, Rockefeller Foundation.

MNRJ 11002. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 11 February 1944. Skin and skull M17242. SEPSFA, Rockefeller Foundation.

MNRJ 11003. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 24 January 1944. Skin and skull M17141. SEPSFA, Rockefeller Foundation.

MNRJ 11004. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 2 February 1944. Skin and skull M17200. SEPSFA, Rockefeller Foundation.

MNRJ 11005. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 27 January 1944. Skin and skull M17165. SEPSFA, Rockefeller Foundation.

MNRJ 11006. Repartimento, Ilhéus, Bahia. Female. Col. Pedro de M. Britto, 24 December 1943. Skin M17004. SEPSFA, Rockefeller Foundation.

MNRJ 11007. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 14 January 1944. Skin and skull M17143. SEPSFA, Rockefeller Foundation.

MNRJ 11008. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 24 January 1944. Skin and skull M17142. SEPSFA, Rockefeller Foundation.

MNRJ 11009. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 28 January 1944. Skin and skull M17176. SEPSFA, Rockefeller Foundation.

MNRJ 11010. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 9 February 1944. Skin and skull M17233. SEPSFA, Rockefeller Foundation.

MNRJ 11011. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 4 February 1944. Skin and skull M17207. SEPSFA, Rockefeller Foundation. (Missing).

MNRJ 11013. Rio do Braço, Ilhéus, Bahia. Female. Col. Pedro M. Britto, 24 February 1944. Skin and skull M17401. SEPSFA, Rockefeller Foundation. (Missing).

MNRJ 11014. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Pedro M. Britto, 19 January 1944. Skin M17107. SEPSFA, Rockefeller Foundation.

MNRJ 11015. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 28 January 1944. Skin and skull M17177. SEPSFA, Rockefeller Foundation.

MNRJ 11016. Rio do Braço, Ilhéus, Bahia. Female. Col. J. Moojen, 24 February 1944. Skin and skull M17402. SEPSFA, Rockefeller Foundation.

MNRJ 11018. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 3 February 1944. Skin and skull M17202. SEPSFA, Rockefeller Foundation.

MNRJ 11019. Rio do Braço, Ilhéus, Bahia. Male. Col. J. Moojen, 24 February 1944. Skin and skull M17427. SEPSFA, Rockefeller Foundation.

MNRJ 11020. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 28 January 1944. Skin and skull M17175. SEPSFA, Rockefeller Foundation.

MNRJ 11021 Rio do Braço, Ilhéus, Bahia. Male. Col. J. Moojen, 26 February 1944. Skin and skull M17410. SEPSFA, Rockefeller Foundation.

MNRJ 11023. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 23 January 1944. Skin and skull M17139. SEPSFA, Rockefeller Foundation.

MNRJ 11024. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 6 February 1944. Skin and skull M17220. SEPSFA, Rockefeller Foundation.

MNRJ 11025. Rio do Braço, Ilhéus, Bahia. Male. Col. Pedro M. Britto, 26 February 1944. Skin and skull M17407. SEPSFA, Rockefeller Foundation.

MNRJ 11026. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 23 January 1944. Skin and skull M17138. SEPSFA, Rockefeller Foundation.

MNRJ 11027 Rio do Braço, Ilhéus, Bahia. Female. Col. J. Moojen, 26 February 1944. Skin and skull M17409. SEPSFA, Rockefeller Foundation.

MNRJ 11028. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 9 February 1944. Skin and skull M17231. SEPSFA, Rockefeller Foundation.

MNRJ 11030. Rio do Braço, Ilhéus, Bahia. Female. Col. Pedro M. Britto, 26 February 1944. Skin and skull M17411. SEPSFA, Rockefeller Foundation.

MNRJ 11031. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 8 February 1944. Skin and skull M17229. SEPSFA, Rockefeller Foundation.

MNRJ 11032. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 6 February 1944. Skin and skull M17218. SEPSFA, Rockefeller Foundation.

MNRJ 11034. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 3 February 1944. Skin and skull M17204. SEPSFA, Rockefeller Foundation. (Missing).

MNRJ 11035. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 23 January 1944. Skin and skull M17137. SEPSFA, Rockefeller Foundation.

MNRJ 11036. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 9 February 1944. Skin and skull M17232 SEPSFA, Rockefeller Foundation.

MNRJ 11038. Ilhéus, Bahia. Unsexed. Col. Galdino Pereira. Skin and skull M17151. SEPSFA, Rockefeller Foundation.

MNRJ 11039. Fazenda Pirataquissé, Ilhéus, Bahia. Female. Col. Galdino Pereira, 29 January 1944. Skin and skull M17187. SEPSFA, Rockefeller Foundation.

MNRJ 11040. Ilhéus, Bahia. Male. Col. Galdino Pereira. Skin and skull M17602. SEPSFA, Rockefeller Foundation.

MNRJ 11041. Ilhéus, Bahia. Female. Col. Galdino Pereira. Skin and skull M17604. SEPSFA, Rockefeller Foundation.

MNRJ 11042. Ilhéus, Bahia. Unsexed. Col. Galdino Pereira. Skin and skull M17585. SEPSFA, Rockefeller Foundation.

MNRJ 11043. Ilhéus, Bahia. Male. Col. Galdino Pereira. Skin. SEPSFA, Rockefeller Foundation.

MNRJ 11044. Ilhéus, Bahia. Unsexed. Col. Galdino Pereira. Skin and skull M17136. SEPSFA, Rockefeller Foundation.

MNRJ 11045. Ilhéus, Bahia. Unsexed. Col. Galdino Pereira. Skin and skull M171584 SEPSFA, Rockefeller Foundation.

MNRJ 11046. Ilhéus, Bahia. Female. Col. Galdino Pereira. Skin and skull M17654. SEPSFA, Rockefeller Foundation.

MNRJ 11047. Ilhéus, Bahia. Female. Col. Galdino Pereira. Skin and skull M11834. SEPSFA, Rockefeller Foundation.

MNRJ 11048. Ilhéus, Bahia. Female. Col. Galdino Pereira. Skin and skull M17158. SEPSFA, Rockefeller Foundation.

MNRJ 23787. Rio do Braço, Ilhéus, Bahia. Female. Col. J. Moojen, 26 February 1944. Skin and skull M17412. SEPSFA, Rockefeller Foundation.

MNRJ 23788. Ribeira das Pedras, Rio do Braço, Ilhéus, Bahia. Male. Col. H.W.L., 13 October 1944. In *capoeira*. Skin and skull M21871. SEPSFA, Rockefeller Foundation. Wt. 300 g.

MNRJ 23789. Fazenda Quixadá, Rio do Braço, Ilhéus, Bahia. Female. Col. H.W.L., 9 October 1944. In a cocoa plantation. Skin and skull M21885. SEPSFA, Rockefeller Foundation. Wt. 390 g.

MNRJ 23790. Ilhéus, Bahia. Female. Col. Pedro M. Britto, 26 April 1945. Skin M5136. Jardim Zoológico, Rio de Janeiro.

MNRJ 23791. Rio do Braço, Ilhéus, Bahia. Female. Col. J. Moojen, 26 February 1944. Skin M17408. SEPSFA, Rockefeller Foundation.

MNRJ 23792. Ilhéus, Bahia. Male. Col. H.W.L., 8 November 1944. In *capoeira*. Skin M22214. SEPSFA, Rockefeller Foundation. Wt. 310 g. (Missing).

MNRJ 23793. Fazenda Pirataquissé, Ilhéus, Bahia. Male. Col. Galdino Pereira, 6 February 1944. Skin M17221. SEPSFA, Rockefeller Foundation.

MNRJ 23794. Passuí, Belmonte, Bahia. Male. Col. Unknown, 16 July 1949. Skin M29732(33). SEPSFA, Rockefeller Foundation. Wt. 350 g.

MNRJ 24775. Ilhéus, Bahia. Unsexed. Col. Galdino Pereira. Skin M17890. SEPSFA, Rockefeller Foundation.

MNRJ 33519. Ilhéus, Bahia. Male. Col. Galdino Pereira. Skin and skull M5138(7). Jardim Zoológico, Rio de Janeiro.

MNRJ 33520. Ilhéus, Bahia. Female. Col. Galdino Pereira. Skin and skull M5139(84). Jardim Zoológico, Rio de Janeiro.

MNRJ 33521. Ilhéus, Bahia. Female. Col. Pedro M. Britto, Skin and skull M5137 Jar.dim Zoológico, Rio de Janeiro.

MNRJ 33522. Ilhéus, Bahia. Male. Col. Pedro M. Britto. Skin M17858. SEPSFA, Rockefeller Foundation.

MNRJ 43933. S de Boca do Côrrego, Bahia. Unsexed. Col. L. Lorini. Skin, skull and skeleton.

+ 814 skulls.

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Preliminary Evaluation of the Conservation Status of *Callicebus coimbrai* Kobayashi & Langguth, 1999 in the Brazilian State of Sergipe

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Abstract: Endemic to the Atlantic forest of the Brazilian states of Sergipe and Bahia, *Callicebus coimbrai* survives in a highly fragmented landscape characterized by small remnants of forest in a matrix of plantations and pasture. First described only seven years ago, the species is still poorly known and, until the present study, had been recorded from only fifteen sites in Sergipe, in fragments of no less than 40 ha. Here, we report on a survey of the presumed range of the species in Sergipe, with the primary aims of identifying remnant populations and evaluating the influence of factors, such as fragment size, on survival. Populations of *C. coimbrai* were recorded through either sightings or response to playbacks of vocalizations at 30 of 147 sites surveyed (including 15 confirmed previously), and consistent reports from local residents were obtained at a further 46 localities. Six of the confirmed fragments were less than 20 ha, including one of only 3 ha. This indicates that the species is relatively tolerant of habitat fragmentation, and is able to survive in isolated forests of small size. Together with the growing number of known (and potential) populations, this tolerance is a positive factor for the long-term conservation of the species. However, based on the results of this survey, estimates of the total area of forest occupied by the species, and numbers remaining in the wild are only 100–150 km² and 500–1,000 individuals, respectively. Clearly, this situation requires urgent measures, including the implementation of protected areas and provisions for metapopulation management.

Resumo: Endêmica à Mata Atlântica dos Estados de Sergipe e Bahia, *Callicebus coimbrai* sobrevive em uma paisagem altamente fragmentada, caracterizada por pequenos remanescentes de floresta inseridos em uma matriz de plantações e pastagens. Descrita pela primeira vez há apenas sete anos, a espécie permanece muito pouco conhecida e, até o presente estudo, tinha sido registrada em apenas quinze localidades de Sergipe, em fragmentos maiores que 40 ha. Neste estudo, foi realizado um levantamento dentro da distribuição geográfica presumida da espécie em Sergipe com o objetivo principal de identificar populações remanescentes, e avaliar a influência de fatores como o tamanho de fragmento sobre sua sobrevivência. Populações de *C. coimbrai* foram registradas, por meio de avistamentos ou respostas à reprodução de vocalizações gravadas, em 30 dos 147 sítios investigados (incluindo os 15 confirmados anteriormente), e relatos consistentes de ocorrência foram obtidos de moradores locais em outras 46 localidades. Seis dos fragmentos confirmados tinham extensões com menos de 20 ha, sendo o menor de apenas 3 ha. Isto indica que a espécie é relativamente tolerante à fragmentação de habitat, e que consegue sobreviver em matas isoladas de tamanho reduzido. Junto ao número crescente de populações conhecidas (e indicadas), esta tolerância constitui um fator positivo para a conservação da espécie em longo prazo. Entretanto, baseado nos resultados deste levantamento, as estimativas da área total de floresta ainda ocupada pela espécie e do número de indivíduos que sobrevivem na natureza, são de apenas 100–150 km² e 500–1.000 indivíduos, respectivamente. Obviamente, esta situação demanda medidas urgentes, que incluem a implementação de áreas protegidas, e a aplicação de estratégias de manejo metapopulacional.

Key Words: Coimbra-Filho's titi monkey, *Callicebus coimbrai*, conservation, Northeast Brazil

Introduction

Coimbra-Filho's titi monkey, *Callicebus coimbrai*, was first described by Kobayashi and Langguth in 1999, and is considered to be one of the most endangered of all Neotropical primates (Brazil, MMA 2003; IUCN 2004). Its known range covers little more than 30,000 km², straddling the border between the states of Sergipe and Bahia, an area that has suffered deforestation and habitat fragmentation virtually since the beginning of European colonization, five centuries ago (Coimbra-Filho and Câmara 1996).

By the beginning of the 20th century, the Atlantic forest of Sergipe had been reduced to approximately 40% of its original cover, and to less than 1% over the subsequent 100 years (Siqueira and Ribeiro 2001). This remnant forest cover is distributed in isolated fragments of no more than 900 ha. Prior to the present study, *C. coimbrai* had been recorded from 15 sites in Sergipe, and two in Bahia (Kobayashi and Langguth 1999; Sousa 2000, 2003; Printes 2005), in forest fragments ranging in size from 40 to 900 ha. It is not known to occur in any officially protected areas in either state (Silva *et al.* 2005).

In the present study, the known and presumed distribution of *C. coimbrai* in the state of Sergipe was surveyed systematically in an attempt to locate additional remnant populations and define ecological parameters such as the minimum size of fragment necessary for the survival of the species. The data collected were used for an overall assessment of the conservation status of the species in this state, and the formulation of basic guidelines for the development of long-term conservation strategies.

Methods

Fieldwork was planned on the basis of known *C. coimbrai* localities in Sergipe (Kobayashi and Langguth 1999; Sousa 2000, 2003) and the identification of potential sites using a digital atlas of the state (Sergipe, SEPLANTEC 2004) using satellite images and aerial photographs. The primary strategy was to survey all fragments of large size (>100 ha), and to sample smaller fragments within the survey area; in particular those for which local residents had indicated the presence of *C. coimbrai*.

Four main study areas were demarcated (Fig. 1) and surveyed during separate excursions between May and September 2004. In November 2004, and March and May 2005, complementary excursions were conducted to survey previously visited localities where the species had been indicated consistently in interviews, but not confirmed directly. During visits to each site, experienced local residents were interviewed in a standardized, undirected manner, supported by photographs and drawings of local mammals, and by recordings of *Callicebus* vocalizations, in an attempt to identify local habitat in which titis could be found. Sites indicated consistently by residents were visited and surveyed qualitatively, using existing trails. In addition to observations, recordings of *Callicebus* vocalizations were played through a loudspeaker (Johnny

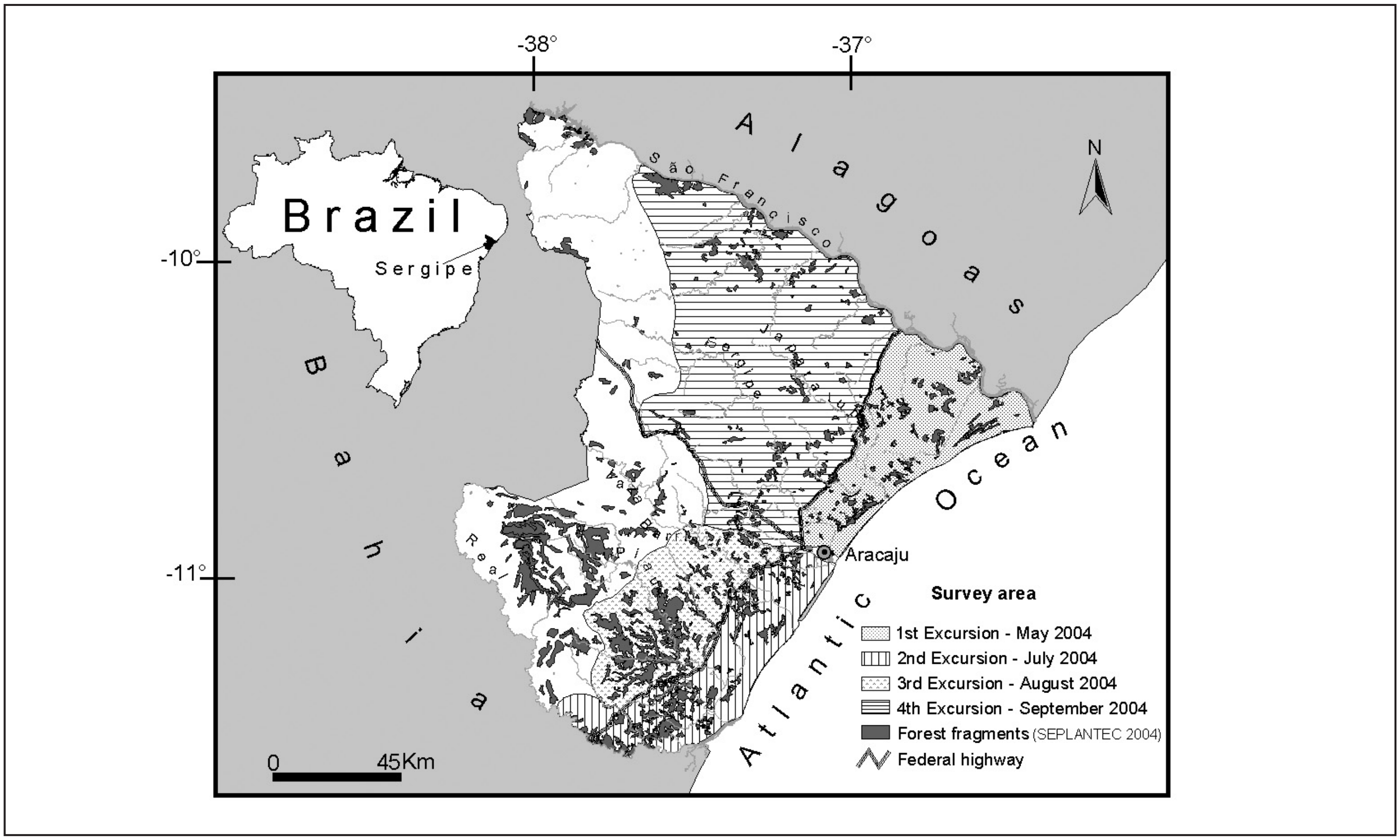

Figure 1. Map of the Brazilian state of Sergipe, showing the four main study areas.

Table 1. Confirmed localities for *Callicebus coimbrai* in the state of Sergipe, Brazil.

Site	Locality	Coordinates	Fragment size (ha)	Type of record[1]	Source[2]
1	Fazenda Cruzeiro	11°29′ S, 37°46′ W	200[3]	SP (1)	KL
2	Povoado de Aragão – Santana	10°32′ S, 36°41′ W	150	SP (2), OBS (3)	KL, SO
3	Fazenda Arauari	10°45′ S, 37°00′ W	500[3]	SP (2), OBS (2)	KL, SO
4	Mata do Crasto	11°22′ S, 37°25′ W	900	OBS (1)	SO
5	Mata do Dira	10°53′ S, 37°21′ W	>100	PB	SO
6	Mata do Serigy	10°33′ S, 36°42′ W	70	PB	SO
7	Mata do Oiteiro	10°39′ S, 37°03′ W	50[3]	PB	SO
8	Mata da Serra Preta	10°30′ S, 37°37′ W	<200[3]	PB	SO
9	Fazenda Aiumas	10°25′ S, 36°39′ W	60[3]	PB	SO
10	Mata da Aguada	10°40′ S, 36°56′ W	40	PB	SO
11	Mata da Nova Descoberta	11°06′ S, 37°19′ W	100[3]	PB	SO
12	Mata do Cadoz	10°23′ S, 36°39′ W	50[3]	PB, OBS (2)	SO, PS
13	Fazenda Sabão – Mata Oeste	11°30′ S, 37°34′ W	300	PB	SO, PS
14	Mata do Junco	10°32′ S, 37°03′ W	400	PB	SO, PS
15	Fazenda Trapsa	11°12′ S, 37°14′ W	600[3]	PB	SO, PS
16	Bugio (Buji)	11°27′ S, 37°43′ W	200	PB	PS
17	Fazenda Capivara	11°11′ S, 37°28′ W	30	OBS (2)	PS
18	Fazenda Imbira	11°14′ S, 37°34′ W	10	PB	PS
19	Fazenda Bomfin VI	11°18′ S, 37°40′ W	15	OBS (4)	PS
20	Fazenda Tuim	11°17′ S, 37°38′ W	3	PB	PS
21	Fazenda Poços	11°16′ S, 37°33′ W	15	PB	PS
22	Mata Chiquinho 2	11°17′ S, 37°41′ W	10	PB	PS
23	Mata do Escôncio	11°26′ S, 37°37′ W	250	OBS (2)	PS
24	Fazenda Sabão – Mata Pequena	11°31′ S, 37°34′ W	7	OBS (1)	PS
25	Mata do Pau Torto	11°23′ S, 37°30′ W	250	PB	PS
26	Mata da Águas Claras	11°22′ S, 37°33′ W	50	OBS (4)	PS
27	Mata da Surucucu	11°21′ S, 37°29′ W	60	OBS (4)	PS
28	Assentamento Chico Mendes	11°30′ S, 37°33′ W	50	PB	PS
29	Fazenda Sabão – Mata Leste	11°29′ S, 37°33′ W	100	PB	PS
30	Fazenda São Pedro/Assentamento	10°02′ S, 37°24′ W	150	PB	PS

[1] SP = specimen collected; OBS = animals observed; PB = response to playback, or vocalizations heard. Different types of records refer to the respective studies. Numbers in parentheses refer to the number of individuals recorded.

[2] KL = Kobayashi and Langguth (1999); SO = Sousa (2003); PS = Present Study.

[3] Estimate obtained during the present study.

Stewart 612 Deluxe professional caller) in an attempt to provoke a response from animals out of sight.

The size of forest remnants was estimated through a combination of the available information (aerial photographs and satellite images) and direct observation. At sites where the presence of *C. coimbrai* was confirmed, the landowner or property manager was also contacted to obtain more detailed information and to refine estimates. Estimates were less systematic at unconfirmed sites, and given their heterogeneity, they have been assigned to size classes for the purposes of the present study.

Results

A total of 147 forest fragments were identified either during planning, or during surveys, when indicated by local residents. All were visited during the four preliminary excursions, and 28 of them were revisited during the three complementary field trips. In many cases, fragments identified on the digital atlas either no longer existed or had been practically eliminated by deforestation or fire.

Overall, 245 residents were interviewed, and a total of 110 sites were indicated as having resident titis in at least one interview. However, the reports referring to 34 of these sites were considered unreliable because of inconsistencies in the identification of the species. Some interviewees confused titis with capuchins (*Cebus*) or marmosets (*Callithrix*), or even other arboreal mammals. The remaining 76 sites included the 15 recorded by Kobayashi and Langguth (1999) and Sousa (2003), and an additional 15 at which the presence of the species was confirmed through either direct observation or response to playbacks (Table 1, Fig. 2). Playbacks proved to be an important survey tool, providing confirmation of the presence of titi monkeys at the majority (63.3%) of the sites.

At the remaining 46 sites (Table 2, Fig. 3), the presence of *C. coimbrai* was indicated consistently in interviews, but was not confirmed directly through surveys. Many of these fragments were relatively small in size, although records from Fazenda Tuim and Fazenda Sabão (Table 1) do indicate that the species is able to survive in fragments of less than 10 ha. As such, it would seem reasonable to assume that titis are present in many, if not all, of these unconfirmed fragments.

The sum of the area of forest at the 30 confirmed sites (Table 1) is just over 5,000 ha, and that of the unconfirmed sites is between 1,500 and 3,500 ha. The results indicate

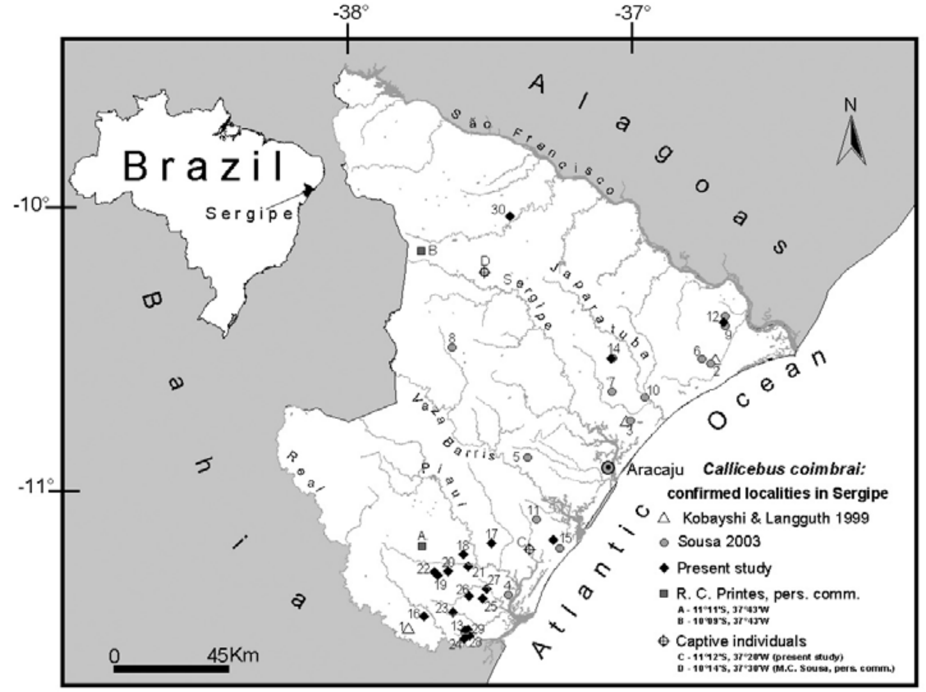

Figure 2. Sites in the state of Sergipe where the presence of *Callicebus coimbrai* has been confirmed. Sites are numbered as in Table 1.

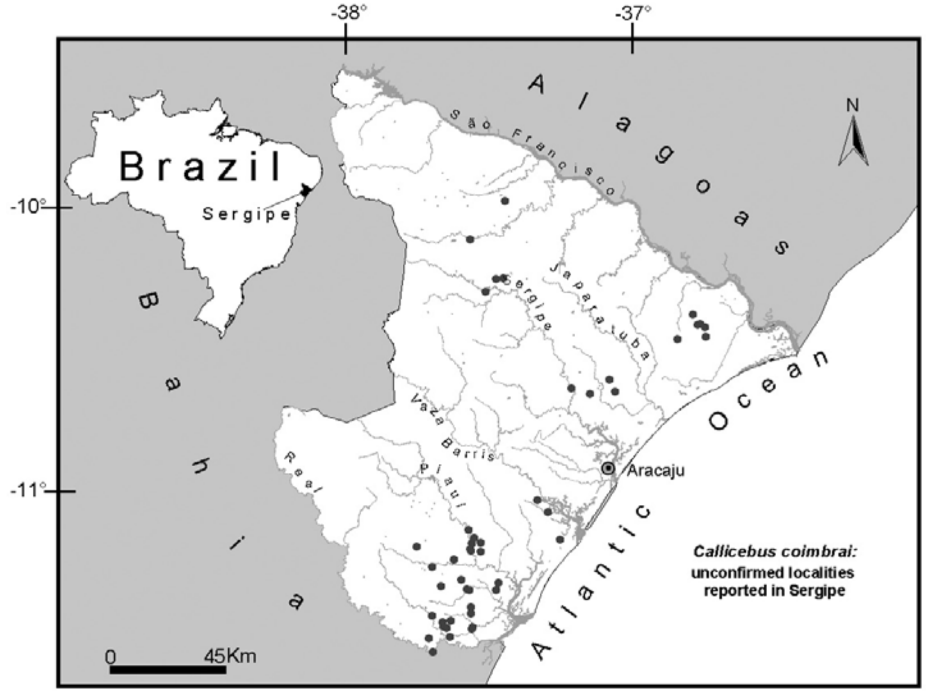

Figure 3. Sites in the state of Sergipe where the presence of *Callicebus coimbrai* was reported by local residents during the present study, but not confirmed directly (see text and Table 2).

that *C. coimbrai* is relatively more abundant in the southern coastal forest zone in comparison with the central and northern coastal zones. More than a half of confirmed (55.9%) and unconfirmed (60.9%) sites are located in the basins of the Rios Piauí and Real (Figs. 2 and 3). This area is characterized by seasonal semi-deciduous forest (Brazil, IBGE 2004).

An additional, unexpected result of the surveys was the recovery of an adult female *C. coimbrai* (Fig. 4) from illegal captivity at Riacho Fundo do Abaís (11°12′S, 37°20′W) on 16 March 2005. The animal was taken to the Aracaju Zoological Gardens on the same day, where it was found to be in good health, and has now survived for almost a year. This is the first time the species has been held officially in captivity, and represents a potentially important first step in the eventual development of programs of captive breeding, translocation, and reintroduction.

A second animal was observed (M. C. Sousa pers. comm.) in private captivity in the town of Nossa Senhora da Glória (Fig. 3), although it escaped before being transferred to Aracaju. This, together with surrounding localities (8, 30, and B in Fig. 2), confirms that, while *C. coimbrai* is rare in caatinga habitats, where it is replaced by *Callicebus barbarabrownae*, its original geographic range extends farther north and west than was previously supposed.

Discussion

In common with most of the platyrrhine species discovered in the wild over the past 15 years (for example, Lorini and Persson 1990; Van Roosmalen *et al*. 2002), *C. coimbrai* has a relatively restricted geographic range, which, like most of the Atlantic forest, is characterized by critical levels of deforestation and habitat fragmentation. There was thus little doubt that the species was at some risk of extinction as soon as it was made known to science, and it is now considered to be one of the most endangered of Brazilian primates (Brazil, MMA 2003; IUCN 2004). This study has done little to alter this initial impression, although the species is now known to occur at many more sites than the three localities identified originally by Kobayashi and Langguth (1999). In addition to the thirty sites confirmed here, R. C. Printes (pers. comm.) has recorded *C. coimbrai* at two additional sites in Sergipe (Fig. 2), bringing the current total to thirty-two. It is important to note that one of the sites reported by Printes is located outside the area surveyed in the present study, suggesting that a certain number of potential sites have yet to be identified.

These sites encompass a total area of approximately 50 km² of forest. While this is almost certainly an underestimate of the total area of forest in Sergipe occupied by populations of *C. coimbrai*, it seems unlikely that the definitive value will surpass 75 km². If it is assumed that a similar situation exists in Bahia, given that the species may be distributed over a similar area in this state (Printes 2005), we can conclude that the total area of forest occupied by the species is between 100 and 150 km².

Table 2. Localities at which the presence of *C. coimbrai* was reported consistently by local residents, but not confirmed via direct observation.

Locality	Coordinates	Size class[1]
Fazenda Cruzeiro – Mata pequena	11°33′S, 37°40′W	A
Fazenda Barro	11°09′S, 37°31′W	A
Mata do Balneário – Fazenda Santa Bárbara	10°24′S, 36°44′W	B
Mata de Pedra do Rumo	11°28′S, 37°38′W	B
Mata da Ladeira Vermelha	11°31′S, 37°41′W	B
Fazenda Santa Cruz – Mata 1	11°12′S, 37°32′W	B
Fazenda Brejo	11°10′S, 37°32′W	B
Matas do Contador 1 – Fazenda Santa Bárbara	10°24′S, 36°44′W	C
Matas do Contador 2 – Fazenda Santa Bárbara	10°25′S, 36°43′W	C
Fazenda Campo Belo	11°01′S, 37°18′W	C
Fazenda Santa Cruz – Mata 2	11°12′S, 37°32′W	C
Fazenda Nova	11°14′S, 37°36′W	C
Fazenda Riacho Seco	11°18′S, 37°34′W	C
Fazenda Salobro	11°20′S, 37°38′W	C
Fazenda Glória	11°15′S, 37°40′W	C
Mata da Bica	11°11′S, 37°44′W	C
Mata de Vila do Padre	10°07′S, 37°32′W	C
Mata dos Olhos d’Água 1 – Gameleiro	10°15′S, 37°27′W	C
Fazenda Capim-Açu	10°38′S, 37°02′W	C
Mata do Canto Escuro – Fazenda Araticum	10°36′S, 37°03′W	C
Matas de Antônio Dias – Maçaranduba	10°28′S, 36°49′W	D
Mata Verde – Fazenda de Citrus	10°22′S, 36°46′W	D
Mata do Projeto A da SERAGRO	10°27′S, 36°43′W	D
Fazenda Castelo – Mata 2	11°19′S, 37°26′W	D
Fazenda Cedro	11°20′S, 37°33′W	D
Fazenda Santa Mônica	11°20′S, 37°32′W	D
Fazenda Escôncio – Mata pequena	11°27′S, 37°36′W	D
Assentamento Osias Silva	11°26′S, 37°40′W	D
Fazenda Curuanha	11°12′S, 37°30′W	D
Mata de Lagoa do Rancho	09°58′S, 37°25′W	D
Mata dos Olhos d’Água 2 – Gameleiro	10°15′S, 37°26′W	D
Mata da Campanha – Fazenda Tabua	10°38′S, 37°11′W	D
Fazenda Colégio	11°04′S, 37°16′W	E
Fazenda Paruí	11°10′S, 37°13′W	E
Assentamento Boa Vista	11°25′S, 37°32′W	E
Fazenda Gavião/Fazenda Cajá	11°28′S, 37°32′W	E
Mata de Valdir Cruz	11°29′S, 37°32′W	E
Mata de Branco – Fazenda Mangueira	11°28′S, 37°37′W	E
Mata da Palmeirinha – Fazenda Jaqueira	11°27′S, 37°38′W	E
Fazenda Cobiça	11°08′S, 37°33′W	E
Fazenda Periperi	11°10′S, 37°30′W	E
Fazenda Limoeiro	10°39′S, 37°07′W	E
Fazenda Castelo – Mata 1	11°20′S, 37°27′W	F
Fazenda Riacho Fundo	11°30′S, 37°36′W	F
Fazenda Guia	10°18′S, 37°29′W	G
Fazenda Gaiofa/Assentamento São José	11°24′S, 37°32′W	G

[1] Size class: A = <5 ha; B = 5–10 ha; C = 10–25 ha; D = 25–50 ha; E = 50–100 ha; F = 100–250 ha; G = 250–500 ha.

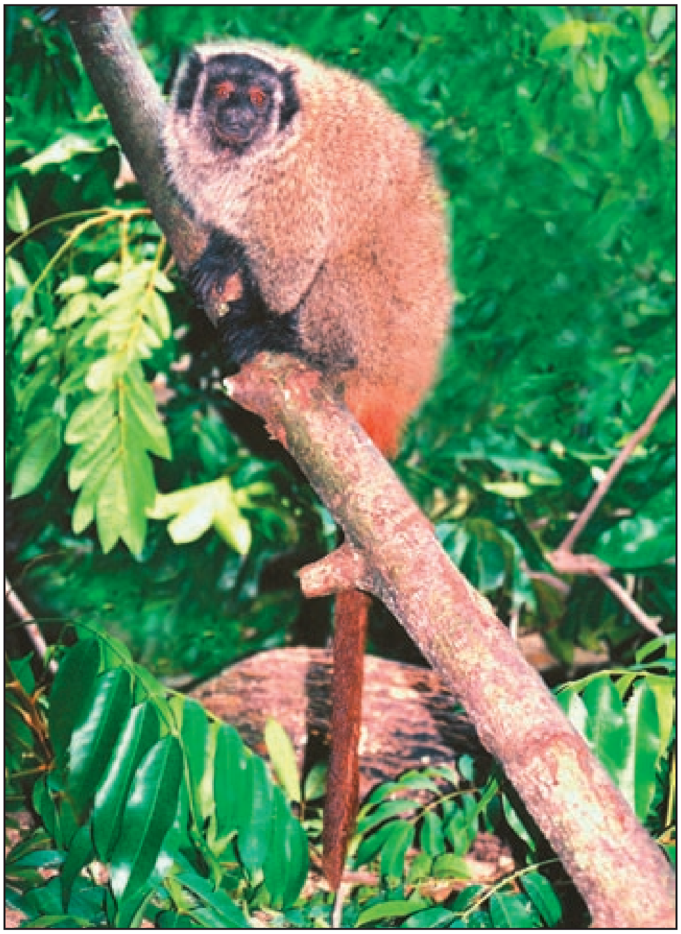

Figure 4. Adult female *Callicebus coimbrai*, resident at the Aracaju Zoological Gardens since 16 March 2005. Photograph by Leandro Jerusalinsky.

Demographic parameters of *C. coimbrai* populations are not known, and few reliable data are available for the genus. The values most relevant to the present study are those of Müller (1996a) and Heiduck (2002), who recorded home ranges of 22–24 ha for two *Callicebus melanochir* groups in the Atlantic forest of southern Bahia. Palacios *et al*. (1997) reported a similar value for the Amazonian *Callicebus torquatus*. Price and Piedade (2001) recorded smaller home ranges in a short-term study of *Callicebus personatus*, although surveys at a number of other sites in southeastern Brazil (Chiarello 2003; São Bernardo and Galetti 2004) returned relatively low population densities for this species, indicative of relatively large home ranges.

Titi monkeys are strictly monogamous and live in small family groups, with three to five members. *Callicebus coimbrai* appears to be typical in this sense (Sousa 2003; R. C. Printes pers. comm.; this study), and a similar pattern has been reported for the closely related *C. melanochir* (Müller 1996a; Heiduck 2002), so it would seem reasonable to use four individuals as an approximate mean group size. Using a generous estimate of five groups/km², the 30 confirmed sites in Sergipe would contain a theoretical total population of approximately 1,000 individuals. Even if this were a gross overestimate, it would still seem reasonable to assume that the number of *C. coimbrai* surviving in the wild (including both Sergipe and Bahia) may be between 500 and 1,000 individuals.

While this provides some room for cautious optimism, the question of habitat fragmentation cannot be overlooked.

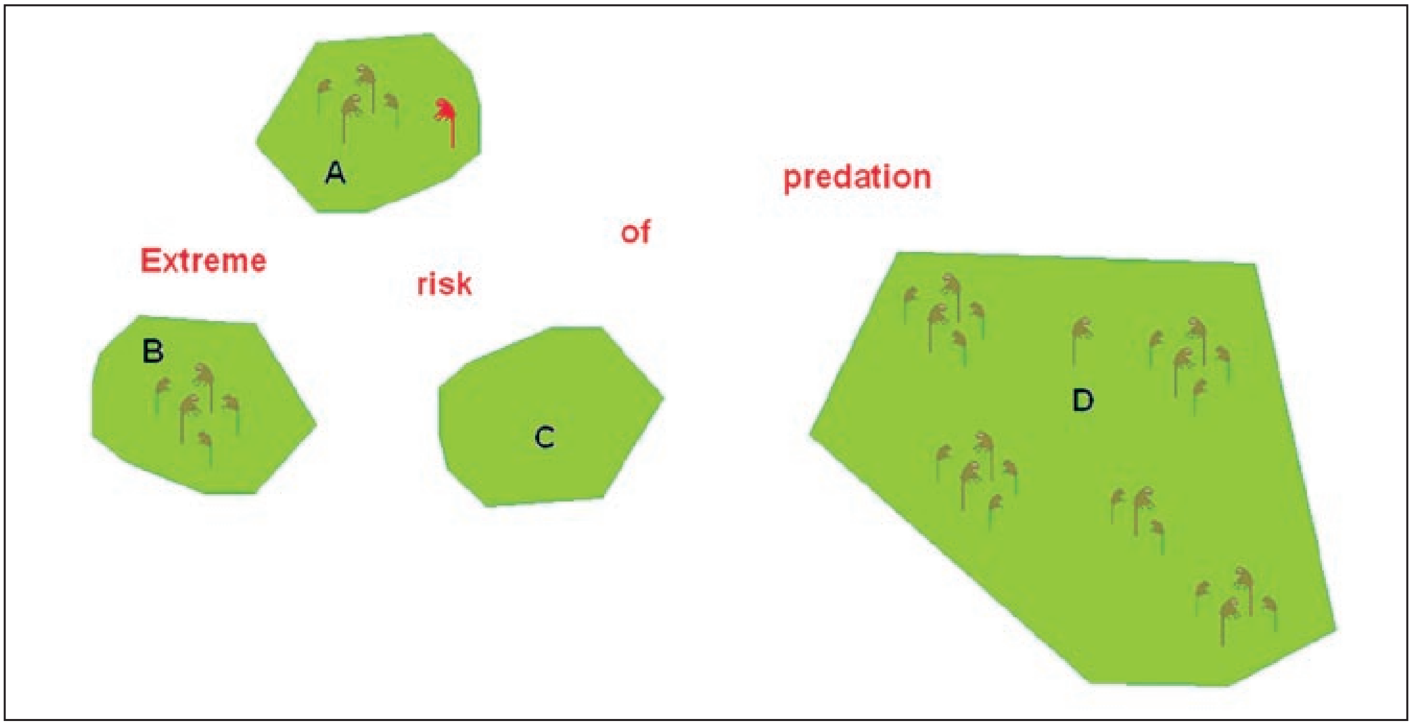

Figure 5. Hypothetical scenario faced by a maturing titi monkey (red animal in fragment A) in the fragmented landscape of the Atlantic forest of Sergipe. Fragment D offers the best opportunities for survival and the establishment of a breeding group, but is farthest from A. Smaller fragments (B and C) are more common, and generally more accessible, but will normally be either at carrying capacity (B) or vacant (C). In either case, the chance to breed will depend on unpredictable, random events such as the disappearance of the same sex adult (B) or the immigration of an adult of the opposite sex (C).

Demographic patterns in fragmented habitat are clearly different from those in continuous forest, although the effects are not always negative, depending on the species. One positive aspect of the present study, for example, was the confirmation of the ability of *C. coimbrai* to survive in forest fragments smaller than 10 ha. Given this, the number of fragments with titis may be as important as the total area of forest for the planning of conservation strategies. The large number of unconfirmed reports (Table 2) certainly suggests that many more small, isolated populations have yet to be discovered.

However tolerant of habitat disturbance *C. coimbrai* may be, the distribution of remnant populations in a large number of isolated fragments clearly presents a deep-seated problem for long-term management (Vieira *et al*. 2003). Titi monkeys present an additional unique behavioral problem, among Atlantic forest primates: While the exact mechanism is still unclear (Müller 1996b; Mayeaux *et al*. 2002), offspring invariably emigrate from their natal groups as they approach sexual maturity, limiting group composition to the breeding pair and their immature offspring.

While this may be an important dispersal mechanism in populations inhabiting continuous forest, it may have deleterious consequences in small fragments, where emigration to a new forest may be the only option for maturing offspring (see Fig. 5). Individuals migrating between fragments over open ground risk predation and exhaustion (mean day range of Atlantic forest titis is approximately 1 km: Müller 1996a; Price and Piedade 2001), with only a very random possibility of encountering a potential reproductive partner. This suggests an extremely inefficient process characterized by high mortality and the frequent loss of reproductive opportunities (for example, animal dispersing to vacant fragments).

This implies, in turn, that active management of the metapopulation, including both translocation and reintroduction, may be relatively more important for the long-term conservation of *C. coimbrai* (and other titi species) than for other Atlantic forest primates. The effective implementation of such management will also depend on the establishment of an integrated system of public and privately owned reserves. One important first step in this process is the creation of a federal conservation unit — with the specific aim of protecting *C. coimbrai* — which is currently being planned by the Brazilian environment institute (IBAMA), based on the results of the present study.

Acknowledgments

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Preliminary Report and Conservation Status of the Río Mayo Titi Monkey, *Callicebus oenanthe* Thomas, 1924, in the Alto Mayo Valley, Northeastern Peru

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Abstract: From October 2004 to September 2005, I conducted a study on the behavioral ecology of the rare and endangered Río Mayo titi monkey (*Callicebus oenanthe*) in a fragmented premontane tropical forest of the Alto Mayo, near the town of Moyobamba, in northern Peru. This is the first such field study on this species. The study group consisted of an adult male, an adult female, and two offspring (a male and a female). An infant was born in May 2005. No offspring dispersed during the study. Data were recorded using instantaneous focal animal sampling and it was possible to obtain detailed information on behavior because the individuals could be identified and the group was easily followed at close range. There are pelage differences among the age and sex categories. Pelage coloration differences in individuals of different groups may indicate color morphs or possible subspecies. The conservation status of *C. oenanthe* is described, with the conservative estimate that it persists in less than 1,800 km² of forest, much of it now fragmented. *Callicebus oenanthe* is extremely threatened by deforestation, a severely fragmented habitat, and the scarcity of large forest tracts to maintain viable populations. I recommend that it should be upgraded to the status of Endangered in the IUCN Red List.

Resumen: Desde octubre de 2004 hasta septiembre de 2005, yo realicé un estudio en la ecología y el comportamiento del mono tocón (*Callicebus oenanthe*), una especie raro y en peligro de extinción, en un bosque tropical premontana y fragmentado de Alto Mayo, cerca del pueblo de Moyobamba, en el nordeste de Perú. Este estudio documenta el primer tal estudio del campo en esta especie y presenta fotografías en vida silvestre de esta especie poco conocida. El grupo del estudio consistió por un macho adulto, una hembra adulta, un juvenil (macho), y una infante (hembra), y luego un infante recién nacido en mayo, 2005. Ninguna migración de descendencia fue observada durante el estudio. Los datos se han tomado usando el método “focal instantáneo”. Este estudio permitió los datos detallados en el comportamiento, porque los individuos pudieran ser identificados y habían podido ser observado de cerca. Se observaron diferencias en la coloración entre las categorías de la edad y del sexo, y se los describen en detalle. Se han notado diferencias en coloración de los individuos puede indicar “color morphs” o posible un subespecie. El estado de conservación de esta especie se describe, con la estimación que esta especie persiste en menos de 1800 km² de bosque restante, mucho de esto fragmentado. *Callicebus oenanthe* esta sumamente amenazado por las tasas altas de deforestación, un hábitat severamente fragmentado, y escasez de bosque continuo para mantener las poblaciones viables, y yo recomiendo que *C. oenanthe* se deben actualizar al estado de En Peligro en las inscripciones de IUCN.

Key Words: New World, Pitheciidae, primate ecology, conservation, Andean premontane forest, forest fragmentation

Introduction

The first long-term study on the behavior and ecology of the endangered Río Mayo or Andean titi monkey, *Callicebus oenanthe*, was conducted on the western side of the upper Río Mayo (Alto Mayo), in northern Perú from October 2004 until September 2005. *Callicebus oenanthe* is found only in the Alto Mayo valley of northern Peru in the Department of San Martín (Hershkovitz 1990). *Callicebus oenanthe* was reviewed in the recent monograph on the taxonomic revision of the genus *Callicebus* by Van Roosmalen *et al*. (2002), but only a drawing was included. Rowe and Martinez (2003) carried out a four-day survey of *C. oenanthe*, but did not observe it in the wild. Rowe was able to photograph a captive family of *C. oenanthe* at a local market. Mark (2003) carried out a two-month survey of *C. oenanthe* in five sites of the upper Río Mayo valley and conducted interviews to obtain information on its presence or absence in native Aguaruna forests. The photographs presented here, taken by the author (Figs. 1–3), are the first to be published of *C. oenanthe* in its natural habitat.

Figure 1. The Río Mayo titi monkey, *Callicebus oenanthe*. Adult male and infant near Moyobamba (6°01′31.9″S, 76°59′33.7″W, elevation 891 m a.s.l.).

Figure 2. The Río Mayo titi monkey, *Callicebus oenanthe*. Adult female near Moyobamba (6°01′31.9″S, 76°59′33.7″W, elevation 891 m a.s.l.)

Figure 3. The Río Mayo titi monkey, *Callicebus oenanthe*. Juvenile near Moyobamba (6°01′31.9″S, 76°59′33.7″W, elevation 891 m a.s.l.).

I studied a group of five *C. oenanthe* in a privately-owned fragmented forest, near the town of Moyobamba (6°01′31.9″S, 76°59′33.7″W) at an elevation of 891 m a.s.l. The Alto Mayo valley is in the eastern foothills of the Andes, in the northeastern Department of San Martín, which comprises the provinces of Rioja and Moyobamba. The broad valley is flat to undulating, with low hills, high hills, and mountainous terrains. It is surrounded by the Cordillera Oriental to the southwest and the Cahuapanas to the northeast. The forest surrounding Moyobamba is Humid Premontane Tropical Forest, according to the Holdridge system of life zones (Holdridge 1967). The climate is tropical and humid, with the rainy season occurring from October to April, averaging 148 mm of rainfall per month. The dry season is from June to August, averaging 60 mm/month. The months of transition are May and September, during which average rainfall is 103 mm/month. Most variability in rainfall occurs from October through March (wet season). The average monthly temperature ranges from a minimum of 16°C to 21°C and a maximum of 26°C to 30°C, with an average annual temperature of 22°C (Peru, PEAM 2004).

There were a number of distinct vegetation formations in the forest fragment occupied by the titi monkey study group. They include *Cecropia*-dominated stands, bamboo stands, an area of low secondary forest, viney thickets, and fruit crops. The trees in a steep ravine in their range were especially tall and broad-trunked. The forest was surrounded by a rice field, cattle pasture, human settlements, and roads. It is largely isolated from other fragments, with only a few scattered trees in its vicinity, separated by 10 m or more, which could possibly be used by the monkeys. The area used by the titi monkeys during the study was approximately 2 ha. The group used the majority of this area early in the study, but abandoned the use of the ravine after the birth of the infant. A group of 10 saddleback tamarins (*Saguinus fuscicollis leucogenys*) also lived in the fragment, and I noted a number of instances of interactions between the two species.

From October 2004 to May 2005, the group consisted of an adult female, an adult male, a male juvenile (Juvenile I) and a female infant (Infant I) (an infant becomes a juvenile only when independently locomoting [*sensu* Kinzey 1981]). The adult female gave birth on 15 May 2005, and the infant's development was studied in detail (in addition to all other behavioral data) until September 2005. The group consisted thereafter of an adult female, adult male, Juvenile II (male), Juvenile I (female), and Infant II (male).

Pelage color of all individuals was light brown agouti, not dark brown agouti, and the ventral areas (chest, belly, inner limbs) were orange, not red-orange. This differs markedly with the darker coloration of the individuals photographed by Noel Rowe (2003). Mark (2003) reported pelage coloration differences between individuals seen close to the Río Mayo and those in areas to the northeast. This strongly suggests color morphs or possible subspeciation (see Fig. 4).

The pelage of the adults and the young differed in the degree of distinctiveness of the white frontal blaze and the strength of the orange coloration of the chest, belly, and inner limbs. The adult male and female differed in pelage coloration as well (see below); this may, however, be individually based rather than an overall species characteristic. Further research is needed to confirm this.

Sex and Age Differentiation

Adult male

The adult male has a very distinct white frontal blaze, extending upward on the head forming a triangular buffy-colored extension or tuft of whitish hairs on the crown. Its beard is also buffy. The outer surfaces of the limbs, cheiridia, and tail are dominantly light agouti brown to buffy. Hair bases (closest to skin) are black. Super- and subciliary fringes (or patches) around the eyes are black, and the shading is circular around eyes. The inner surface of the limbs, chest, and belly are orange, but not as strongly colored as in the female. The adult male in the study group was much more buffy to pale blonde than the adult female.

Adult female

The face is strongly framed with a distinct white frontal blaze, which extends up onto the crown where it is distinct from the darker agouti hairs. The sideburns are white, and connect with the frontal blaze to frame the face. The white sideburns and frontal blaze contrast sharply with the surrounding beard, which is orange to agouti. The inner surfaces of the limbs, chest, and belly are orange. The outer surfaces of the limbs and tail are darker brown agouti than in the male. Black supra- and subciliary circular eye fringes are present. The adult female appears to be larger than the adult male. This was especially apparent when the female was lactating and the male was carrying the infant the majority of the time. No exact body weights could be obtained.

Juvenile II (approx. 18 months)

The juvenile at this age has light brown agouti-colored pelage on the outer surfaces of the limbs, cheiridia, and tail. The frontal blaze and sideburns are whitish, distinctly framing an orange-agouti beard and crown. Supra- and subciliary fringes are blackish, with the subciliary coloration extending down in a teardrop shape, surrounding the eyes. The pelage is not as long and shaggy as seen in the adults.

Juvenile I (approx. 9 months)

The juvenile at this age is similar in pelage to the older juvenile, but the frontal blaze is not as strongly white and has buffy-colored agouti hairs interspersed. Also, the contrast between orange undersides and light brown agouti outer surface is not as distinct.

Infant II (born 15 May 2005)

The pelage of the infant at birth is uniform in color, with its entire body covered with short, dark agouti-orange hairs. Its pelage contrasts with the adult male's buffy-agouti colored pelage. The frontal blaze around the face, including the malar sideburns, does not become apparent until the infant reaches five weeks of age (whitish hairs become apparent in the eyebrow region as soon as two weeks after birth).

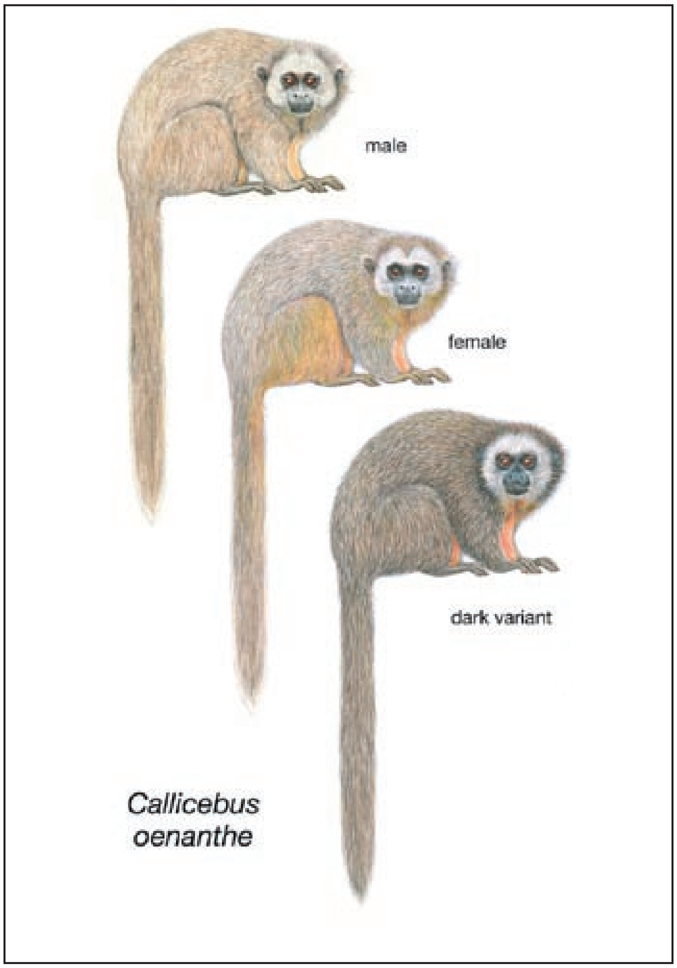

Figure 4. The Río Mayo titi monkey, *Callicebus oenanthe*. Illustrations by Stephen D. Nash.

Methods

The group was habituated for two months before systematic data could be taken consistently and reliably. Data were recorded using an instantaneous focal animal sampling method (Altmann 1974), which could be used reliably because all individuals could be identified and I was able to observe detailed behavior at close range (at an average distance of 5–6 m). This is in contrast to previous studies of *Callicebus*, in which most or all individuals (especially offspring) could not be individually identified. The forest at this site was mostly secondary, and included many vine species. As has been found in other studies of titi monkeys, *C. oenanthe* tended to hide in thick vine clumps in tree crowns. It was much easier to follow individuals because group members were very rarely in full view simultaneously. They tended to forage at some distance from each other.

I collected behavioral data every two minutes, at which time I recorded the individual, the time, activity, activity type, food types and sources, height in vegetation, vegetation type, posture or locomotion type, branch angle and branch size, nearest neighbor, and distance to nearest neighbor. I recorded phenological data using a transect line survey and an index score (0 to 4) on new leaf, fruit, and flower availability. I took measurements (Diameter at Breast Height [DBH], height, and crown diameter) on a sample of trees in the habitat (using line transects) and on all of the trees they fed in.

Data are currently being analyzed, but preliminary observations suggest that the titi monkeys included a large number of liana species in their diet, eating the leaves, tendrils, young pith, young seeds, and fruits. They were also observed eating large quantities of fruits from aerial stem-parasitic plants of the families Viscaceae and Loranthaceae (mistletoes). A lot of their time was spent foraging for insects, which formed a considerable portion of their diet. The group used only three sleeping sites consistently during the entire study, which contrasts with other studies in which *Callicebus* would change their sleeping sites frequently (Kinzey 1977; Easley 1982; Wright 1985).

Survey of the Native Community

I conducted a brief survey of the native Aguaruna community of Yarau (Fig. 5), which occupies 13,840 ha of primary forest. I showed drawings and photographs of various primates to community members, asking them to inform or otherwise detail the presence of *C. oenanthe*, known as "sugkamat" in the Aguaruna language. People mentioned that they are present in Yarao, and also are known to occur in other native communities to the north (Morroyacu and Nuevo Jerusalen), confirming their suspected range besides the areas surveyed by Rowe and Martinez (2003) and Mark (2003). Two other Peruvian endemic primates occur in the Alto Mayo region: the yellow–tailed woolly monkey, *Oreonax flavicauda*, and the Andean night monkey, *Aotus miconax*, both of them highly endangered. The presence of *O. flavicauda* in the higher altitude forests of Yarau (7–8 hours hiking distance) was also mentioned by the Aguarunas. Although I never saw them, I heard the hoot-calling of night monkeys on various occasions and their presence was also confirmed by the community

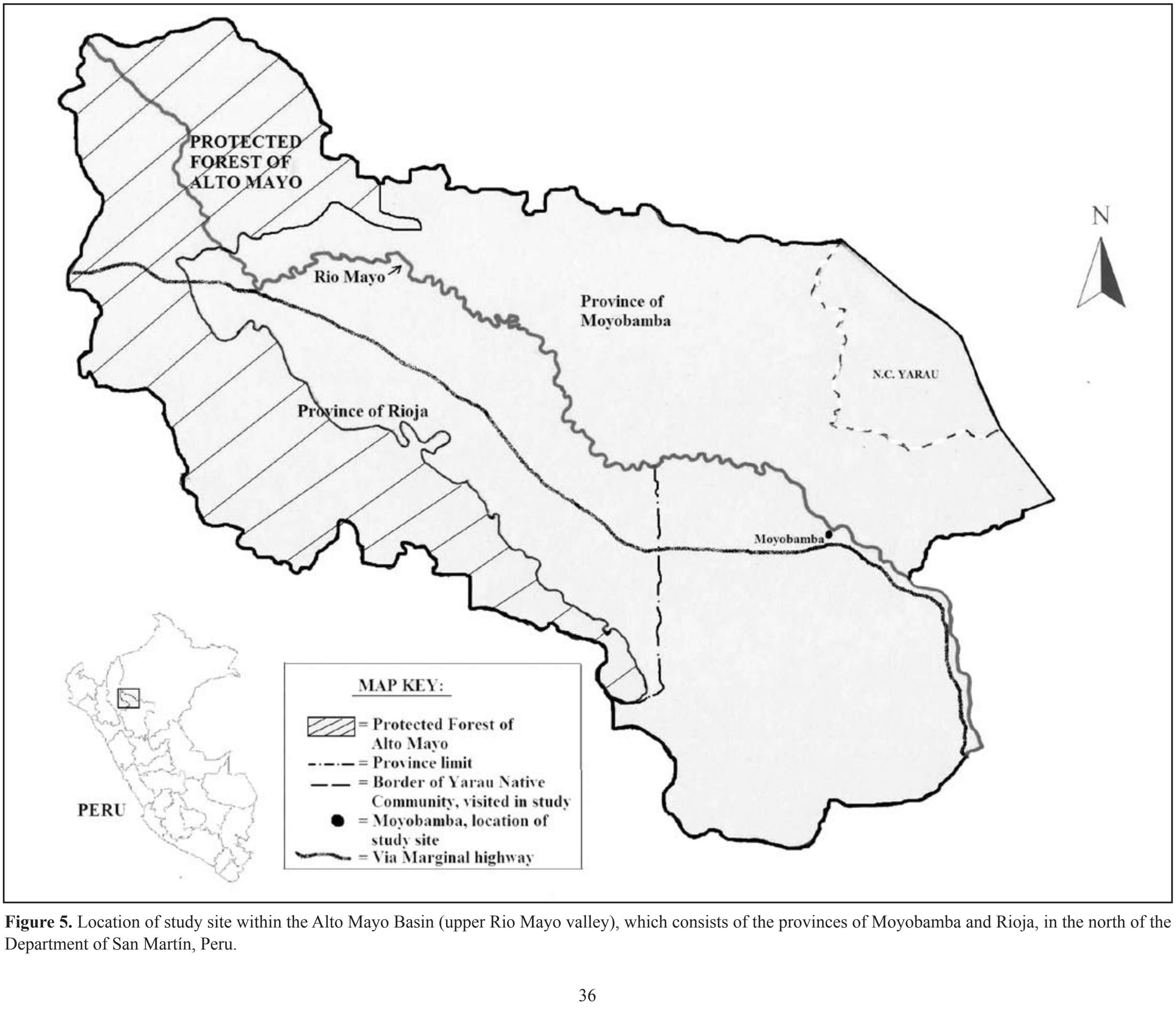

Figure 5. Location of study site within the Alto Mayo Basin (upper Rio Mayo valley), which consists of the provinces of Moyobamba and Rioja, in the north of the Department of San Martín, Peru.

members. Until recently the larger monkeys such as *O. flavicauda* and spider monkeys (*Ateles belzebuth*) were abundant in the lower parts of the forests, but have now been extirpated there due to hunting and deforestation, or have moved into the higher elevation forests.

With the help of community-assisting organizations such as the GTZ (German Technical Cooperation) and PEAM (*El Proyecto Especial Alto Mayo*), the Aguaruna have attempted to integrate domestication of animals such as *majas* (*Agouti* and *Dasyprocta*) and *sajino* (*Tayassu tajacu*) into their subsistence. Just a few families were raising agouti when I visited the community. Some game, such as agouti and peccary, is taken to markets and sold. Large game is scarce and even small birds are hunted. I did not witness the Aguarunas hunting any monkeys during my stay there, although the smaller species are game whenever the opportunity arises. The larger primates have long disappeared from the more easily accessed parts of the forests. *C. oenanthe* is hunted by locals outside the Aguaruna native community lands, and one I saw had been killed by a landowner to provide food for his dogs. Titis are also captured for the local pet trade and are sold in markets. New land invasions and occupation by *mestizo* peoples and the annexation of land (splitting into new territories) by indigenous community members are common, resulting in increasing conflict. There are a total of 14 indigenous Aguaruna communities located throughout the Alto Mayo region, occupying a considerable portion of forested area. These areas, due to their large expanses of forest, are key to conservation initiatives in the region. Indigenous community members in Yarau use the land to plant mostly yucca, corn, and coffee, a growing practice in the area.

Conservation Implications

The entire geographic range of *C. oenanthe* is restricted to the upper Río Mayo valley (Alto Mayo), which covers an area of approximately 630,700 ha. I made a number of trips into the higher altitude cloud forests of the Bosque de Protección (Fig. 5), which extends north along the border between the departments of San Martín and Amazonas. I did not encounter *C. oenanthe* there and their altitudinal range, it would seem, is restricted to below 1,000 m. The Instituto de Investigaciones de la Amazonia Peruana (IIAP), Iquitos, estimated that 268,487 ha of the Alto Mayo region had been deforested by 2004, thus leaving an estimated 362,213 ha of forest as potential habitat for *C. oenanthe* (Peru, IIAP 2004). Subtracting the area of the high-altitude forest of the Bosque de Protección (182,000 ha), this leaves an estimated potential distribution (area of occurrence) of *C. oenanthe* of a mere 180,213 ha (1,802 km^2). This forest is disappearing at an alarming rate, and during my stay many patches were burned or cut down. Estimated rates of deforestation in the region of San Martín vary from 50,000 to 100,000 ha per year (Brack 2004; López Cardeñas 1994, respectively). The forest is also becoming much more fragmented, so titi monkey groups are increasingly isolated, surrounded by cattle pasture and rice fields. This fragmentation precludes the titi monkey's ability to migrate into new areas to reproduce and establish new territories. Titi monkeys were absent from a number of fragments I visited, and the locals informed me they had not been heard or seen in them for some four years or more.

Another severe problem in this region is the unregulated influx of migrants from the sierras, which has increased considerably over recent years. The conclusion in 2003 of a two-lane asphalt highway running alongside the Río Mayo has also contributed to this increase in immigrants, and a change from traditional subsistence and small-scale farming. The Alto Mayo was a focus of a major agrarian program (the second largest in the entire country) attracting large numbers of immigrants to San Martín during the latter part of the 1980s, and deforestation increased considerably accordingly (Rengifo Ruiz 1994). The most important crops being promoted were rice and corn. This influx did not just cause an increase in population density, it changed its spatial distribution. Before the construction of the highway, settlements had been established mainly along rivers and creeks, but now they accompany the highway, extending far into the valley and high forests (Maskey *et al*. 1991). This intense colonization, combined with a lack of state regulation of land use and territory occupation, places protected areas and the remaining forests at high risk.

An agriculturalist from the area of Moyobamba can earn between 10 to 15 soles per day ($3 – 4). One of the major crops grown in the valley is rice, which sells for 75–80 cents per kilogram (other crops include coffee, corn, plantain, yucca, and cotton). Such a low price demands fields larger than 20 ha for the crop to be profitable. Rice, however, is still unprofitable for the region because it is also imported from a number of countries, and due to the poor soils it is necessary to apply large quantities of costly fertilizer. Intense application of fertilizer results in severe water and soil contamination throughout the valley's watersheds. Coffee is grown even in the lower altitude regions on the steep slopes, and can bring a better price than rice, although it is subject to a fluctuating market. The coffee is mostly not shade-grown and the plantations result in total deforestation. Forests are cleared using slash-and-burn techniques and crops grown in this manner give rise to non-sustainable markets. Custom and lower cost mean that cooking is mostly with firewood even when propane is available. The remaining fragments where *C. oenanthe* live are prime forests that are rapidly cut and used for fuel and to build houses and fences.

Other areas where *C. oenanthe* were heard calling during my surveys and reported to exist by local people were in *renacales* (*Ficus*-dominated forests) and *aguajales* (*Mauritia flexuosa* palm-dominated forests), both of which are semi-inundated forests found near rivers. The *aguaje* palm fruit is an important agroforestry food product, and *aguajales* are crucial ecosystems, maintaining rare species of animals and plants that rely on the palm trees and the swampy grasslands. These palms are a crucial component for titi monkeys (they eat the fruit of these and several other palm species), and their sustainable use and exploitation by humans provides an important conservation opportunity for *C. oenanthe* and the remaining forests of the region.

The provision of forest corridors is urgent throughout the highly fragmented range of *C. oenanthe*, being as they are the only means to ensure that remaining groups and individuals can disperse and colonize isolated forest patches. Local government should support landowners to do this and reward those still keeping forests intact, even through financial aid based on acreage of intact forest. It is important to control and implement regulations over new farming settlements in the region, as well as those existing.

A local association, Sacha Llaqta (meaning "Forest Land"), was recently formed by the author and Rosse Mary Vásquez Ríos of Moyobamba in the hopes of creating a foundation for the preservation of the forests in the area and for restoration efforts to reconnect forest fragments. The association is seeking participation with national and international organizations, with these goals in mind. Strong interest in a multitude of conservation initiatives needed for the region exists; I was approached by the municipal leaders of two towns in the area interested in the sustainable use and preservation of their large expanses of *aguajales* and cloud forests.

Further surveys of *C. oenanthe* are still urgently needed to obtain population estimates and densities, in order to assist in the management and protection of its remaining habitat. We have no information on their numbers and ranges in larger (continuous) forest tracts. Its minute geographical range and narrow altitudinal range (750–950 m a.s.l) indicates that a large proportion of the population is now restricted to isolated forest fragments. *Callicebus oenanthe* is currently listed as Vulnerable on the *IUCN Red List of Threatened Species* (IUCN 2004), but due to the extremely high rate of deforestation in the Alto Mayo area, the increasing fragmentation of the forest, and the scarcity of potential forest habitat (<1,800 km²), I recommend that its status be upgraded to Endangered. Additional surveys and studies will confirm the urgency of protection and conservation measures needed in this region.

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Apparent Confirmation that *Alouatta villosa* (Gray, 1845) is a Senior Synonym of *A. pigra* Lawrence, 1933 as the Species-Group Name for the Black Howler Monkey of Belize, Guatemala and Mexico

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Abstract: The revision of the Mesoamerican howler monkeys by Barbara Lawrence in 1933 (*Bull. Mus. Comp. Zool. Harv*. 75: 313-354) resulted in the black howler of the Yucatán Peninsula, Mexico, Belize, and northern Guatemala being referred to as *Alouatta pigra* Lawrence, 1933. In her revision, Lawrence (1933) recognized the existence of a previous name, *Mycetes villosus* Gray, 1845, for the black howlers of the region, but considered that it was not possible to use it because the holotype (in the Natural History Museum, London) was restricted to a damaged skull of an immature female (the skin had been lost), the type locality was imprecise and confused, and she was unable to determine to which of two forms she named (*A. palliata pigra* [Mexico and Guatemala] and *A. palliata luctuosa* [Belize]) it may have belonged. James D. Smith (1970, *J. Mammal*. 51: 358-369) argued that *luctuosa* was indistinguishable from *pigra*, but that *pigra* should be considered a species distinct from *palliata*. Here I discuss the type specimen of *Mycetes villosus* and its probable type locality, and argue, as Prudence Napier did (1976, *Catalogue of Primates in the British Museum (Natural History). Part 1: Families Callitrichidae and Cebidae*. British Museum [Natural History], London), that *Alouatta pigra* Lawrence, 1933 is a junior synonym of *Alouatta villosa* (Gray, 1845).

Key Words: Taxonomy, Black howling monkey, Mesoamerica, *Alouatta villosa*, *Alouatta pigra, Alouatta palliata*

The holotype of *Mycetes villosus* Gray, 1845 is a young adult howler monkey ZD.1843.9.14.3 with incompletely erupted maxillary canines and minimal dental attrition, purchased from Leadbeater and preserved at the Natural History Museum, London, UK (Napier 1976, p. 87). For years Leadbeater father and son were the leading natural history agents in London, with premises in Brewer Street, Golden Square (Sharpe 1906, p.411). The canine morphology of the skull of the holotype diagnoses it as female. A central puncture in the frontal bone and the loss of the right nasal bone, along with damage to the surrounding bones, are compatible with shotgun wounds. A round hole through the left parietal near the cranial summit drilled from another one in the basisphenoid, indicates the skull was once supported by a rod inside a mounted skin.

Gray (1845) lamented the poor condition of the skin. In his view it marred its chief diagnostic feature, the growth direction of the frontal hair, later shown by Schlegel (1876, pp.145, 152) to be individually variable. Gray (1845, p. 220) judged the frontal hair to be forward-directed, and stressed “the abundance, softness and length of the hair” which, other than the brownish roots of the cheek hairs, is entirely “silky” black. Sclater (1872) considered an adult male skin ZD.1865.5.18.3 that Osbert Salvin collected in the mountains of Chilascó (15°07′N, 90°05′W), above 6,000 feet (1,800 m) in Vera Paz, Guatemala, to be the same species, and doubted the type locality “Brazils” given by Gray (1845). In the Accessions Register, however, Gray annotated the holotype as from “Central America (Mexico?)”; the question mark later being lined out. The skull locality reads: “Mexico”. The date of disposal of the skin is unrecorded, but it must have been available for Elliot (1913, p.269) to take the body dimensions he supplied. His description, “Entire pelage, hands, feet and tail jet black, base of hairs Prout’s brown” may not be based solely on the holotype.

Employing the next available name of *Mycetes palliatus* Gray, 1849, Lawrence (1933) recognized seven subspecies. She discarded *M. villosus* as indeterminable owing to her inability to establish which is its synonym of two new subspecies she instigated; *Alouatta p. pigra* from northern Guatemala and *A. p. luctuosa* from Belize. Hall and Kelson (1959) accepted the synonymy and priority of *A. villosa*, recognizing an eighth nominotypical subspecies from central and eastern Guatemala, the source of ZD.1865.5.18.3. The size, pelage colour and texture of *A. villosa* suggested to Hill (1962, p.103) that it is specifically distinct from the smaller mantled howler, *A. palliata*. Smith (1970) deemed this confirmed by cranial and pelage characters and by the sympatry of *A. p. mexicana* at Macuspana in Tabasco, Mexico. He named the Guatemalan species *A. pigra*, with *A. p. luctuosa* as its synonym. Employing Smith's (1970) nomenclature, Horwich (1983) detected differences in troop size and male genitalia between the two species. Its cranial affinities remained to be evaluated, but Napier (1976, p.76) considered the *A. villosa* holotype indistinguishable from *A. pigra*. Its maxillary molar cusp pattern is much as Smith (1970) described for *A. pigra*. The skull, although smaller, resembles that of a Guatemalan male, ZD.1911.7.27.1.

Groves (2001, p.179) contended that the immaturity of the holotype, its lost skin, and the "several other taxa of completely black howlers of which [Sclater (1872)] was unaware" makes *Mycetes villosus* indeterminable. This is an exaggeration. The holotype is mature enough to be morphologically adult and *Alouatta nigerrima* Lönnberg, 1941 is the only completely black howler taxonomically unrecognized in Sclater's time. Specimens of it did exist, however, such as an adult male skull and round skin ZD.1851.4.23.1 from "Rio Negro", purchased from the dealer, Stevens. The accession date, 23 May 1851, and purported locality indicate the specimen was collected by Henry Walter Bates or Alfred Russel Wallace who used Samuel Stevens (1817-1899) as their agent (Wallace 1905, p. 266). If so, it may well be the "large, entirely black kind" that Bates (1863, p.295) shot "in the narrow channels near Breves" (1°40′S, 50°29′W), Brazil, on about 27–30 September 1849 (Bates 1863, p.223). Wallace (1854) specified that only the "red species, *M. ursinus*" occurs on "the Rio Negro and Upper Amazon". His "black species, *M. caraya*?" on "the Upper Amazon" was probably *A. nigerrima*.

An already well-known contender can probably be eliminated by its reverse frontal hair direction, which Sclater (1872) illustrated, and also by the sex of the *Mycetes villosus* holotype. Only adult males of the sexually dichromatic *Alouatta caraya* (Humboldt, 1812) are black. The determination of *M. villosus* is thus effectively a two-horse race. However, for the sake of completeness, I examined adult male *A. caraya* skins at the Natural History Museum, London, to cover the improbability that the holotype skin and skull are from different individuals. Listed by Napier (1976, p.79), these all differ from Gray's (1845) description of *M. villosus* by the presence of pale hairs on the scrotum, throat and ventral midline. The four Natural History Museum *A. nigerrima* skins, ZD.1851.4.23.1, ZD.1968.103, ZD.1968.104 and ZD.1970.1028 differ from the two Natural History Museum *A. villosa* skins in the absence of a brownish tinge to the pelage which is ventrally much sparser. Its relatively coarse texture is not readily described as "silky". In the males, ZD.1851.4.23.1, ZD.1968.103 and ZD.1970.1028 the scrotal hairs are orange. ZD.1970.1028 further differs in the intermingling of reddish hairs among the blackish ones of the flank. Brownish hair roots are widespread in *A. villosa* ZD.1911.7.27.1, but more restricted to the back, brachium and cheek in ZD.1865.5.18.3.

Groves (2001, p.179) described the palate of "*Alouatta pigra*" as "distinctively narrow, deep, and V-shaped toward the back". The palate of *A. nigerrima* "slopes evenly down from post-incisive region to level of M^2; mesopterygoid fossa is narrow, as is back of cranium. Nasal concave" (Groves, 2001, p. 184). However, the only verified "*A. pigra*" skulls at the Natural History Museum, ZD.1875.4.6.2 and ZD.1911.7.27.1 conform more with the latter description than with the former. The available skull sample is too small to satisfactorily gauge individual variation, but in all *A. caraya*, *A. nigerrima* and most *A. palliata* skulls at the Natural History Museum the zygomaxillary suture enters the orbit lateral to its sagittal midline. The only exception is skull ZD.1970.811 from the Salvin collection which may belong to skin ZD.1865.5.18.3. As in ZD.1843.9.14.3, ZD.1875.4.6.2 and ZD.1911.7.27.1, its zygomaxillary suture enters the orbit very close to the lacrimomaxillary suture. Except in ZD.1875.4.6.2, the infraorbital foramen on the zygomatic bone in these four skulls is smaller than that of *A. nigerrima*. They also differ in that the rear palatal rim is thin and sharp-edged with virtually no mesial protuberance, whereas in *A. nigerrima* it is thickened and emarginate, with a posteriorly projecting boss.

Neither ZD.1875.4.6.2 nor ZD.1911.7.27.1 have a well-developed mesostyle on the maxillary second molar, but it is better developed in ZD.1843.9.14.3 than in ZD.1875.4.6.2. The maxillary third molar in ZD.1843.9.14.3 lacks a stylar shelf, but is square and almost as large as the first molar. In ZD.1875.4.6.2 and ZD.1911.7.27.1 it is less square and a stylar shelf is barely present. All three have larger maxillary third molars than those of females ZD.1913.10.24.2 and ZD.1913.10.24.6 from Ecuador which do have stylar shelves. Although smaller, their second molars are not morphologically distinct from those of ZD.1843.9.14.3, ZD.1875.4.6.2 and ZD.1911.7.27.1. Smith (1970, p.363) reported that of all *Alouatta palliata* subspecies, *A. p. aequatorialis* (Eduador to western Panama) most resembles *A. pigra*. "Both are large monkeys and frequently the typical mantle coloration of *palliata* is reduced or lost completely in some individuals of *aequatorialis.*" Its cranial and dental traits, corroborated by its revised type locality (Mexico), indicate that the holotype of *M. villosus* is not one of these dark individuals, but represents the howler monkey later redescribed as *A. pigra*.

Acknowledgments

It is satisfying to apparently vindicate my late mentor, Prue Napier who was dismayed at the reluctance to respect the nomenclatural priority of *Alouatta villosa* (Gray, 1845). I thank Ms Paula Jenkins for permission to study the howler monkey collection in her care and for assistance with some technical terms.

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Conservation Assessment of the Recently Described John Cleese's Woolly Lemur, *Avahi cleesei* (Lemuriformes, Indridae)

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Abstract: John Cleese's woolly lemur (*Avahi cleesei*) was discovered in 1990 and officially defined and named in 2005. This nocturnal lemur is known to occur only in the Tsingy de Bemaraha Strict Nature Reserve, a UNESCO World Heritage Site in central western Madagascar. In this article we summarize available relevant information on morphology, distribution, habitat, and behavior including vocalizations to assess the conservation status and facilitate future investigations, surveys in particular. According to the IUCN Red List categories, *A. cleesei* is clearly in the category Endangered. Further studies might show, however, that the species should be classified as Critically Endangered, because of its very limited distribution and particularly specialized biological requirements.

Résumé: Découvert en 1990 et officiellement définit et nommé maki laineux de John Cleese (*Avahi cleesei*) en 2005, cette espèce de lémurien nocturne est seulement connue de la 'Réserve Naturelle Intégrale du Tsingy de Bemaraha' au centre-ouest de Madagascar, sîte classé du Patrimoine Mondial de l'UNESCO. Dans cet article nous résumons les informations disponibles sur la morphologie, la distribution, l'habitat et le comportement (y compris les vocalisations) pour définir le statut de conservation et faciliter des investigations futures, notamment sur la distribution. Selon les Catégories de l'UICN pour la Liste Rouge, *A. cleesei* doit être classé au moins dans la catégorie En Danger. Pourtant, des investigations futures pourraient démontrer qu'un classement Critiquement en Danger soit justifié, à cause de la distribution extrèmement limitée et des besoins biologiques très spécialisés.

Key Words: Cleese's woolly lemur, *Avahi cleesei*, conservation, Bemaraha, western Madagascar

Introduction

Although we first saw John Cleese's woolly lemur in 1990 (Mutschler and Thalmann 1990) and, as a result of our revision of the western woolly lemurs (Thalmann and Geissmann 2000), we had realized then that we had found a new taxon, we officially described and named the species only recently (*Avahi cleesei* Thalmann and Geissmann, 2005). In this article we summarize all available conservation-relevant information (published or unpublished), including information and recommendations that will facilitate future surveys for the species.

Species Description

The single individual of *Avahi cleesei* captured so far, an adult male (Fig. 1), had a body mass of 830 g. The facial fur is only slightly paler than that of the upper forehead and crown. The facial area above the nose extends upward toward the forehead. This upward extension contrasts with the virtually opposite pattern created by the triangle of forehead pelage that invades the facial area in other western *Avahi* (for example, *A. occidentalis* and *A. unicolor*). The forehead fur immediately bordering the facial area is blackish and forms a dark chevron pattern above the facial area. The eyes are maroon, and the eyelids are black and hairless. The snout is also black and hairless. The fur surrounding the corners of mouth is whitish. The fur on the head and body has a brown-gray coloration and a woolly (slightly curled) flecked appearance. The tail is beige or brown-gray, and is slightly reddish only on the dorsal side of the root. The inner dorsal surface of the lower limbs is white. The fur of the chest, belly, and inner surface of the upper limbs is relatively thin, downy, and very light gray. *Avahi cleesei* is distinguished from *A. occidentalis* by its lack of a white facial mask and broad dark eye-rings, and from both *A. occidentalis* and *A. unicolor* by the presence of a dark chevron pattern on the forehead.

Geographic Range

So far, *Avahi cleesei* is known to occur in only a single location, the Tsingy de Bemaraha National Park in central western Madagascar (Fig. 2), a UNESCO World Heritage Site. Within the reserve it has been sighted in two localities, in the forest of Ankindrodro (19°08′S, 44°49′E; n = 5 weaned individuals in two groups) and the type locality (18°59′S, 44°45′E), a forest 3 – 4 km east-northeast of the village of Ambalarano at the base of the western Tsingy precipice (n = 4 weaned individuals in two groups). The species was outside the reserve's boundaries in 1994, in the heavily disturbed forest in the surroundings of the village of Ankinajao (19°03′S, 44°47′E; n =10 weaned animals in five groups: Thalmann and Geissmann 2000). The forest was completely destroyed since we made the sightings at Ankinajao, and no woolly lemurs have been found there since 2003 (U. Thalmann pers. obs.). It appears that the species was last detected on 1 October, 2003 by one of us (UT), approximately 2 km to the south of the type locality. Surveys in the vicinity and wider surroundings of the Bemaraha region (different forests and forest types including the southern bank of the Manambolo River to the south and reaching as far north as the National Park of Namoroka, the Mahavavy du Sud River, and the Betsibioka River) did not reveal any evidence for the presence of the species (Rakotoarison *et al*. 1993; Thalmann and Rakotoarison 1994; Curtis 1997; Ausilio and Raveloanrinoro 1998; Hawkins *et al.* 1998; Sterling 1998; Thalmann *et al*. 1999; U. Thalmann unpubl. data). Based on these findings, it has to be concluded at present that the species occurs only in the Reserve Tsingy de Bemaraha to the north of the River Manambolo, and in certain forest types within the closer surroundings of the Tsingy de Bemaraha region (see 'Habitat'). The northern distribution beyond the type locality is completely unknown, but is evident, under any circumstances, that the species has an extremely restricted geographic range. Moreover, its ecological range may also be very narrow (see below).

Habitat

Avahi cleesei definitely occurs in subhumid, dry deciduous forests close to the western Tsingy precipices (Ankindrodro, type locality close to Ambalarano, Figs. 3, 4), in the larger Tsingy crevasses or gorges, and forests along small seasonal rivulets and seasonal swamps close to the Bemaraha massif (forest 2 km south of type locality, Ankinajao). To date, *A. cleesei* has not been detected in any of the region's typical dry deciduous forests of western-type, similar to the Kirindy (Ganzhorn and Sorg 1996) or Marosalaza forests (Hladik 1980). Based on a comparison of a 400 m² forest sample (Fig. 4) from the type locality of *A. cleesei* with the forest of Marosalaza (Hladik 1980), the subhumid dry deciduous forest has more green-leafed trees during the dry season, a higher floristic diversity, and the trees are larger in diameter at breast height and in canopy height (Thalmann *et al*. 1994; Thalmann unpubl.).

Figure 1. Photograph of adult male *Avahi cleesei* (type) after capture on 3 October 1991.

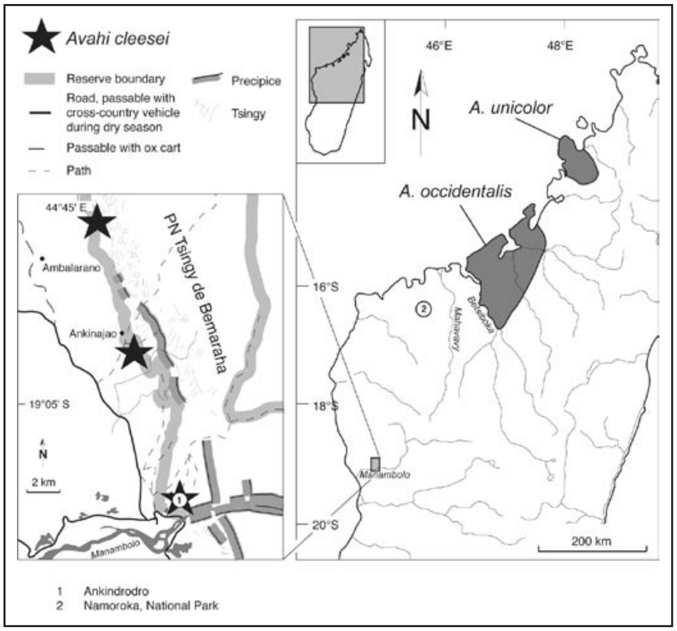

Figure 2. Distribution map of western taxa of woolly lemurs, *Avahi*.

Behavior and Ecology

A short-term field study of *A. cleesei* using telemetry was conducted 4–14 October 1991 (Figs. 5 and 6). During this time, the group (which included the type specimen) was

Figure 3. Subhumid, dry deciduous forest at the base of the tsingy precipice (type locality).

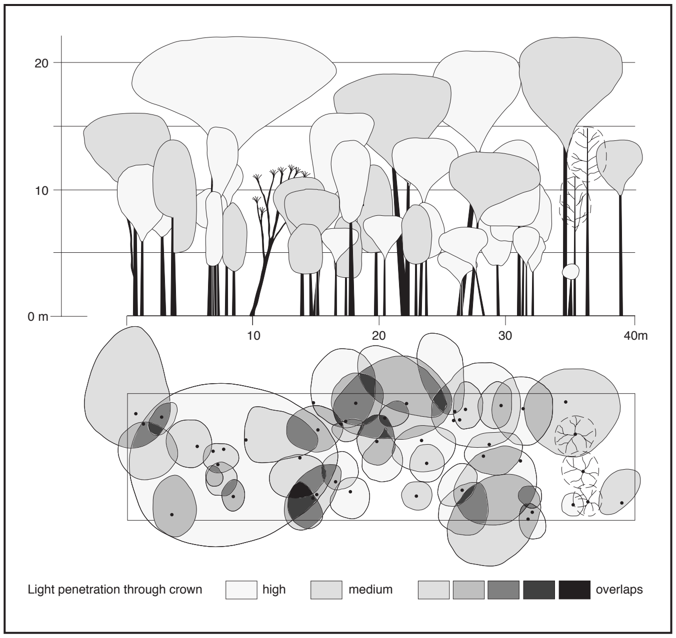

Figure 4. Schematic drawing of the subhumid dry deciduous forest (10 × 40 m). Note that most trees have mature leaves even toward the end of the dry season (October).

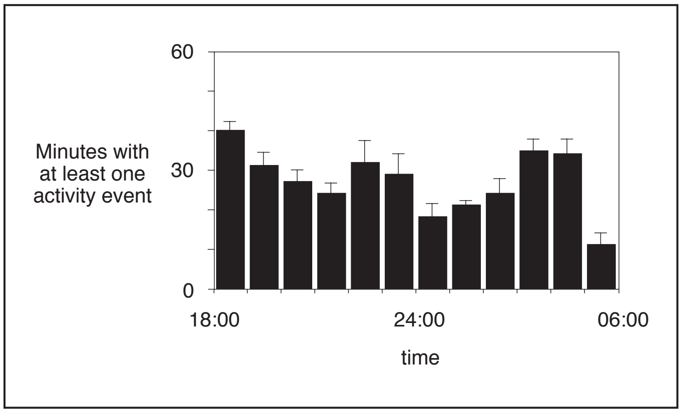

Figure 5. Nocturnal activity (18:00–06:00) of the study group in the nights from 5/6 to 13/14 October 1991 (total observation time 92 hours and 40 minutes). Error bars indicate standard error.

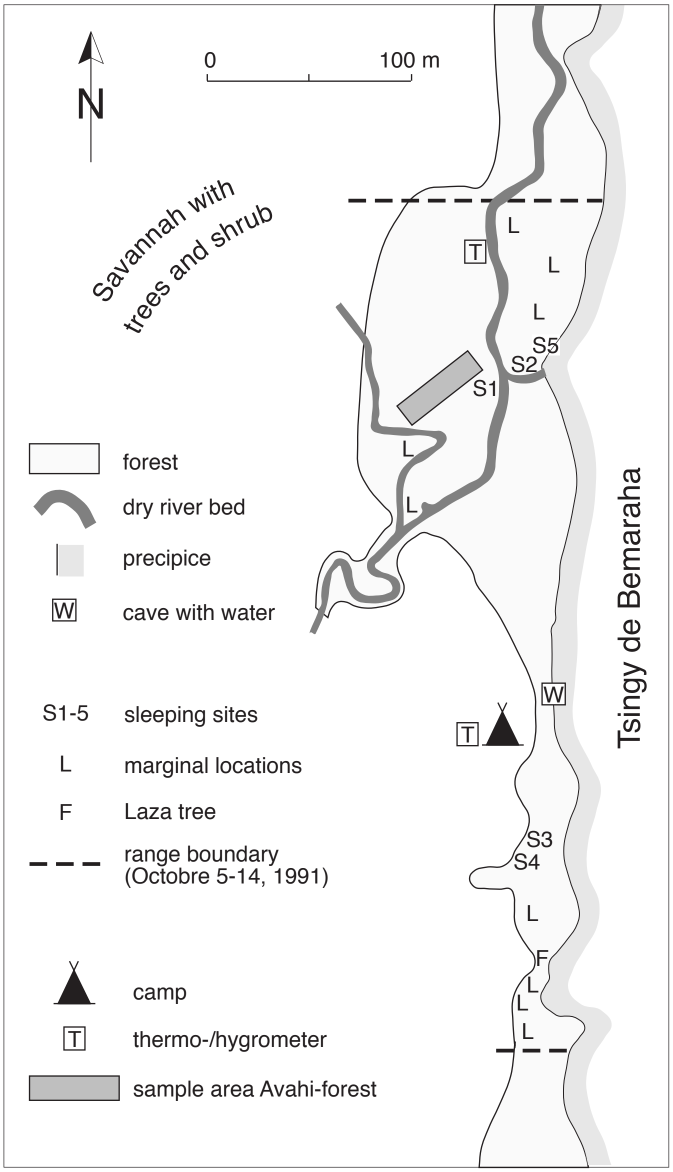

Figure 6. Map of the study site (type locality) near Ambalarano, Bemaraha.

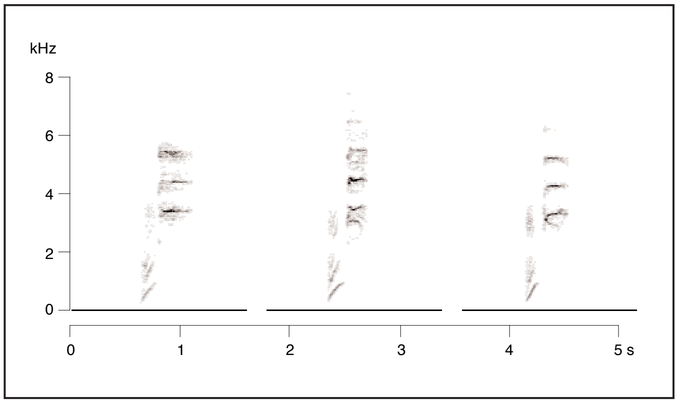

Figure 7. Sonagrams of typical *Avahi cleesei* 'vou-hy' calls (a) and whistle calls (b) at Ambalarano, Bemaraha, 9 October 1991, 19:40–20:14. Calls can be heard at http://www.gibbons.de/main/non-gibbon/2006avahi_cleesei.html.

only active at night; used a home range of approximately 2 ha and five different sleeping sites; and fed on buds, sprouting buds, and young leaves. According to the signals of the activity transmitter, Cleese's woolly lemur shows three distinct nocturnal activity peaks: the first between 18:00 and 20:00, a second more variable between 22:00 and 24:00, and the third between 03:00 and 05:00. Although detailed observations on feeding behavior have not been made, it is probable that Cleese's woolly lemur exhibits a comparable feeding behavior as its northerly congener *A. occidentalis*. The latter is a specialized folivore, feeding on selected relatively rare tree species that, in addition, are relatively large in size (Thalmann 2001, in press). Such a narrow niche may explain why members of the genus *Avahi* may occur locally in high densities but may be absent in other localities due to the lack of preferred tree species.

Vocalizations

We recorded three different classes of vocalizations for Cleese's woolly lemur in Bemaraha: 'vou-hy' calls (Fig. 7), whistles, and growls. Only the 'vou-hy' call is loud and conspicuous, whereas the other vocalizations are difficult to hear and locate. The 'vou-hy' calls did not occur every night and did not appear to be uttered at any regular times during the active period. They seem, however, to be linked with the activity peaks. During 85 hours and 10 minutes of indirect observations we noted 105 such calls. 'Vou-hy' or whistle calls by one indiviual were often answered by a corresponding call by another individual. Examples of typical 'vou-hy' and whistle calls can be heard on the Internet as soundfiles (WAV-format) at http://www.gibbons.de/main/non-gibbon/2006avahi_cleesei.html.

Survey Recommendations

Given the extremely small known range of Cleese's woolly lemur, surveys are obviously urgently needed to find additional populations. Interviews with local inhabitants may be one source of information, it became evident to us that Cleese's woolly lemur is one of the least known species, along with the aye-aye (*Daubentonia madagscarensis*), and is considered very rare. The local name is *Dadintsifaky*. Some people call it *Bekola be*—the big *Bekola*—*Bekola* being the local name for *Hapalemur occidentalis* (Rakotoarison *et al.* 1993; Thalmann unpubl. data). Field surveys in potential habitat are necessary as a second source of information. During daytime surveys, the immobile and cryptically colored Cleese's woolly lemurs are virtually impossible to find. Therefore, surveys at night with head lamps are necessary, using the reflecting eye shine to find them. Given the comparable size and eye shine of the sportive lemurs (*Lepilemur ruficaudatus*) and *A. cleesei*, four main characteristics besides knowledge of their general appearance (such as body proportions) may be used to distinguish between *Lepilemur* and *Avahi* at night: (1) *Avahi* are often encountered in groups, thus several animals may be spotted sitting or feeding closely together, although this may also sometimes apply for *Lepilemur*. (2) In *Lepilemur*, the ears are clearly protruding, whereas *A. cleesei* has much smaller ears. (3) When resting, woolly lemurs usually hide their tail between their body and the substrate, whereas in sportive lemurs the tail hangs down. (4) Sportive lemurs often move their heads sideways, probably to have a better look at the observer. Woolly lemurs seem to be less curious, and look at the observer without moving the head in the same way as do the sportive lemurs.

Conservation Assessment

According to the IUCN Red List categories and criteria, *A. cleesei* clearly falls into the category Endangered under the criteria B1ac(i, ii, iii, v) (IUCN 2001): The extent of occurrence is estimated to be less than 5,000 km² (B1), the species is known from just one location (B1a), and the known population is declining (B1c) in extent of occurrence (i); area of occupancy (ii); area, extent and/or quality of habitat (iii); and in number of mature individuals (v).

More detailed analyses and surveys may reveal, however, that this avahi should even be moved to the Critically Endangered category. For example, the disturbed forest close to the village of Ankinajao, which supported a substantial number of individuals in 1994 (Thalmann and Geissmann 2000) had been cut completely by 2003 (Thalmann unpubl. data). The subhumid forest occurring at the base of the escarpment of the Tsingy de Bemaraha is under continuous pressure from annual bushfires. In some places, the forest has been reduced to only a few meters in width (Fig. 6). Such subhumid forests are the only habitat where *A. cleesei* is known to occur. In addition, migrating individuals are forced to travel through stretched ranges (Fig. 6) that are possibly much easier to control and defend by the range holders because part of the borders are made up of savanna and the rocky tsingy precipice (Fig. 6). This may make it extremely difficult for migrating animals (for example, young animals leaving the family group) to cross established territories in order to find a mate and its own range.

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Distribution and Conservation Status of Two Newly Described Cheirogaleid Species, *Mirza zaza* and *Microcebus lehilahytsara*

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Abstract: The northern giant mouse lemur, *Mirza zaza* Kappeler and Roos in Kappeler *et al.*, 2005, and Goodman's mouse lemur, *Microcebus lehilahytsara* Roos and Kappeler in Kappeler *et al.*, 2005, are known from the region of the Ampasindava peninsula in northwestern Madagascar, and Andasibe and surrounding regions in east-central Madagascar, respectively. The presence of *M. zaza* in protected areas has yet to be confirmed, but it may occur in the Manongarivo Special Reserve and the Tsingy de Namoroka National Park. *Microcebus lehilahytsara* occurs in the Analamazaotra Special Reserve and Mantadia National Park. In this paper, we review what little is known of these two species in terms of their distributions and conservation status. *Mirza zaza* is possibly Vulnerable, following the IUCN Red List criteria, whereas *Microcebus lehilahytsara* is Data Deficient.

Key Words: Northern giant mouse lemur, *Mirza zaza*, Goodman's mouse lemur, *Microcebus lehilahytsara*, Madagascar, distribution, conservation status

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Introduction

In 2005, we identified and described two species of cheirogaleid primates that were new to science. The genus *Mirza* was long known to occur in a disjunct fashion in western Madagascar. The taxonomic status of different subpopulations remained unknown, however. In particular, it was not clear whether all giant mouse lemurs belonged to one and the same species (*Mirza coquereli*), or whether there was any significant taxonomic variation. Our field studies and subsequent genetic analyses revealed a number of behavioral, morphological, and genetic differences between a population from the northern end of the range on the Ampasindava peninsula and a second population from the southern part of the range in Kirindy forest. The differences were such as to warrant their separation at the species level (*Mirza zaza* Kappeler and Roos in Kappeler *et al*. 2005). While compiling genetic data for an assessment of the magnitude of genetic variation within and between closely related species to assess the status of the northern and southern *Mirza*, we also identified a highly divergent sequence from a mouse lemur (*Microcebus* spp.) from Andasibe. These animals also represented a new species that we named *Microcebus lehilahytsara* Roos and Kappeler in Kappeler *et al.* 2005. Here, we update information on their distribution and conservation status.

Northern Giant Mouse Lemur*, Mirza zaza*

Distribution

As for many newly described species, information about the exact distribution area of *M. zaza* is limited. Currently, *M. zaza* is known from the region of the Ampasindava peninsula in northwestern Madagascar, specifically from Ambato and Pasandava (Kappeler *et al.* 2005) (Fig. 1). Further genetic studies confirmed the species' occurrence also in the forests of Ankarafa in the Sahamalaza region, and it is likely that the giant mouse lemurs from the Befotaka region also belong to *M. zaza* (Mittermeier *et al*. 2006). The southern limit of the distribution of this species is particularly uncertain; it may range as far south as the Tsingy de Namoroka National Park. However, the identity of this population is unclear — it may be *M. coquereli* and not *M. zaza*.

Conservation status

Andrianarivo (1981) and Kappeler *et al.* (2005) have both reported high local population densities for *M. zaza* near Pasandava. Indeed, their estimates of 385 and 1,086 individuals/km² are several times higher than those obtained for *M. coquereli* in Kirindy forest (Kappeler 1997). The concentration of animals in rather isolated forest fragments and the presence of mango, cashew, and other introduced food tree species in the Ambato region may help to explain the higher densities. Detailed surveys throughout the Sambirano region are clearly indicated to determine the distribution and abundance of *M. zaza* on a regional scale.

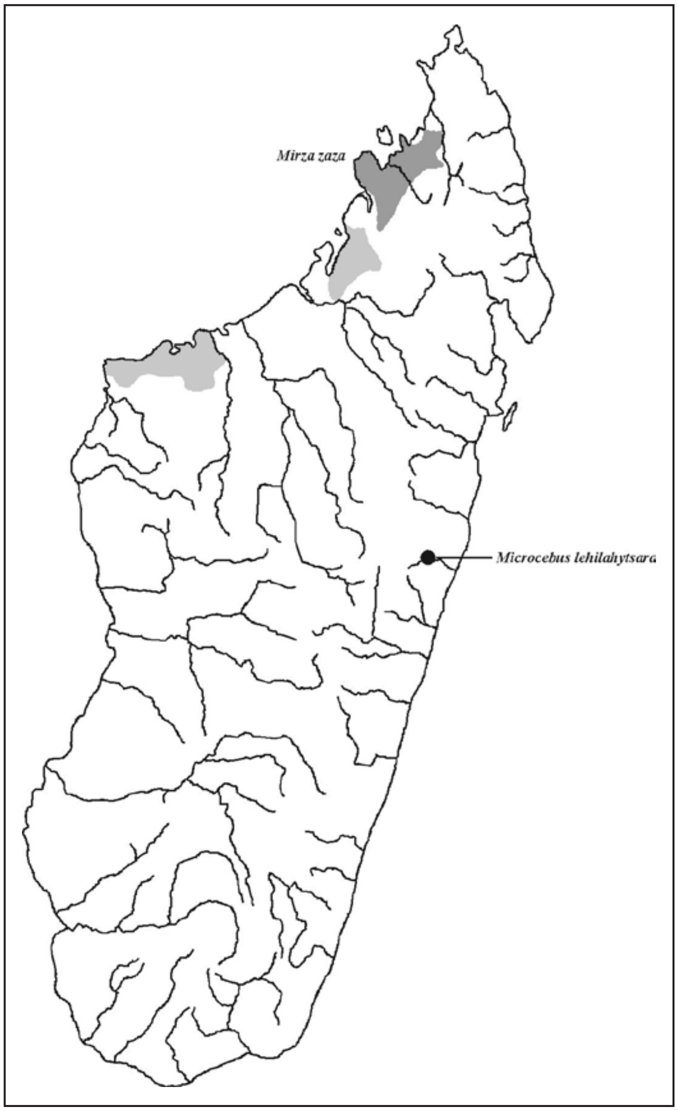

Figure 1. Distribution of *Mirza zaza* and *Microcebus lehilahytsara*. The dark and light grey areas indicate confirmed and inferred distribution zones for *M. zaza*, respectively.

Figure 2. *Mirza zaza*. Photograph by D. Haring.

Because the species is newly described and its conservation status has yet to be assessed by further research, it has been tentatively categorized as Data Deficient (Mittermeier *et al*. 2006). However, given that *M. coquereli* is currently listed as Vulnerable (VU A2c) (IUCN 2006), and that *M. zaza* most likely has a much smaller distribution—albeit perhaps with a higher population density—than *M. coquereli*, *M. zaza* must be considered at least as Vulnerable and could very well be Endangered. Although the species' presence in any protected areas has yet to be confirmed, *M. zaza* may occur in the Manongarivo Special Reserve and the Tsingy de Namoroka National Park.

Goodman's Mouse Lemur, *Microcebus lehilahytsara*

Distribution

The exact distribution area for *M. lehilahytsara* has still to be assessed. Currently, it is known only from the type locality of Andasibe and surrounding regions (for example, Maromizaha Forest; Randrianambinina and Rasoloharijaona 2006), including the two protected areas Analamazaotra Special Reserve and Mantadia National Park (Kappeler *et al.* 2005; Mittermeier *et al*. 2006) (Fig. 1). The extent of the distribution of this species to the south and north is still unknown. Based on currently available information, it is unlikely that Goodman's mouse lemurs occur in sympatry with other mouse lemur species. The maximum extent of its range to the south may be Ranomafana National Park, where it is replaced by *M. rufus*, and to the north to the Betampona Strict Nature Reserve and Zahamena Strict Nature Reserve

Figure 3. *Microcebus lehilahytsara*. Photograph by D. Haring.

Figure 4. *Mirza zaza*. Photograph by R. Zingg

and National Park, where it is replaced by *M. simmonsi* (Kappeler *et al*. 2005; Louis *et al*. 2006).

Conservation status

The conservation status of *M. lehilahytsara* remains unknown, so that it has to be categorized as Data Deficient (Mittermeier *et al*. 2006). It occurs in at least two protected areas (Analamazaotra Special Reserve and Mantadia National Park), but whether the species is present in a third, Mangerivola Special Reserve, remains to be confirmed.

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A West African Black-and-White Colobus Monkey, *Colobus polykomos dollmani* Schwarz, 1927, Facing Extinction

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Abstract: The conservation status of several African colobines has been studied extensively during recent years; however, this is not the case for the West African black-and-white colobus monkeys, notably *Colobus polykomos dollmani* of Côte d'Ivoire. In 2003 and 2004, we conducted surveys in three forest reserves and Marahoué National Park between the Sassandra and Bandama rivers in Côte d'Ivoire to assess the status of the primates there, with a special focus on *Colobus p. dollmani*. Thirteen primate taxa were expected in the south-central part of the interfluvial region. We confirmed the presence of eight, including *Colobus p. dollmani*. Only two of the eight taxa, however, were found to be relatively frequent in all of the four protected areas: *Cercopithecus (c.) lowei* and *Cercopithecus p. petaurista*. The presence of *Cercopithecus (diana) roloway* and *Pan troglodytes verus* in all four reserves could only be inferred from interviews with local people. *Procolobus badius badius* was mentioned as present by local people in only one reserve. We detected *Colobus p. dollmani* in only one of the forests visited but indirect evidence of its presence in a second reserve. Poaching and habitat destruction are the main threats to this subspecies as well as to the other taxa. Without immediate and vigorous action, this colobine taxon will probably be extinct in the near future.

Résumé: L'état de conservation de plusieurs espèces de Colobes d'Afrique a beaucoup été étudié ces dernières années. Cependant, cela n'a pas été le cas des Colobes noirs et blancs d'Afrique de l'ouest, en particulier *Colobus polykomos dollmani* de Côte d'Ivoire. Par conséquent, des investigations ont été menées de 2003 en 2004 dans trois forêts classées et le Parc National de la Marahoué situés entre les fleuves Sassandra et Bandama en Côte d'Ivoire, en vue d'établir le statut des espèces de primates vivant dans ces forêts avec un intérêt particulier pour *Colobus p. dollmani.* D'après les informations recueillies, treize taxa de primates pouvaient être rencontrées dans la partie centre-sud de cette région inter fluviale. La présence de huit taxa (incluant *Colobus p. dollmani*) a été confirmée. Cependant, seulement deux ont été plus fréquemment rencontrées. Ces deux taxa étaient *Cercopithecus (c.) lowei* et *Cercopithecus p. petaurista*. La présence de *Cercopithecus (diana) roloway* et *Pan troglodytes verus* a été signalée au cours d'interviews menées auprès de villageois dans toutes les réserves. Celle de *Procolobus badius badius* n'a été signalée que dans une seule forêt. *Colobus p. dollmani* n'a été observé que dans une seule des forêts visitées, alors que sa présence a été mentionnée dans une seconde forêt par les villageois. La chasse et la destruction des forêts sont les principales sources de menaces pour cette sous-espèce mais aussi pour d'autres taxa. Sans une action immédiate et vigoureuse, ce Colobe va probablement disparaître dans un proche futur.

Key Words: Black-and-white colobus monkey, *Colobus polykomos dollmani*, endemic, primate survey, extinction, conservation, south-central Côte d'Ivoire

Introduction

With at least 20 different taxa, Côte d'Ivoire has a high primate diversity. Most of these taxa are listed as threatened on the IUCN Red List (IUCN 2006), and three are among the world's 25 most threatened primates — *Cercocebus atys lunulatus*, *Cercopithecus diana roloway*, and *Procolobus badius waldronae* (see Mittermeier *et al.* 2006), the last considered already extinct by Oates *et al.* (2000), although new evidence suggests that it still survives (McGraw 2005). Most studies on primates in Côte d'Ivoire have focused on the western part of the country, especially the Taï National Park (for example, Noë and Bshary 1997; Wachter *et al.* 1997; Boesch and Boesch-Acherman 2000). Long-term field studies are still underway in the Taï forest, including the Taï Monkey Project (TMP) and the Taï Chimpanzee Project (TCP). Surveys for *C. diana roloway* and *P. badius waldronae* have been conducted in the eastern part of the country (McGraw *et al.* 1999; Oates *et al.* 2000), but only a few studies have focused on central Côte d'Ivoire, between the Bandama and Sassandra rivers. This region is of special interest because it is a zone where ranges of related taxa (including primates) overlap and where hybridization may occur (Kingdon 1997).

There are two species of black-and-white colobus in West Africa, *Colobus polykomos* (Zimmerman, 1780), the king or western pied colobus, and *C. vellerosus* (I. Geoffroy, 1834), the ursine or Geoffroy's pied colobus (see Oates and Trocco 1983; Oates *et al*. 1994). Both occur in Côte d'Ivoire (Fig. 1). *Colobus vellerosus* ranges from the Bandama River to western Nigeria (Oates *et al*. 1994; Kingdon 1997). *Colobus polykomos* ranges from Guinea to the Sassandra River in western Côte d'Ivoire (Napier 1985; Oates *et al*. 1994; Groves 2001).

The form *dollmani*, Dollman's colobus, was first described by Schwarz (1927) as a subspecies of *Colobus polykomos* (the single species of black-and-white colobus that he recognized; see Schwarz 1929), occurring east of the Sassandra River in the narrow strip extending to the Bandama River. *Colobus p. dollmani* differs from *C. p. polykomos* by coat pattern, and especially by a white band on the thighs; a characteristic of *C. vellerosus*. While *dollmani* continues to be referred to by some authors as a subspecies of *polykomos* (see for example, Napier 1985; Kingdon 1997), the recognition of *C. vellerosus* as a valid species (distinct from *polykomos*) by Oates and Trocco (1983; see also Grubb *et al.* 2003), and its closer resemblance to *C. vellerosus*, led Groves (2001) and Grubb *et al.* (2003) to refer to it as *C. vellerosus dollmani*, and as a junior synonym of *C. vellerosus*.

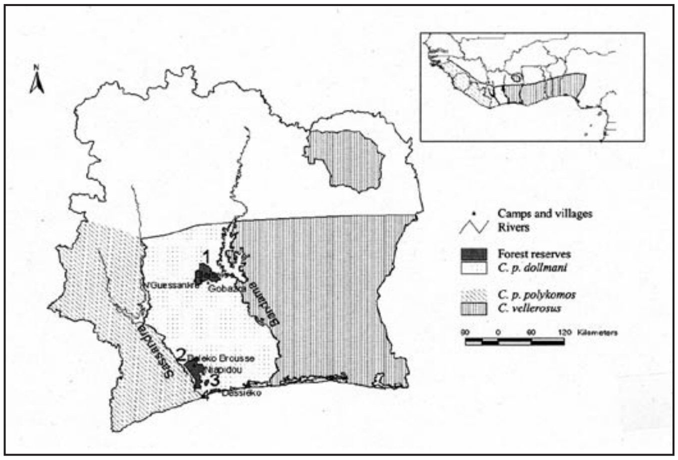

Figure 1. The approximate distribution of West African black-and-white colobus monkeys in West Africa and in Côte d'Ivoire. Rivers suggested as geographic barriers for a number of species and survey sites are also indicated (1 = Marahoué; 2 = Niégré; 3 = Bolo West; 4 = Dassiéko).

Dandelot (1974) pointed out that "Booth (1954) observed interbreeding *between* [the subspecies] *vellerosus* and *dollmani* in the Bouaflé Forest Reserve" (p.30), and that Rahm (1970) had supposed *dollmani* to be a hybrid between *vellerosus* and *polykomos*. Groves *et al.* (1993), Oates (1996), Kingdon (1997), Groves (2001, 2005) and Grubb *et al*. (2003) all consider it to be a hybrid between *C. polykomos* and *C. vellerosus*. Groves (2001, 2005) and Grubb *et al.* (2003) listed it as a junior synonym of *C. vellerosus*. It is not known, however, whether it constitutes a consistent morphotype or whether there are local populations that differ according to the degree of gene influx from *C. polykomos* or *C. vellerosus*. A number of studies have focused on aspects of the socioecology of *C. polykomos* (see Moresco-Pimentel 1994; Nijssen 1999; Bitty 2001), but information on *C. p. dollmani* is still scarce.

The primates in Côte d'Ivoire are threatened by hunting for bushmeat and the clear-cutting of forest for agriculture. *Colobus p. dollmani* is endemic to the forests of Côte d'Ivoire, occupying just a small range from the Sassandra River to the Bandama River. This and our ignorance of its status make it particularly vulnerable to extinction. For this reason we carried out surveys to obtain an assessment of the general status of primates in central Côte d'Ivoire, between April 2003 and October 2004, in Dassioko, Bolo West, and Niégré forest reserves and Marahoué National Park, focusing especially on *C. p. dollmani*. We also interviewed people whenever we could on the presence and absence of all the primates with ranges extending into central Côte d'Ivoire, including, besides *C. p. dollmani*, *Perodicticus p. potto*, *Cercopithecus (c.) lowei*, *Cercopithecus p. petaurista*, *Cercopithecus (diana) roloway*, *Chlorocebus (aethiops) sabaeus*, *Cercocebus atys lunulatus*, *Papio anubis, Procolobus verus*, *Procolobus b. badius*, and *Pan troglodytes verus*. *Galagoides demidoff* and *Galagoides thomasi* are also expected to occur in southern Côte d'Ivoire, but we neither looked for them in particular nor did we ask about them in the interviews.

Methods

Prior to our survey, we consulted relevant literature from the Société de Développement des Forêts en Côte d'Ivoire (SODEFOR 1996; Anonymous 1999) to learn more of the historical distribution of *C. p. dollmani* and the status of the forests and their wildlife. Previous studies in the protected areas of Côte d'Ivoire noted the presence of *C. p. dollmani* in Marahoué National Park, and Bolo, Dassiéko, and Niégré forest reserves (Fig. 1). Relying on this information, we started our investigations in these forest reserves and provisionally treated all black-and-white colobus monkeys from the region between the Sassandra and Bandama rivers as *C. p. dollmani*. We interviewed people (particularly hunters) in the nearby villages, asking them to describe the primates they knew and to mimic their calls. We showed them photographs or paintings of the species afterward to confirm their identifications. We gathered information about the past and recent presence of primates, particularly *C. p. dollmani*, in the forest reserves and in neighboring forest fragments. We also visited a number of restaurants in these villages to gather information on primate species being offered as bushmeat.

We surveyed on foot, walking slowly and quietly along old logging roads and existing paths at about 1–1.25 km/hour for an average of 10 hours per day. During that time, we walked the paths repeatedly, noting any visible or acoustic sign of the presence of primates, and determining their position with a global positioning system. Primates in these forests are hunted and therefore shy, and we were usually unable to approach them closer than about 50 m. We began early in the morning at 06:00 and continued until 13:00. After an hour's rest, we continued the survey until 18:30. We collected fecal samples of *Cercopithecus (c.) lowei*, *Cercopithecus p. petaurista*, *Cercocebus atys lunulatus*, and *C. p. dollmani* for genetic analysis. Once a group of monkeys was detected we stayed with it and observed it for as long as we could. We used Kingdon (1997) for the identification of species and subspecies.

Because we noted mainly just presence-absence, our survey method did not allow for reliable estimates of population densities. We distinguished two reliability levels concerning our data. A taxon was classified as present in a certain forest reserve if we saw or heard it directly or if we found it on sale as bushmeat in nearby villages. A taxon was classified as most likely present if it was mentioned only as present in interviews. Furthermore, we defined three population density categories: a species was considered frequent when it was detected at least once a day during the survey; rare when observed occasionally or at least once in three days of survey or found as bushmeat in the restaurants; and very rare when it was not encountered during the survey, but its presence was reported by hunters (seen in last 12 months).

Survey sites

The location of the survey sites is shown in Figure 1. The Dassiéko Forest Reserve (11,317 ha) is situated between the towns of Fresco and Sassandra (5°02′44″N, 5°48′19″W). In 1990, this forest was divided into Dassiéko South (7,980 ha) and Dassiéko North (3,337 ha) by a road. The road improved access to the forest's interior and enhanced forest destruction. The conservation status of Dassiéko South seems to be better than the northern part. The Bolo Forest Reserve is north of the Dassiéko Forest, between 5°07′ and 5°26′N and 5°47′and 6°03′W. It is made up of three forest blocks: Haute Bolo (18,750 ha), Bolo West (7,700 ha), and Bolo East (14,306 ha). The Niégré Forest Reserve (97,300 ha) is in the northwest of Côte d'Ivoire. The coordinates for the center of this forest are 5°20′N, 6°10′W. The Dassiéko, Bolo, and Niégré forests belong to the Guinean domain, and include dense and marshy forests, and marshy, evergreen coastal forests with coastal lagoons, swamps, marshes, and mangroves.

Marahoué National Park (101 km²) has a relatively undulating terrain, drained in the southeast by the Bandama Rouge (Marahoué River) and its tributaries. This reserve is notable for its geographic location, with Guinean savannah woodlands in the east and northeast, and dense deciduous forest and some gallery forest in the south and southeast. This was the only site where we expected to find *Chlorocebus (aethiops) sabaeus* and *Papio anubis*, because the other three are to the south, and outside the known range of these two species.

In total, we spent 14 days and 10 nights in the Bolo West forest during the rainy season in May 2004, and 6 days and 5 nights in the Dassiéko South forest in July 2004. Three days were spent in Baleko Brousse, a village bordering the Niégré Forest reserve, and 13 days and 7 nights in the Niégré forest in April 2004. We did surveys on 16 days and 8 nights in various parts of the Marahoué National Park during the dry season in December 2003. See Table 1 for the precise dates.

Results

According to the criterion "directly seen or heard or found among bushmeat," we were able to confirm the presence of eight of the 13 possible primate taxa during our surveys in at least one of the four protected areas (Table 1). They were: *Perodicticus p. potto*, *Cercopithecus (c.) lowei*, *Cercopithecus p. petaurista*, *Cercocebus atys lunulatus*, *Papio anubis*, *Procolobus verus*, and *Colobus polykomos dollmani.* We did not see *Cercopithecus (diana) roloway*, *Procolobus b. badius*, and *Pan troglodytes verus*, although local people indicated that *Cercopithecus (diana) roloway* and *Pan troglodytes verus* were present in all four of the reserves. *Procolobus b. badius* was reported only for Dassiéko.

The presence and frequency of sightings of these eight primates varied among the reserves. *Perodicticus potto* was found being sold as bushmeat, and interviewees reported its occurrence at all four sites. *Papio anubis*, a savanna species, was found in Marahoué National Park but not in the southern forest reserves which are out of its known range. Similarly, *Chlorocebus aethiops sabaeus*, another savanna species, was reported as present only for Marahoué National Park during interviews.

Dassiéko Forest Reserve

We saw and heard *Cercopithecus (c.) lowei*, *Cercopithecus p. petaurista*, *Cercocebus atys lunulatus*, and *Procolobus verus* in Dassiéko South Forest. We also heard sounds of monkeys moving in the trees that were typical of the larger colobines, but we were unable to determine whether it was *Colobus p. dollmani* or *Procolobus b. badius*. *Cercopithecus (diana) roloway*, *Colobus p. dollmani*, and *Procolobus b.*

Table 1. Presence of primate taxa in three forest reserves (Dassiéko, Bolo West, and Niégré) and the Marahoué National Park between the Sassandra and the Bandama rivers, Côte d'Ivoire.

Species	Sites[1]	Interviews or found among bushmeat[2]	Observation[2]
Demidoff's dwarf Galago *Galagoides demidovii*	all sites	?	NO
Thomas' dwarf Galago *Galagoides thomasi*	all sites	?	NO
Western potto *Perodicticus potto potto*	Dassiéko	P	NO
	Bolo West	P	NO
	Niégré	BP	NO
	Marahoué	P	NO
Lowe's monkey *Cercopithecus (campbelli) lowei*	Dassiéko	BP	O/H
	Bolo West	P	O/H
	Niégré	BP	O/H
	Marahoué	P	O/H
Eastern lesser spot-nosed monkey *Cercopithecus petaurista petaurista*	Dassiéko	BP	O/H
	Bolo West	P	O/H
	Niégré	BP	O/H
	Marahoué	P	O/H
Roloway monkey *Cercopithecus (diana) roloway*	Dassiéko	P	NO
	Bolo West	P	NO
	Niégré	P	NO
	Marahoué	P	NO
White-naped mangabey *Cercocebus atys lunulatus*	Dassiéko	P	O/H
	Bolo West	P	NO
	Niégré	P	NO
	Marahoué	P	NO
Green monkey *Chlorocebus aethiops sabaeus*	Dassiéko	A	NO
	Bolo West	A	NO
	Niégré	A	NO
	Marahoué	BP	NO
Olive baboon *Papio anubis*	Dassiéko	A	NO
	Bolo West	A	NO
	Niégré	A	NO
	Marahoué	P	H
Olive colobus *Procolobus verus*	Dassiéko	P	O/H
	Bolo West	P	O/H
	Niégré	P	O/H
	Marahoué	P	H
Upper Guinea red colobus *Procolobus badius badius*	Dassiéko	P	NO
	Bolo West	A	NO
	Niégré	A	NO
	Marahoué	A	NO
Dollman's colobus *Colobus polykomos dollmani*	Dassiéko	P	NO
	Bolo West	P	O/H
	Niégré	P	NO
	Marahoué	P*	NO
Western chimpanzee *Pan troglodytes verus*	Dassiéko	P	NO
	Bolo West	P	NO
	Niégré	P	NO
	Marahoué	P	NO

[1] Surveys. Marahoué: 15–31 December 2003. Niégré: 2–18 April 2004. Bolo West: 5–19 May 2004. Dassiéko: 27 July – 2 August 2004.

[2] B = Species was found as bushmeat; P = Species was indicated as present in interviews; A = species was indicated as absent in interviews; O = Species was observed directly; H = Species was confirmed by vocalizations; NO = Species neither seen nor heard. * = Taxon was reported as last seen in 2002. ? = Status was not evaluated in interviews. Density estimates are not available because our survey methods did not meet the criteria necessary for line transect sampling (Burnham *et al.* 1980).

badius were reported by local people, but we were unable to confirm their presence. No evidence was forthcoming for the occurrence of *Pan troglodytes verus* in Dassiéko, although chimpanzees were mentioned as present in interviews.

We found a number of snares, many shotgun shells and a poachers' camp in the forest. When visiting local markets in the vicinity of the Dassiéko reserves, we found remains of *Cercopithecus (c.) lowei* and *Cercopithecus p. petaurista*, and in Dagbego, a nearby village, a hunter told us that he saw a group of *Colobus p. dollmani* in the forest in 2003.

Bolo Forest Reserve

We heard and saw the following primates in the Bolo Forest Reserve: *Cercopithecus (c.) lowei*, *Cercopithecus p. petaurista*, *Procolobus verus*, and *Colobus p. dollmani*. This was the only site where we found *Colobus p. dollmani*—one group of four individuals close to an area that had been recently clearcut, near the Davo River (05°22.72′N, 005°59.55′W). Interviews with people cutting the forest and poachers we met in the forest revealed the presence of *Cercopithecus (diana) roloway*, *Cercocebus atys lunulatus*, and *Pan troglodytes verus*. This forest is under heavy human pressure. We found many recent clearings, hunters' paths, and many shotgun shells.

Niégré Forest Reserve

During surveys in the Niégré Forest we confirmed the presence of *Cercopithecus (c.) lowei, Cercopithecus p. petaurista*, and *Procolobus verus*. This reserve is under particular threat due to agricultural activities. Two- to three-year-old cocoa plantations and recent clearings were found inside the reserve. A poacher we met in the forest told us that he caught a young *Cercocebus atys lunulatus* 2 years previously and sold it in Djakouakoukro, a village inside the reserve. Following his advice, we visited the village and found the monkey still alive and kept has a pet. Other hunters told us that *Cercopithecus (diana) roloway*, *Colobus p. dollmani*, and *Pan troglodytes verus* still occurred there, but were rare. The restaurants in Baleko Brousse, a village bordering the forest, were frequently serving *Cercopithecus (c.) lowei, Cercopithecus p. petaurista*, and *Perodicticus potto*. We also found a young *Cercopithecus p. petaurista* being kept as a pet by a farmer in the same village.

Marahoué National Park

In Marahoué National Park we were able to confirm (by vocalizations and sightings) the presence of *Cercopithecus (c.) lowei, Cercopithecus p. petaurista*, *Papio anubis,* and *Procolobus verus.* Some of the farmers we met told us that *Cercopithecus (diana) roloway*, *Cercocebus aty lunulatus*, and *Pan troglodytes verus* were still present in this forest. Interviews of poachers in N'Guessankro and Blaisekro revealed that their most recent sightings of *Colobus p. dollmani* were in 2002. They also informed us that *Chlorocebus (aethiops) sabaeus* was present in Marahoué, and we found some remains of this monkey in a restaurant in Bouaflé, a town just outside the park. However, even the remotest parts of the forest are disturbed by cocoa farms, and have poacher camps and trails. We also surveyed forest patches inside the savanna zone of the park. We heard baboons around the camp, but found recently cut clearings in the forest along with young cocoa plantations.

Discussion

During our survey, we gathered presence-absence information on 11 primate taxa, *Perodicticus potto*, *Cercopithecus (c.) lowei*, *Cercopithecus p. petaurista*, *Cercopithecus (diana) roloway, Chlorocebus (aethiops) sabaeus, Cercocebus atys lunulatus*, *Papio anubis*, *Procolobus verus*, *Procolobus badius badius*, *Colobus polykomos dollmani*, and *Pan troglodytes verus*, in four forest reserves between the Sassandra and the Bandama rivers in southern Côte d'Ivoire. We were able to confirm the presence of just three of these in all four of the protected areas we visited: *Cercopithecus (c.) lowei*, *Cercopithecus p. petaurista*, and *Procolobus verus*. From the numbers of encounters we could infer that the two guenons were the most abundant of the diurnal primates in these reserves. Although we recorded *Cercocebus atys lunulatus* in Dassiéko, we had only the reports of hunters as evidence for its permanence in the other three sites.

Indirect evidence suggested that another three taxa still occur in the four areas: *Perodicticus potto*, *Cercopithecus (diana) roloway*, and *Pan troglodytes verus*. The status of *Perodicticus potto* was difficult to assess due to its nocturnal activity and we might have overlooked it during our diurnal surveys. However, even this species was found among bushmeat in the markets, and its number may also be decreasing rapidly. *Pan troglodytes verus* was detected in only one reserve (Dassiéko), but reported by interviewees for the other three sites. Chimpanzees have been the focus of conservation efforts in the Taï National Park, but less attention has been given to other populations in the region. Given their rarity and low population sizes, they will soon go extinct in the forest reserves if no immediate conservation action is taken. In 2004, The Wild Chimpanzee Foundation (WCF) has begun a number of initiatives, particularly in Marahoué, Banco National Parks.

We found no evidence for the presence of *Procolobus badius badius* in any of the four reserves. Poachers living in the vicinity of Dassiéko informed us that its disappearance was recent, and it would seem to be due to hunting, rather than habitat loss. *Papio anubis* and *Chlorocebus (aethiops) sabaeus* occur only in Marahoué National Park which, unlike the three forest reserves, consists of a mosaic of Guinean savannah woodlands and dense deciduous forest. The two dwarf galagos, *Galagoides thomasi* and *Galagoides demidoff* might be present in the reserves, but we do not have any information about their status.

The main aim of our survey was to gather information about the status of *Colobus p. dollmani* in the interfluvial region of Côte d'Ivoire; its historical range. It was observed in only one of the four sites, Bolo Forest Reserve — and just one group was found — evidently very low numbers. Local people said that it occurred at the other four sites, but the last report in the Marahoué National Park was in 2002. No information was available for this colobine subspecies prior to our study, and its restricted range compared with that of the other black-and-white colobus monkeys, the destruction of its habitat, and hunting pressure could lead to its extinction in the near future. According to Oates and Trocco (1983), Groves *et al.* (1993), Groves (2001), and Grubb *et al.* (2003), *C. p. dollmani* is most likely a hybrid form of *C. polykomos* × *C. vellerosus*, both of which are already on the *IUCN Red List of Threatened Species* (IUCN 1994, 2006): *Colobus polykomos* is listed as Lower Risk/Near Threatened, and *Colobus vellerosus* as Vulnerable. A more recent assessment (resulting from a status assessment workshop held in Orlando, Florida, 27–30 January 2005, and using the IUCN [2001] criteria) has yet to be incorporated into the IUCN Red List, but places both species as Vulnerable (Hoffmann 2006).

Colobus p. dollmani is not included on the Red List because it is regarded as a hybrid and a synonym of *C. vellerosus*. Genetic analyses are necessary to clarify its taxonomic status and to estimate the degree of genetic exchange with its possible parent species and whether the population is monophyletic or paraphyletic. It is also important to determine whether its morphotype varies locally or whether it is consistent over its range. We would argue that even if it is a hybrid form, it is worthwhile preserving it — it is an evolutionary unit and possibly undergoing speciation. A comparable situation exists for the West African scaly-tailed squirrel, *Anomalurus pelii*, where different subspecies are recognized to the east and west of the interfluvial region, and the form between the Sassandra and Bandama rivers was recently recognized as a distinct, third subspecies (Schunke and Hutterer 2005).

The conditions of the four reserves in southern Côte d'Ivoire are not good. Only Dassiéko South was found to be relatively undisturbed — most likely at least in part an effect of a long-term ecological monitoring project there. The frequent presence of researchers in the forest might be discouraging potential poachers and farmers to hunt and farm the forest. The other three reserves have numerous clearings made by farmers, and only a very few parts remain undisturbed. There are camps, small villages, and many people in these forest reserves. In February 2005, the illegal camps and villages inside Marahoué National Park were destroyed, and the people were forced to leave the park.

Hunting is a major threat to primates and other wildlife in these forest reserves. Although wildlife is legally protected, there is almost no control of poaching. The first concern of the managers of forest reserves in Côte d'Ivoire is forestry, and not the protection of wildlife. Civil unrest in Côte d'Ivoire since 2002 has created social and economic instability, and the protection of forests and wildlife is not currently a priority for the government. People have taken advantage of this and there have been dramatic increases in encroachment in these supposedly protected forests. The National Protected Areas Management Program (PCGAP), a project funded by the European Development Fund (EFD), World Wildlife

Fund, Agence Française de Développement, the Global Environment Facility (GEF), and Kreditanstalt für Wiederaufbau (KfW), was ceased pre-term, and the resulting benefits of forest management and protection have been lost, with a corresponding upsurge of illegal forest clear-cutting and poaching. There are now numerous cocoa plantations, forest clearings, trails, snares, and poacher camps even in the remotest parts of the forests.

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Taxonomy, Distribution, and Conservation Status of Three Species of Dwarf Galagos (*Galagoides*) in Eastern Africa

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Abstract: This paper reviews the complicated nomenclatural history for the Kenya coast galago, *Galagoides* cf. *cocos*, and examines whether '*cocos*' is the valid species name for this recently resurrected taxon. This paper also reviews the phenotypic and vocal differences among *G. cocos*; the Zanzibar galago (*Galagoides zanzibaricus zanzibaricus*); the Udzungwa galago (*Galagoides zanzibaricus udzungwensis*); and the Mozambique galago (*Galagoides granti*), as well as their geographic ranges and conservation status. The following are among the findings: (1) '*Galagoides cocos*' is the name that should be applied to the Kenya coast galago; (2) in the field, the loud calls of these three species are diagnostic and remain the best means for identification; (3) there is a suite of phenotypic characters that, when taken together, can be used to distinguish among these three species when in the hand or viewed in the field in good light at close range; (4) *G. z. zanzibaricus* is phenotypically distinct from *G. z. udzungwensis*; (5) the three species are parapatric or, perhaps, narrowly sympatric; (6) the three species are endemic to the coastal forests of eastern Africa with *G. cocos* in the north (Kenya and northeastern Tanzania), *G. zanzibaricus* in Tanzania, and *G. granti* from southern Tanzania to southern Mozambique; and (7) none of the three species is threatened at this time, although *G. z. zanzibaricus* meets the *IUCN Red List* criteria for an Endangered subspecies.

Key Words: Dwarf galagos, *Galagoides*, *cocos*, *granti*, *zanzibaricus*, *udzungwensis*, taxonomy, conservation

Introduction

Many of the species and subspecies of the family Galagidae (galagos or bushbabies) have been subjected to repeated taxonomic revisions and name changes over the past century (for example, Elliot 1913; Allen 1939; Hill 1953; Groves 1977, 1993, 2001, 2005; Grubb *et al.* 2003). The Kenya coast galago (or Diani small galago), *Galagoides cocos*, is no exception (Figs. 1 and 2). *Galagoides cocos* is a recently revived, highly cryptic species of the coastal forest of eastern Africa.

In this paper we (1) review the nomenclatural history for the Kenya coast galago, (2) provide new information that confirms that '*cocos*' is the valid name for this recently revived species, (3) summarize the phenotypic and the main qualitative vocal differences among *G. cocos*, the Zanzibar galago (*Galagoides zanzibaricus*), and the Mozambique or Grant's galago (*Galagoides granti*), (4) review their geographic ranges, and (5) examine their conservation status (Figs. 1–7).

Nomenclatural History for the Kenya Coast Galago

On 16 December 1911, Edmund Heller (1912) collected an adult male dwarf galago (one of 10 specimens) at Mazeras, Kenya, which he named *Galago moholi cocos.* This taxon was raised to species status (*Galago cocos*) by Elliot (1913), but later placed as a subspecies of the Somali galago (*Galago gallarum cocos*), as a subspecies of the Zanzibar galago (*Galago zanzibaricus cocos*), or simply not recognized as a valid taxon and placed as a junior synonym of the Zanzibar galago (*Galago senegalensis zanzibaricus* or *Galago zanzibaricus zanzibaricus* or *Galago zanzibaricus* or *Galagoides zanzibaricus*) (Table 1). Most recently, this taxon has been provisionally referred to as '*Galagoides* cf. *cocos*' (Bearder *et al*. 2003; Grubb *et al*. 2003). This binomial is 'provisional' because the validity of the use of the name '*cocos*' requires confirmation.

Figure 1. Adult (sex not known) Kenya coast galago (*Galagoides cocos*) from Arabuko-Sokoke Forest Reserve, southeastern Kenya (near Gedi). Note the muzzle patches and buffy-brown dorsum. Photograph by Harald Schuetz.

Figure 2. Adult female Kenya coast galago (*Galagoides cocos*) from Diani, southeastern Kenya. Note the muzzle patches. Photograph by Andrew Perkin.

Figure 3. Adult male Zanzibar galago (*Galagoides zanzibaricus udzungwensis*) from Pande Game Reserve, Tanzania (near Dar es Salaam). Note the absence of muzzle patches. Photograph by Nike Doggart.

Figure 4. Adult (sex not known) Udzungwa (or Matundu) galago (*Galagoides zanzibaricus udzungwensis*) from Matundu Forest Reserve, Udzungwa Mountains, south-central Tanzania (near Ifakara). Note that the hairs of the tail are of even length, sparse, and wiry, that the bone of the tail is visible, and that the tip of the tail is dusky. Photograph from Honess (1996).

Many of the more recent taxonomic studies on Galagidae make no mention of *cocos,* but presumably they consider *cocos* to be a synonym of *Galago zanzibaricus* (for example, Groves 1977; Nash *et al.* 1989; Masters 1998; Zimmermann 1990) or of *Galagoides zanzibaricus* (for example, Honess 1996; Anderson 1999, 2000; DelPero *et al*. 2000; Masters and Bragg 2000; Masters and Brothers 2002).

The Need for Confirmation of the Name '*cocos'* for the Kenya Coast Galago

Until recently, *G. zanzibaricus* was considered a polytypic species of the coastal forests from southern Somalia through Kenya and Tanzania (including Unguja Island, Zanzibar, Tanzania) to southern Mozambique, and inland to central

Figure 5. Adult (sex not known) Mozambique galago (*Galagoides granti*) from Rondo Forest Reserve, southeastern Tanzania (near Lindi). This individual is emerging from a tree hole and, thus, its tail is not visible. Note the relatively large, blackish ears and buffy-brown dorsum. Photograph by Simon Bearder.

Figure 6. Typical adults of three *Galagoides* spp. at the British Museum of Natural History, London. Bottom to top: Kenya coast galago (*Galagoides cocos*) from Gande, Kenya, Udzungwa galago (*Galagoides zanzibaricus udzungwensis*) from Kissarawe, Tanzania, and Mozambique galago (*Galagoides granti*) from Coguno, Mozambique. Note the great similarity in the color of the dorsum, and that *G. granti* is the largest of the three species and has a wider, fuller, tail. Photograph by Tom Butynski.

Table 1. Summary of the nomenclature changes for the Kenya coast galago (*Galagoides cocos*).

Authority	**Latin name**
Heller (1912)	*Galago moholi cocos*
Elliot (1913), Hollister (1924)	*Galago cocos*
Allen and Loveridge (1927)	*Galago gallarum cocos*
Schwarz (1931), Hill (1953), Allen (1939), Hill and Meester (1977)	*cocos* a synonym of *Galago senegalensis zanzibaricus*
Jenkins (1987)	*cocos* a synonym of *Galago zanzibaricus zanzibaricus*
Kingdon (1971, 1997), Groves (2005)	*cocos* a synonym of *Galago zanzibaricus*
Groves (1993)	*cocos* a synonym of *Galagoides zanzibaricus*
Groves (2001)	*Galago zanzibaricus cocos*
Bearder *et al.* (2003), Grubb *et al.* (2003)	*Galagoides cocos*

Figure 7. Two adult Zanzibar galagos (*Galagoides zanzibaricus zanzibaricus*) (left) from Unguja Island, Zanzibar, Tanzania, and two adult Udzungwa galagos (*Galagoides zanzibaricus udzungwensis*) (right) from Kissarawe, Tanzania. All four specimens are at the British Museum of Natural History (BMNH), London. The two specimens of *G. z. zanzibaricus* represent the extremes in pelage coloration among the 10 adult specimens at the BMNH. Note that the dorsum, tail, and outer front limbs are medium to bright cinnamon in *G. z. zanzibaricus* and buffy-brown in *G. z. udzungwensis.* Photograph by Tom Butynski.

Tanzania, Malawi, and extreme eastern Zimbabwe (Hill 1953; Groves 1977; Hill and Meester 1977; Smithers and Wilson 1979; Jenkins 1987; Courtenay and Bearder 1989; Skinner and Smithers 1990; Groves 2001, 2005; Bearder *et al*. 2003; Grubb *et al.* 2003). The ecology, behavior, and vocal repertoire of the mainland subspecies, *G. z. cocos*, is well known, having been the focus of detailed field studies at Diani and Gedi Forests, Kenya (Harcourt 1986; Harcourt and Nash 1986a, 1986b). Far less well known is the nominotypical subspecies, *G. z. zanzibaricus*, an endemic of Unguja Island, Zanzibar. It was not until A. Perkin visited Unguja Island in 1998 and recorded the species-specific advertising call of topotypical *G. zanzibaricus* (Fig. 8) that it became clear that these two forms were different:

(1) The species-specific advertising call of *G. z. zanzibaricus* is very different from that of *G. z. cocos*. *Galagoides z. zanzibaricus* has a 'single unit rolling call' (Fig. 8), and *G. z. cocos* has an 'incremental call' (Fig. 9) (Honess 1996; Honess and Bearder 1996; Perkin *et al.* 2002; Grubb *et al*. 2003).

(2) The species-specific advertising call of *G. z. zanzibaricus* is identical, or nearly so, to the species-specific advertising call of the recently named Udzungwa (or Matundu) galago, *Galagoides udzungwensis* (see A. Perkin unpubl. data, cited in Bearder 1999). This led to the realization that *G. udzungwensis* may not be a new species, but rather synonymous with, or a subspecies of, *G. zanzibaricus* (see Perkin *et al*. 2002; Bearder *et al*. 2003; Grubb *et al*. 2003). Here we treat the Udzungwa galago as a distinct mainland subspecies (*G. z. udzungwensis*), but emphasize that the taxonomic status of the Udzungwa galago is far from resolved (see below).

Based on a considerable body of knowledge concerning the species-specific advertising calls of the Galagidae, and their wide use and acceptance as a robust species recognition and taxonomic tool (Zimmermann *et al*. 1988; Courtenay and Bearder 1989; Harcourt and Bearder 1989; Nash *et al.* 1989; Zimmermann 1990; Masters 1991; Bearder *et al*. 1995, 2003; Honess 1996; Honess and Bearder 1996; Butynski *et al*. 1998; Ambrose 1999, 2003; Bearder 1999; Groves 2001; Perkin *et al*. 2002), it was judged that the level of difference between the advertising calls of *G. z. cocos* and *G. z. zanzibaricus/G. z. udzungwensis* is far greater than can be accommodated at the subspecies level. In fact, the advertising call of *G. z. cocos* is far more similar to the advertising 'incremental' call of *G. granti* (formerly *G. zanzibaricus granti*) (Fig. 10) than it is to the 'single unit rolling' call of *G. z. zanzibaricus* (see Bearder *et al*. 1995). As such, *G. z. cocos* was reassigned species status, *G.* cf. *cocos* (Bearder *et al*. 2003; Grubb *et al*. 2003). Interestingly, the geographic range of *G. zanzibaricus* is located between the geographic ranges of *G. cocos* and *G. granti* (see below).

Grubb and co-authors give a succinct overview of this complex situation.

> "Galagos at Diani, which were thought to be *Galagoides zanzibaricus* (Harcourt and Nash, 1986a, b) are vocally distinct from true or topotypical *G. zanzibaricus* of Zanzibar. They are provisionally identified as *Galagoides* cf. *cocos*, and we assign them to the *G. granti* group. Galagos from the Udzungwa Mtns and other localities in Tanzania have been named *Galagoides udzungwensis* (Honess, 1996) but, on the basis of their vocalization, do not differ from those of topotypical *G. zanzibaricus* of Zanzibar (A. Perkin unpubl. data, cited in Bearder, 1999). The form *udzungwensis* may prove to be a valid taxon at the subspecific level but until the systematics is clarified, we relegate it to the synonymy of *Galagoides zanzibaricus*." (Grubb *et al*. 2003, pp.1315–1316).

And below

> "The galago recorded from Diani is vocally distinct from *Galagoides zanzibaricus* and has been

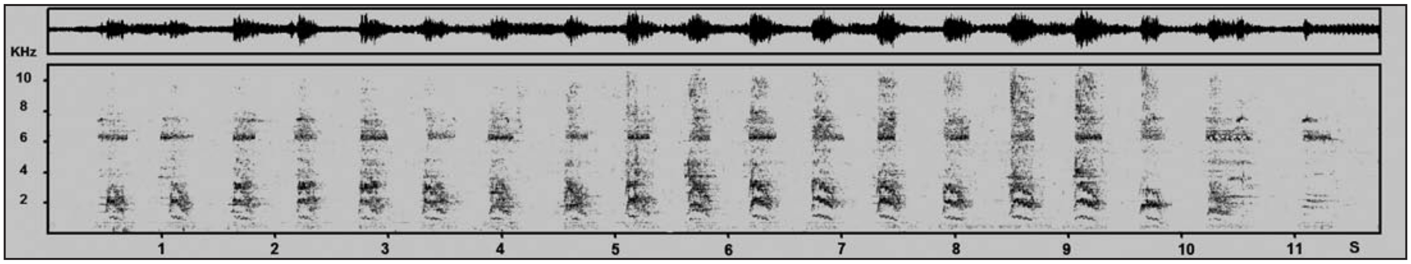

Figure 8. Sonogram and oscillogram of the 'single unit rolling' advertising call of the Zanzibar galago (*Galagoides zanzibaricus zanzibaricus*) from Unguja Island, Zanzibar, Tanzania, the type locality for this species. Call recorded by Andrew Perkin. This call is comprised of a series of 'rolling' trill units that, after a few units, increase in frequency and amplitude before reaching a mild crescendo and then trailing off with trill units of lower amplitude and frequency. The lowering of the frequency is achieved by eliminating the higher frequency elements. The lowest frequency elements remain constant. Each trill unit is made up of a very rapid series of trill subunits. The number of units per 'single unit rolling' call varies considerably (Honess 1996; A. Perkin, pers. obs.). For the above recording: Call length = 10.8 seconds. Frequency range = 0.62–11.12 kHz. Fundamental frequency = 0.75 kHz. Range of unit frequency modulation = 0.81–3.57 kHz. Number of phrases = 0. Number of units = 19. For the Udzungwa galago (*Galagoides zanzibaricus udzungwensis*) population in the Matundu Forest Reserve, south-central Tanzania, the type locality for this subspecies: Mean number of units per single unit rolling call = 14 (SE = 0.17, range = 1–46, n = 2,122). Mean unit interval = 0.28 seconds (n = 181). Mean unit length = 0.22 seconds (n = 196). Range of fundamental frequency = 0.95 to 1.00 kHz (Honess 1996, Honess and Bearder 1996, A. Perkin unpubl. data). Oscillograms of the single unit rolling call of *G. z. udzungwensis* are presented in Bearder *et al*. (1995), Honess (1996), Honess and Bearder (1996), and Kingdon (1997).

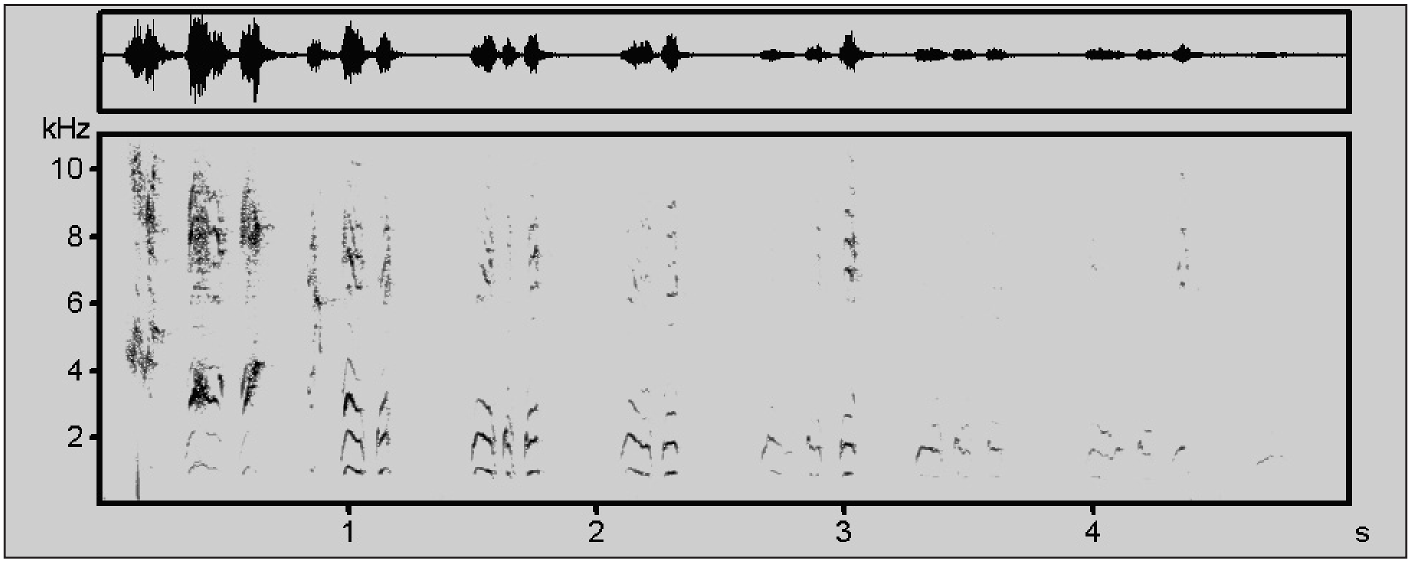

Figure 9. Sonogram and oscillogram of the 'incremental' advertising call of the Kenya coast galago (*Galagoides cocos*) from Diani Beach, southeastern Kenya. Call recorded by Simon Bearder. This call often, but not always, starts with a series of high-pitched, rapidly uttered, "chirrups" followed by units arranged in phrases that are high in frequency and amplitude, and that gradually become lower in amplitude. The number of units within each phrase increases incrementally until the end of the call. Often, as in this case, phrases with same number of units are repeated. The number of units per phrase rarely decreases. Units are often frequency modulated. For the above recording: Call length = 4.7 seconds. Frequency range = 0.65–11.15 kHz. Fundamental frequency = 0.98 kHz. Range of unit frequency modulation = 0.68–10.37 kHz. Number of phrases = 6 (with three introductory "chirrup" units and one incipient unit at the end). Mean number of units per phrase = 2.8. For the *G. cocos* population at Diani: Mean call length = 4.3 seconds (range = 1.7–8.6 seconds, n = 12). Frequency range = 0.8–9.3 kHz. Fundamental frequency = 0.8–1.2 kHz. Mean number of phrases = 6 (range = 3–11, n = 13). Mean number of units per phrase = 2.5 (range 1–11, n = 60). Mean unit interval = 0.35 seconds (range 0.20–0.59 seconds, n = 27). Mean unit length = 0.41 seconds (range 0.15–0.57 seconds, n = 33) (Courtenay and Bearder 1989). See also the acoustic measurements presented in Zimmermann (1990). Additional sonograms and oscillograms of the incremental advertising call, and other calls of *G. cocos,* are presented in Courtenay and Bearder (1989), Harcourt and Bearder (1989), Zimmermann (1990), Bearder *et al.* (1995), and Kingdon (1997).

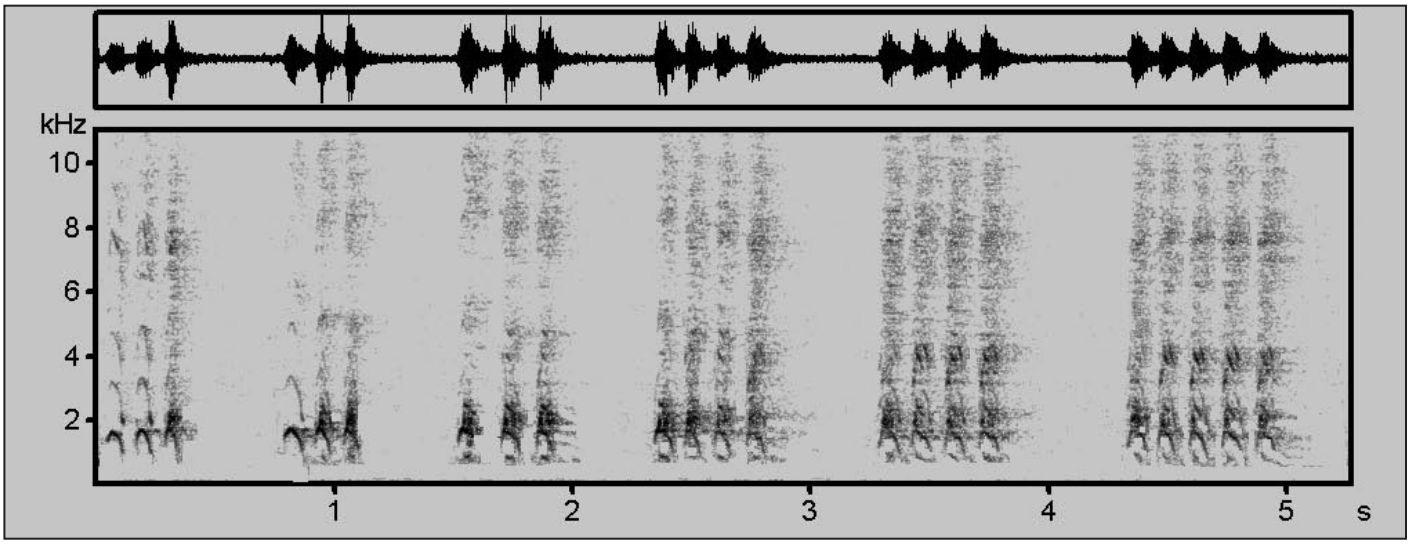

Figure 10. Sonogram and oscillogram of the incremental advertising call of the Mozambique galago (*Galagoides granti*) from Rondo Forest Reserve, Rondo Plateau, southeastern Tanzania (near Lindi). Call recorded by Paul Honess. This sonogram is an example of a full incremental call in which the numbers of units in each phase gradually increase incrementally. Compared with the incremental call of *G. cocos*, the incremental call of *G. granti* maintains relatively consistent amplitude, has more units per phrase, and is more staccato. In the above example, the amplitude increases slightly during the middle phrases and decreases slightly during the last phrase. For the above recording: Call length = 4.9 seconds. Frequency range = 0.56–11.18 kHz. Fundamental frequency = 0.75 kHz. Range of unit frequency modulation = 1.03–5.08 kHz. Number of phrases = 6. Mean number of units per phrase = 3.6 (range 3–5). In the *G. granti* population of the Rondo Forest Reserve: Mean number of phrases per incremental call = 5.8 (SE = 0.2, range = 1–17, n = 211). Mean unit interval = 0.55 seconds (n = 41). Mean unit length = 0.41 seconds (n = 53) (Honess 1996, Honess and Bearder 1996). Additional oscillograms of the incremental advertising call, and other calls, of *G. granti* are presented in Honess (1996), Honess and Bearder (1996), and Kingdon (1997).

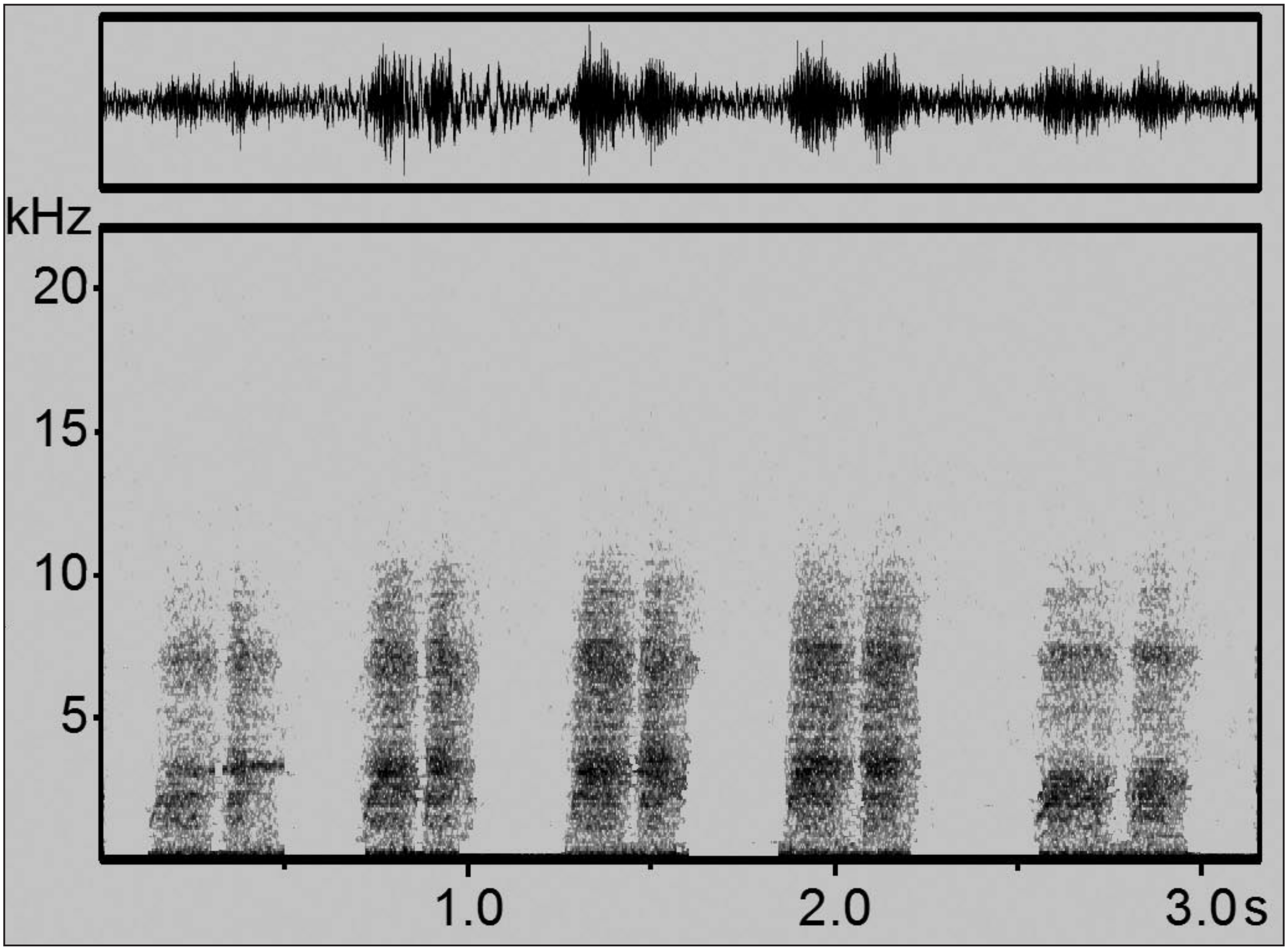

Figure 11. Sonogram and oscillogram of the incremental advertising call of the Kenya coast galago (*Galagoides cocos*) from Kaya Chijembeni (Rabai), 4 km northeast of Mazeras, southeastern Kenya, the type locality for this species. Call recorded by Yvonne de Jong and Tom Butynski. Although numerous full incremental calls were heard and recorded at Kaya Chijembeni during two nights, there was much background noise and wind, and none of the recordings of the full incremental call were suitable for the production of a clear sonogram. The sonogram presented here is of an incomplete or incipient incremental call. Nonetheless, the first five phrases of incremental units are present and identifiable as the species-specific advertising call of *G. cocos.* In this case, there are no "chirrup" phrases and the number of units does not increase incrementally but the call still follows the typical high-pitched, rapid or staccato pattern of the *G. cocos* incremental call. For the above recording: Call length = 2.8 seconds. Frequency range = 0.98–12.4 kHz. Fundamental frequency = 0.77 kHz. Number of phrases = 5. Number of units per phrase = 2. Frequency modulation is not detectable, probably due to the low amplitude of the call.

> recorded elsewhere in Kenya and in Tanzania, where A. Perkin (*in litt*.) reported it from the northern tip of the East Usambara Mtns, seemingly close to *G. zanzibaricus* (Table IV). The form *Galago moholi cocos* Heller, 1912, was described from Mazeras (Manzeras), relatively close to Diani (Table IV). Groves (2001) recognized *cocos* as a mainland form of *Galagoides zanzibaricus*. Vocalizations typical of *G. zanzibaricus* have not been recorded in Kenya. Therefore, it seems highly likely that the Diani galago is a separate species, *Galagoides* cf. *cocos*. Nevertheless it is important to confirm this. Vocalizations recorded from as near to the type locality of *Galagoides cocos* as possible should be compared with the voice of the Diani galago. The forest at the type locality (Kaya Mazeras) has been destroyed, but forests 5 km and 20 km distant (Kaya Mtswakana and Kaya Fungo respectively) and some others might be visited (Butynski unpubl., including information from Q. Luke). Museum specimens of *Galagoides cocos* should be compared with the Diani galago further to ensure that we are dealing with a single taxon. We provisionally consider the Diani galago to be conspecific with *Galagoides cocos*, under the vernacular name Kenya coast galago." (Grubb *et al*. 2003, p.1317).

In other words, in considering the Kenya coast galago once again a valid species, one important action remains: the confirmation of '*cocos'* as the species name. This is necessary because the tape recordings used to describe the loud call for the Kenya coast galago were made at Diani, Kenya (04°18′S, 39°35′E) (Zimmermann 1990; Bearder *et al*. 1995), *c*.40 km south of the type locality for *G. cocos* (i.e., Mazeras). There are three rivers between these two sites that are potential barriers to dispersal (Maji ya Chumvi, Mambome, and Pemba/Cha Shimba). A visit to Mazeras was, therefore, required to determine whether the species-specific loud call of *G. cocos* at the type locality is the same as that of the dwarf galago at Diani.

Note that, in the above quotation, Grubb *et al.* (2003) assume that the holotype of *G. cocos* was collected in the forest of 'Kaya Mazeras', which has since been destroyed. What Heller (1912) actually says about the type locality is:

> "The Mazeras specimens were all obtained on the brushy borders of the cocoa-palm groves. These groves are the dominant feature in the landscape of the coast belt, and extend almost unbroken from the sea beaches inland a distance of ten or fifteen miles. They mark the tropical littoral zone more precisely than any other plant growth." (Heller 1912, p.2).

In short, Heller obtained the holotype (and nine other specimens) of *G. cocos* in an area of coconut palms (*Cocos nucifera*) and bushland, and not in forest.

Confirmation of the Name '*cocos*' for the Kenya Coast Galago

T. Butynski and Y. de Jong visited the Mazeras area on 10–12 February 2004. The first night was spent searching for *G. cocos* in the Mazeras Botanical Garden (03°57′58″S, 39°33′05″E, 134 m a.s.l.) in Mazeras town. No dwarf galagos were heard or seen, although the small-eared greater galago, (*Otolemur garnettii*), was common (about eight individuals seen or heard).

The second night was spent searching for *G. cocos* on the edge of Kaya Chijembeni (Rabai) (03°56′42″S, 39°34′54″E, 210 m a.s.l.), a relatively large coastal forest located about 4 km northeast of Mazeras town, 17 km from the Indian Ocean, and 40 km north of Diani. Coconut palms are an extremely common species there on the forest edge and, with cashew nut (*Anacardium occidentale*) and mango (*Mangifera indica*), are scattered throughout the farmlands and bush lands that surround Kaya Chijembeni. Many dwarf galagos were heard and seen at this site (both on the forest edge and inside the forest), and tape recordings were acquired of 'incremental' advertising calls and other vocalizations. To our ears, the advertising call recorded in Kaya Chijembeni matched that recorded for the dwarf galago at Diani, as well as the advertising call that T. Butynski has heard many hundreds of times (and recorded) at others sites on the coast of Kenya (for example, Kilifi, Watamu, Gedi), and in forests along the lower Tana River (02°30′S, 40°30′E), *c.*150 km to the north of Mazeras.

That the incremental advertising call recorded from *G. cocos* at Kaya Chijembeni is the same as that recorded from the dwarf galago at Diani is confirmed through comparisons of the sonograms and oscillograms of these calls (Figs. 9 and 11). The advertising calls from these two sites have a very similar incremental structure pattern, frequency range, and call duration.

T. Butynski and Y. de Jong heard about 100 *G. cocos* incremental calls during one night at Kaya Chijembeni. As at other sites where *C. cocos* is similarly common, there was a distinct 'dusk chorus' (*c.* 19:05–19:15h) of incremental calls, a much lower rate of incremental calls throughout the night, and a slight 'dawn chorus' (*c.* 05:45–05:55h) of incremental calls.

The only other species of galago heard at Kaya Chijembeni was *O. garnettii*. Thus, only two species of galagos were seen or heard in the Mazeras/Kaya Chijembeni/Rabai area — *G. cocos* and *O. garnettii.* Y. de Jong and T. Butynski returned to Kaya Chijembeni on 20 February 2006 to obtain better (digital) recordings of the dwarf galago (Fig. 11). Again, the only galagos heard were *G. cocos* and *O. garnettii*.

Incremental calls identical to those of topotypical *G. cocos* at Mazeras have been recorded (by A. Perkin, T. Butynski, Y. de Jong, S. Bearder, N. Cordiero, N. Svoboda, A. Kempson and S. Gregory) at several localities along the Kenya coast both north and south of Mazeras, as well as in the northern lowland coastal forests of the East Usambara Mountains in northeastern Tanzania. These calls were analyzed by A. Perkin and S. Bearder.

Visual examination of the type *G. cocos* and eight other adult specimens of *G. cocos* from Mazeras (housed at the United States National Museum, Washington, DC) reveal that they are not phenotypically different from the three specimens of *G. cocos* at the National Museums of Kenya that were collected along the Tana River (NMK 992), and on the Kenya coast at Gedi (NMK 5351) and Kipendi (no specimen number). One of the specimens at the National Museums of Kenya (MR14) was collected at Mrima Hill, Kenya, very near the border with Tanzania. This specimen has an intact penis, the morphology of which helps to identify this population as *G. cocos* (see below).

We conclude that there is now no doubt that the type of *G. cocos* that Heller (1912) described from Mazeras is conspecific with the dwarf galago found along much of the coast of Kenya and into northern Tanzania. In short, the name '*cocos*' can correctly be used as the species name of the Kenya coast galago.

This clarification of the correct name for the Kenya coast galago has at least three important implications for previous research conducted on *G. cocos*, *G. zanzibaricus*, and *G. granti*. First, most of the field research that has been conducted on the distribution, abundance, behavior, and ecology of '*G. zanzibaricus'* was, in fact, conducted on *G. cocos* (for example, Harcourt 1984, 1986; Harcourt and Nash 1986a, 1986b; Harcourt and Bearder 1989). Second, the distinctive rolling calls of galagos on mainland Tanzania that led Honess (1996) and Honess and Bearder (1996) to name this form *G. udzungwensis*, belong to *G. zanzibaricus* (i.e., *G. z. udzungwensis*). Third, those researchers who obtained data from specimens initially assigned to '*G. zanzibaricus*' have sometimes, unknowingly, combined data from two species (*G. cocos* and *G. zanzibaricus*), and, on occasion, from a third species (*G. granti*). This is especially the case for specimens collected from coastal Kenya, from coastal Tanzania south of the East Usambara Mountains, and from Unguja Island, Zanzibar. This means that (1) the results and conclusions of some previous studies of '*G. zanzibaricus*' may need to be reviewed and reevaluated, and (2) that the providence of each and every specimen labeled '*G. zanzibaricus*' must be known in order to help ensure that the specimen is not, in fact, *G. cocos* or *G. granti*.

Morphological Differences Among *G. cocos, G. zanzibaricus* and *G. granti*

Galagoides cocos, *G. zanzibaricus*, and *G. granti* are among the most cryptic of primate species. That they are similar phenotypically and morphologically is demonstrated by the inability of some of the foremost primate taxonomists of their time to differentiate among them. For example, Schwarz (1931), in reference to *G. senegalensis zanzibaricus,* states (p. 56):

> "There can be no doubt that Heller's *cocos* is identical with this race. The size, coloration, and the large upper M^3 are found both in the series at Berlin and the one of *cocos* studied by Heller and Hollister. By the identification of the two the known range of *zanzibaricus* is considerably extended. There is no difference between the island and coast specimens."

What is needed next is a detailed comparison of large numbers of *G. cocos* and *G. zanzibaricus* specimens to determine their morphological differences, coupled with ecological, behavioral, acoustic, and molecular studies. Other than the highly distinctive species-specific advertising call, one of the differences noted thus far is that *G. cocos* is slightly larger than *G. z. zanzibaricus*. For example, the mean length of the head+body for *G. cocos* from southeast Kenya and northeast Tanzania is 158 mm (n = 46, range = 142–183 mm) (Appendix I, Tables A and B), while the mean length of the head+body for *G. z. zanzibaricus* from Unguja Island, Zanzibar, is 143 mm (n = 11, range 125–150) (Appendix I, Table C). This size difference extends to body weight; *G. cocos* has a mean body weight of 144 g (n = 78, range = 117–172), whereas *G. z. zanzibaricus* has a mean body weight of 127 g (n = 10, range = 104–172).

Of the two subspecies of *G. zanzibaricus*, it appears that the island form, *G. z. zanzibaricus,* is smaller than the mainland form, *G. z. udzungwensis* (Appendix I, Tables C and D). Mean length of the head+body for *G. z. udzungwensis* is 162 mm (n = 17, range = 139–180) and mean body weight is 145 g (n = 6, range = 118–105). The data available suggest that *G. granti* is larger than *G. z. zanzibaricus*, and very similar in size to *G. z. udzungwensis* and *G. cocos* (Appendix I, Tables E, F and G).

Color of the nose stripe, chin, throat, cheeks and ventrum, length of the nose stripe, and length of the tail relative to length of the head+body, have all been proposed as useful for distinguishing among *G. cocos*, *G. z. zanzibaricus*, *G. z. udzungwensis*, and *G. granti* (for example, Elliot 1913; Nash *et al*. 1989; Honess 1996; Groves 2001). However, our studies lead us to conclude that there is (1) too much intraspecific variation and, especially, (2) too much interspecific overlap for these characters to serve as diagnostic features.

The full range of phenotypic variation present in *G. cocos*, *G. z. zanzibaricus*, *G. z. udzungwensis*, and *G. granti* remains unknown. Although they need to be examined quantitatively, and with sample sizes far larger than those currently available, the following phenotypic characters hold promise for distinguishing among *G. cocos*, *G. z. zanzibaricus*, *G. z. udzungwensis*, and *G. granti*, especially when taken together:

Muzzle patches

G. cocos – patch on either side of muzzle dark, blackish, and prominent (Figs. 1 and 2).

G. z. zanzibaricus – patch on either side of muzzle less dark, grayish, and less prominent.

G. z. udzungwensis – patch on either side of muzzle less dark, grayish, and less prominent (Figs. 3 and 4).

G. granti – patch on either side of muzzle less dark, grayish, and less prominent (Fig. 5).

Ears

G. cocos – seldom longer than 38 mm, dusky behind.

G. z. zanzibaricus – seldom longer than 35 mm, dusky behind.

G. z. udzungwensis – seldom longer than 33 mm, dusky behind.

G. granti – seldom shorter than 37 mm, blackish behind. Ears not only long but also relatively broad (Fig. 5).

Dorsum

G. cocos – hairs c.10 mm long, tipped buffy-brown (Figs. 1 and 6).

G. z. zanzibaricus – hairs c.8 mm long, tipped cinnamon or rufous-cinnamon (Fig. 7).

G. z. udzungwensis – hairs c.9 mm long, tipped buffy-brown (Figs. 6 and 7).

G. granti – hairs c.12 mm long, tipped buffy-brown with slight pinkish tint (Figs. 5 and 6).

Tail

G. cocos – even length hairs over tail; hairs dense, c.14 mm long, soft. Proximal c.25% of tail same color as dorsum (i.e., buffy-brown); distal c.33% dark buffy-brown in some (Mazeras) specimens, but same color as dorsum in other specimens (Fig. 6).

G. z. zanzibaricus – even length hairs over tail; hairs sparse, c.13 mm long, wiry, rufous-cinnamon, cinnamon, or dusky-cinnamon (highly variable). Tail darker/brighter cinnamon than dorsum, and either evenly colored or with gradual darkening to reddish or dusky toward tip (Fig. 7).

G. z. udzungwensis – even length hairs over tail; hairs sparse, c.11 mm, wiry. Proximal c.75% of tail same color as dorsum (i.e., buffy-brown); distal c.25% slightly darker brown or dusky. Some with tail tipped white (Figs. 4, 6, and 7).

G. granti – bushy, wider over distal c.80%; hairs dense, c.15 mm long, soft. Tail darker than dorsum with distal c.10 – 60% blackish-brown. Some with tail tipped white (Fig. 6).

Of these four taxa, *G. z. zanzibaricus* and *G. granti* are phenotypically the most distinctive. The dorsum of *G. z. zanzibaricus* is cinnamon and the tail has at least some rufous, whereas the dorsum of the other three taxa is buffy-brown and all lack rufous in the tail (Fig. 7). The color of the dorsum of *G. cocos, G. z. udzungwensis*, and *G. granti* is virtually identical, although there is a slight pinkish tint to the dorsum of *G. granti* when seen in good light (Fig. 6).

When observed at close range in the field, *G. granti* is distinguished from *G. cocos, G. z. zanzibaricus,* and *G. z. udzungwensis* by its relatively large, broad, round, and blackish (behind) ears, and by the very full, bottlebrush-shaped tail, which is blackish-brown over the distal part (Figs. 5 and 6).

The particularly large ears of *G. granti* have been noted previously (for example, Honess 1996; Masters and Bragg 2000).

As a species, *G. zanzibaricus* is probably best distinguished phenotypically from *G. cocos* and *G. granti* by the relatively short, wiry, stiff hairs over the tail. This hair type makes it relatively easy to see the skin of the tail through the pelage (Fig. 4). *Galagoides cocos* and *G. granti* have relatively long, soft, lax hairs over the tail.

Of the four taxa considered here, *G. cocos* and *G. z. udzungwensis* are, phenotypically, the most difficult to distinguish from one another (Fig. 6). The presence in *G. cocos* of a prominent dark, blackish patch on either side of the muzzle is probably the best phenotypic character available for distinguishing *C. cocos* and *G. z. udzungwensis* in the field (Figs. 1–4) (A. Perkin pers. obs.). As already stated, however, all of the characters listed above are in need of detailed quantitative study in order to determine their reliability, both in the field and in the museum.

The penile morphology of *G. cocos*, *G. zanzibaricus*, and *G. granti* is diagnostic (Fig. 12). For details, see Honess (1996), Honess and Bearder (1996), Anderson (2000), and Perkin (in press). See sketches in Kingdon (1997).

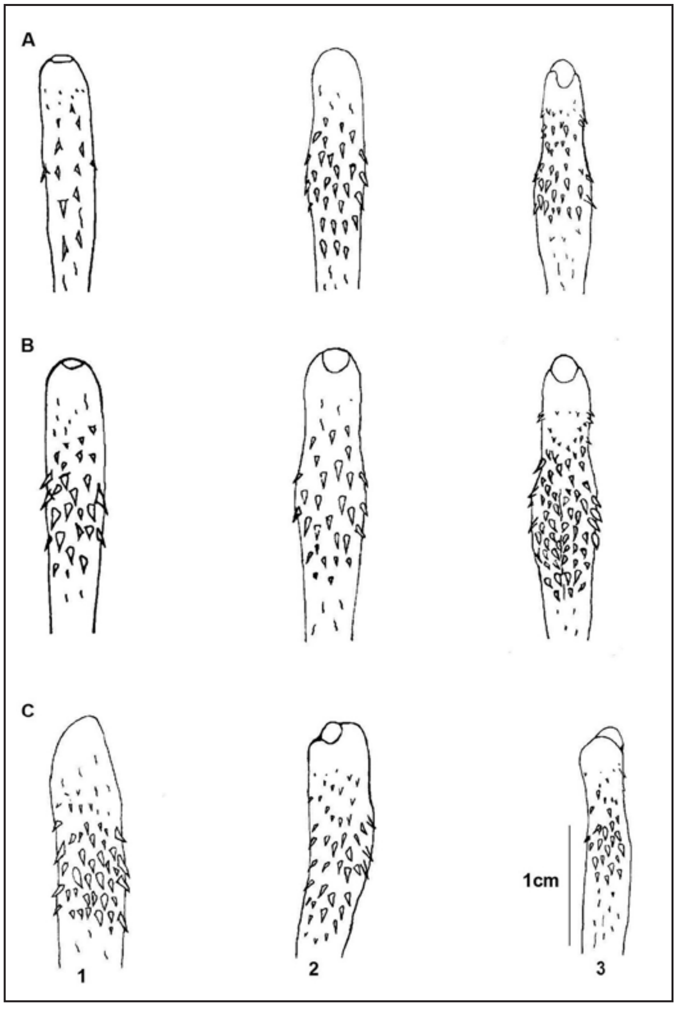

Figure 12. Schematic drawings showing the penile morphology of: 1 – *Galagoides cocos*; 2 – *Galagoides granti*; 3 – *Galagoides zanzibaricus udzungwensis*. A – ventral view; B – dorsal view; C – lateral view (dorsum right). Scale is indicated on the right. See Perkin (in press) for details. Adapted from Perkin (in press).

Vision plays an important role in the life histories of all galagos, perhaps especially for species recognition. Detailed study of the light and dark facial markings of these four taxa may reveal that they are species-specific and, therefore, a useful diagnostic tool. This is not only a priority topic for research related to the search for species-typical differences among *G. cocos*, *G. z. zanzibaricus*, *G. z. udzungwensis*, and *G. granti*, but also among the many other cryptic taxa within the Galagidae (Bearder 1999; Bearder *et al.* 2006).

The differences noted here among *G. cocos, G. zanzibaricus,* and *G. granti* in their species-specific advertising calls, body measurements, and phenotypic characters are consistent with the species-level differences observed for other species in the Galagidae (Honess 1996; Honess and Bearder 1996; Masters and Bragg 2000; Masters and Brothers 2002).

In contrast to the great similarity among *G. cocos*, *G. zanzibaricus*, and *G. granti*, these three species are readily distinguished from the other seven species of galagos with which one or all are sympatric or parapatric. These are *O. garnettii*, the thick-tailed (or large-eared) greater galago (*Otolemur crassicaudatus*), Somali lesser galago (*Galago gallarum*), northern lesser galago (*Galago senegalensis*), southern lesser galago (*Galago moholi*), mountain dwarf galago (*Galagoides orinus*), and Rondo dwarf galago (*Galagoides rondoensis*). The main morphological characters for distinguishing among *G. cocos*, *G. gallarum*, and *G. senegalensis* are summarized in Butynski and De Jong (2004).

Geographic Ranges of *G. cocos, G. zanzibaricus* and *G. granti*

Galagoides cocos occurs in evergreen forest all along the coastal strip (plain) of Kenya, south of the Tana River (Nash *et al*. 1989; Bearder *et al.* 2003; Grubb *et al*. 2003) southward to at least the Mgambo Forest Reserve in northern Tanzania at the north end of the East Usambara Mountains (A. Perkin unpubl. data) (Fig. 13). *Galagoides cocos* is reported to occur as far north as the Webi Shabeelle River in southern Somalia (Nash *et al*. 1989), but this needs confirmation.

Thomas Butynski recorded the advertising call of a galago in the Ololua Forest, Nairobi, that S. Bearder identified as that of the *G. cocos*. Ololua Forest is *c.*390 km inland from the coast of Kenya and, at 1,850 m a.s.l., well above the known altitudinal range for *G. cocos* elsewhere (0–350 m). This record for Ololua Forest requires confirmation.

Galagoides cocos and *G. z. udzungwensis* are parapatric or, perhaps, sympatric at a few sites *c.*2–8 km to the north of the East Usambara Mountains in the coastal strip of northeastern Tanzania (Figs. 13 and 14) (A. Perkin *in litt*. in Grubb *et al*. 2003). Although there is a complex mosaic of habitat types in this region, preliminary observations indicate that *G. cocos* is present in the dry mixed coastal forests and mixed woodland of the northernmost forests of Tanzania's coastal strip (for example, Bombo East I and Bombo East II For-

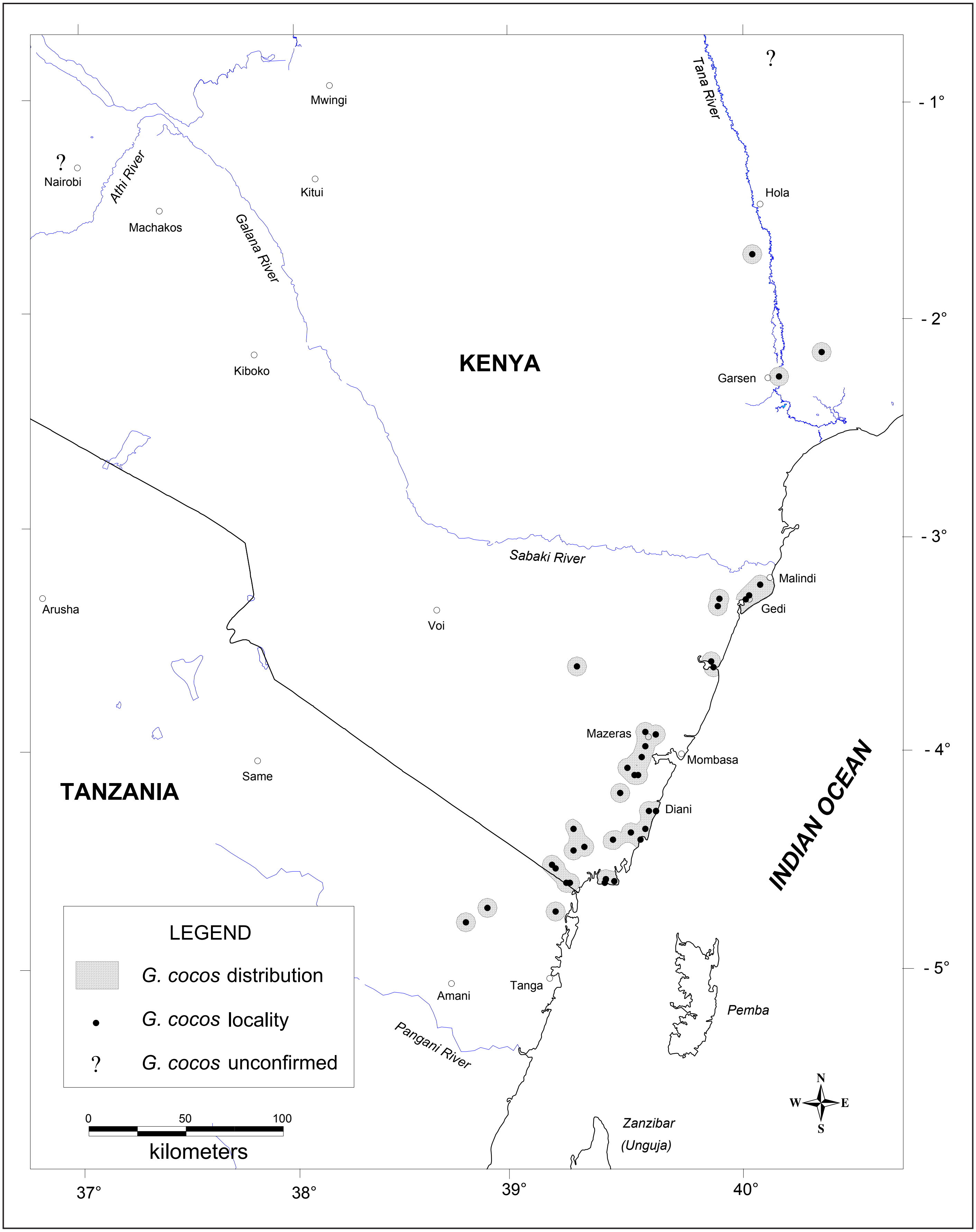

Figure 13. Approximate geographic distribution of the Kenya coast galago (*Galagoides cocos*). The shaded area extends out 5 km from the center of each locality point. The distribution of this species remains poorly known. Names of the sites plotted on this map, and the sources of these data, are available from Yvonne de Jong (e-mail: <yvonne@wildsolutions.nl>).

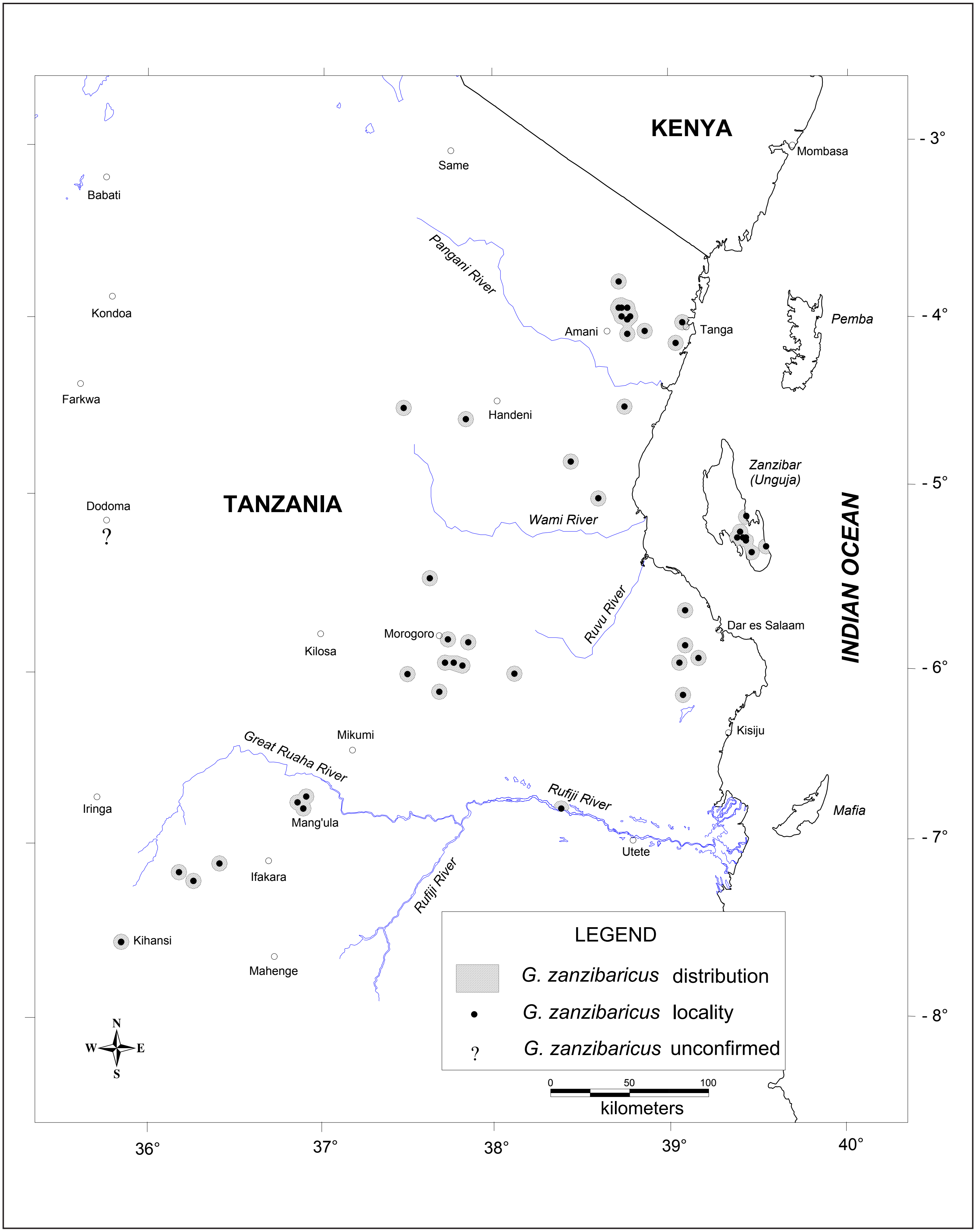

Figure 14. Approximate geographic distributions of the Zanzibar galago (*Galagoides zanzibaricus*) The shaded area extends out 5 km from the center of each locality point. The distribution of this species remains poorly known. Names of the sites plotted on this map, and the sources of these data, are available from Yvonne de Jong (e-mail: <yvonne@wildsolutions.nl>).

est Reserves), as well as in the more moist (but relatively tree-species and bird-species poor) groundwater forests and adjacent woodlands on the lower northern slopes of the East Usambara Mountains (for example, Mgambo Forest Reserve) (A. Perkin and N. Cordeiro unpubl. data). In this region, *G. z. udzungwensis* appears to be confined to the more moist (and relatively tree-species and bird-species rich) forest on the eastern slopes of the East Usambara Mountains (for example, Kambai, Segoma, Manga, and Marimba forest reserves) (A. Perkin unpubl. data).

Galagoides z. udzungwensis and *G. granti* appear to be parapatric at the Kilombero-Rufiji River with *G. z. udzungwensis* reaching its southern limit on the north (left) bank (Fig. 14) and *G. granti* reaching its northern limit on the south (right) bank (Fig. 15) (Honess 1996; A. Perkin *in litt.* in Grubb *et al.* 2003). In addition, the geographic ranges of *G. z. udzungwensis* and *G. granti* either approach one another or meet at the southern end of the Udzungwa Mountains in south-central Tanzania. Here, *G. granti* is present at 1,500 to 1,800 m a.s.l. in the Lulanda Forest Reserve at the headwaters of the Kilombero River (A. Perkin *in litt*. in Grubb *et al*. 2003; A. Perkin unpubl. data), and *G. z. udzungwensis* is present from 400 to 1,070 m a.s.l. at Kihanzi (which is *c*.24 km to the east of Lulanda) (Honess 1996; Butynski *et al*. 1998; N. Cordeiro pers. comm.). Kihanzi is the known southwestern limit for *G. z. udzungwensis*, and Lulanda is the known northwestern limit for *G. granti.*

David Moyer and E. Mulungu (pers. comm.) tape recorded the loud call of a *Galagoides* sp. at three sites in extreme western Tanzania: Mbala Forest, Sitebe-Sifuta Mountains (6º04′40″S, 30º32′10″E, 1,700 m a.s.l., 16 August 2005), Mahale Mountains National Park at Mfitwa Mountain (6º07′55″S, 29º47′38″E, 2,440 m a.s.l., 20 November 2005), and at Pasagulu Mountain (6°03′47″S, 29°45′14″E, 1,500 m a.s.l., 6 February 2006). The species recorded may have been *G. granti*. If so, this extends its geographic range *c.*700 km to the northwest (Fig. 15).

Groves (2001) identified three specimens collected in submontane forest at Bagilo (800–1,000 m a.s.l.) in the Uluguru Mountains (south of Morogoro, Fig. 15) as *G.* cf. *granti* (Grubb *et al*. 2003). If these are *G. granti*, then the Uluguru Mountains represent the northernmost site for this species, and the only known site for *G. granti* that is north of the Rufiji River. These three specimens had earlier been identified by Lawrence and Washburn (1936) as *G. senegalensis zanzibaricus*. A. Perkin has since examined them at Harvard University's Museum of Comparative Zoology (specimen numbers: 22450, 22449, 22451) and also ascribes them to *G. zanzibaricus*. In 1993, P. E. Honess and S. K. Bearder (Honess 1996) visited the forest at Bagilo but did not find *G. granti* there — only *G. orinus* was present. Unfortunately, there is no longer any forest at Bagilo (Perkin 2000; Doggart *et al*. 2004) but A. Perkin (unpubl. data) found *G. zanzibaricus* at 900 m a.s.l. on the edge of the Uluguru North Forest Reserve (*c.*2 km west of Bagilo Village) and up to 700 m a.s.l. in the Uluguru Mountains.

The known southern limit for *G. granti* is the Limpopo River in southern Mozambique. The western limit in the southern part of the range appears to be extreme eastern Zimbabwe (Smithers and Lobão Tello 1976; Smithers and Wilson 1979; Skinner and Smithers 1990).

In summary, present information indicates that *G. cocos*, *G. zanzibaricus*, and *G. granti* are parapatric, or narrowly sympatric, species of the evergreen forests of the coastal strip of eastern Africa from northern Kenya (perhaps southern Somalia) to extreme southern Mozambique and extreme eastern Zimbabwe. *Galagoides cocos* is the northern species, *G. zanzibaricus* is the central species, and *G. granti* is the southern species.

Conservation Status of *G. cocos*, *G. zanzibaricus,* and *G. granti*

Galagoides cocos, G. zanzibaricus, and *G. granti* now survive in highly fragmented, probably declining, populations as a result of the extensive (>65%) loss of eastern Africa's original coastal forest cover. More than 90% of the original coastal forest of Kenya and Tanzania has either been destroyed or degraded (Burgess *et al*. 2004). Fortunately, all three species are able to persist in secondary forest and in mosaics of mixed agriculture where some forest remains.

As a recently resurrected species (Grubb *et al*. 2003), *G. cocos* does not yet appear on the IUCN Red List. It is the most abundant and widespread galago in the coastal forests of Kenya, with densities of approximately 170–180 individuals/km² both at Gedi and Diani (Harcourt and Nash 1986a). *Galagoides cocos* is found at elevations from sea level to at least 210 m a.s.l. over the coastal zone of Kenya (T. Butynski and Y. de Jong unpubl. data), and to at least 350 m a.s.l. in the foothills of the East Usambara Mountains, Tanzania (A. Perkin unpubl. data). The information available indicates that *G. cocos*, when assessed for the IUCN Red List using the 2001 criteria (IUCN 2001), will be placed in the Least Concern category.

G. zanzibaricus is listed as Lower Risk/Near Threatened on the *2006 IUCN Red List* (IUCN 2006), but assessed only using the 1994 criteria (IUCN 1994). *G. zanzibaricus* is the most abundant and widespread galago in the coastal forests of Tanzania, including 'coastal' forest sites located at least 370 km inland (for example, Udzungwa Mountains) to *c.*1,100 m a.s.l. The density of *G. zanzibaricus* varies greatly from site to site. In the Udzungwa Mountains (for example, Matundu Forest Reserve), *G. z. udzungwensis* is estimated to occur at densities of more than 500 individuals/km² (Butynski *et al*. 1998), whereas <100 individuals/km² occur at many other sites (T. Butynski and A. Perkin pers. obs.). Although *G. z. zanzibaricus* is confined to Unguja Island, it is widespread over the eastern and southern parts of the island (Lumsden and Masters 2001), and is common in at least some places (e.g., >200 individuals/km² in Jozani–Chwaka Bay National Park (T. Butynski and Y. de Jong pers. obs). The information available indicates that *G. zanzibaricus*, when reassessed for the IUCN Red List*,* should be placed in the 'Least Concern' category.

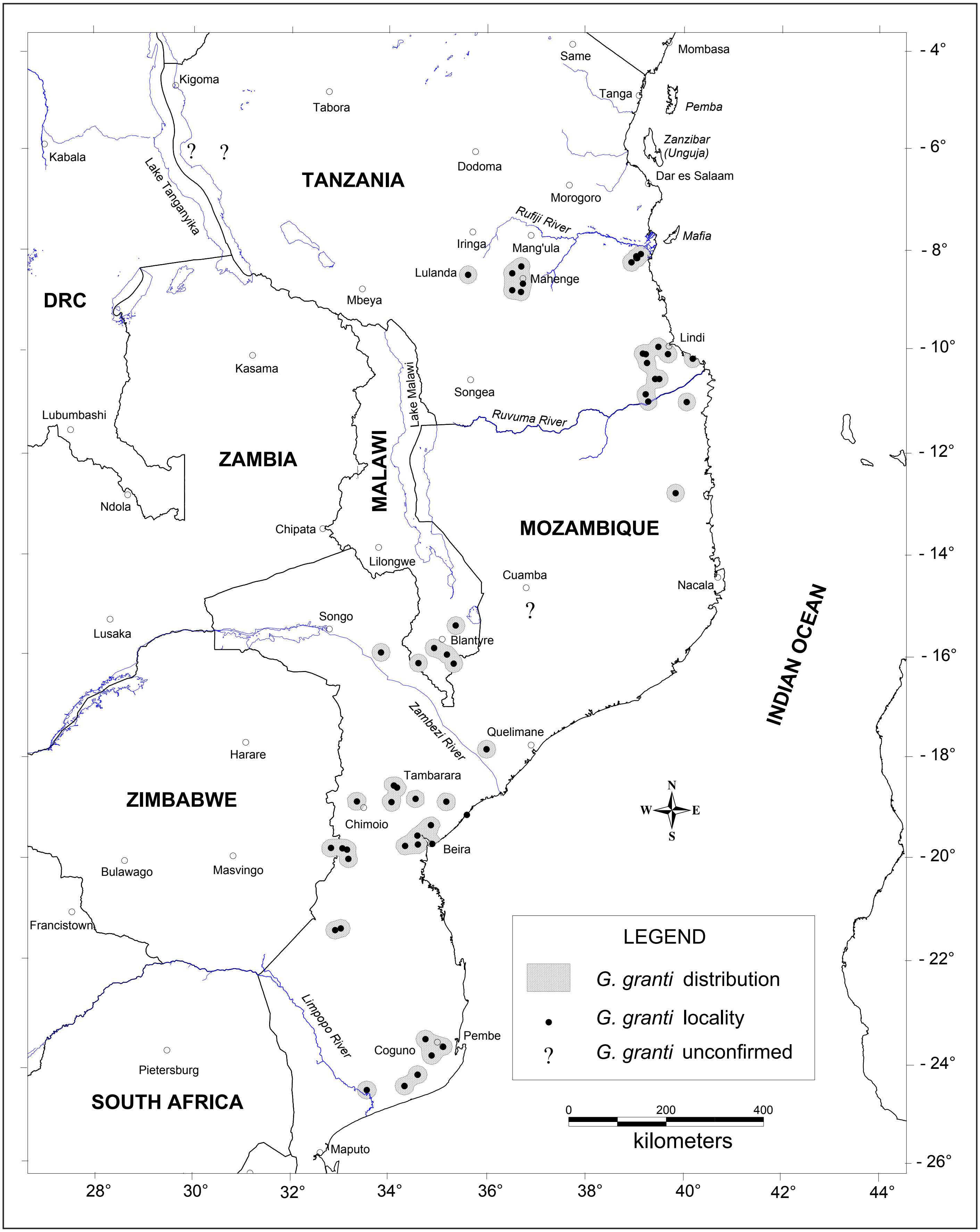

Figure 15. Approximate geographic distributions of the Mozambique galago (*Galagoides granti*). The shaded area extends out 20 km from the center of each locality point. The distribution of this species remains poorly known. Names of the sites plotted on this map, and the sources of these data, are available from Yvonne de Jong (e-mail: <yvonne@wildsolutions.nl>).

The two subspecies, *G. z. zanzibaricus* and *G. z. udzungwensis,* have not as yet been assessed for the IUCN Red List. While *G. z. udzungwensis* is a widespread subspecies that will likely be assessed as Least Concern, *G. z. zanzibaricus* has a far smaller 'extent of occurrence', being endemic to Unguja Island, Zanzibar (*c*.2,000 km²) where rates of habitat degradation, loss, and fragmentation are particularly high. As such, *G. z. zanzibaricus* is expected to be assessed as an Endangered taxon.

Galagoides granti, assessed under the 1994 criteria (IUCN 1994), is listed as Data Deficient in the *2006 IUCN Red List* (IUCN 2006). *Galagoides granti* is present in coastal and submontane evergreen forest, gallery forest, and species-rich woodlands, including some hilly miombo woodlands (e.g., Mahenge foothills). In the southern part of its range, *G. granti* is present between the coast and about 200 km inland (i.e., eastern Zimbabwe) up to 360 m a.s.l. (Smithers and Wilson 1979; Skinner and Smithers 1990). According to the specimen tags, C. H. B. Grant collected this species up to 400 m a.s.l. at Tambarara in central Mozambique. In the northern part of its range, *G. granti* occurs from the coast to at least 310 km inland (i.e., Lulanda, Tanzania) up to at least 1,800 m a.s.l. *Galagoides granti* occurs over a much greater range of habitat types, altitudes, and climates than does *G. cocos* or *G. zanzibaricus*. There is now enough information available for an IUCN Red List assessment of this species. The available data indicate that *G. granti*, once reassessed, will be placed in the Least Concern category. *Galagoides cocos, G. zanzibaricus,* and *G. granti* are all currently CITES Appendix II species (http://www.cites.org).

Acknowledgments

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Appendix I

Body measurements for adults of the Kenya coast galago (*Galagoides cocos*), the Zanzibar galago (*Galagoides zanzibaricus*), and the Mozambique (galago (*Galagoides granti*). All measurements are either known to be, or believed to be, from living or fresh adult specimens.

Table A. Measurements for eight *Galagoides cocos* collected at Mazeras, Kenya, the type locality for *G. cocos* (Hollister 1924). All measurements taken from the tags of specimens collected by E. Heller and housed at the United States National Museum (specimen numbers: 181810, 184218, 184219, 184220, 184221, 184222, 184223, and 184225). Because adult male and adult female body linear measurements for *G. cocos* are not significantly different (Harcourt and Nash 1986b), the data for males and females are combined in this sample.

Measurement	Mean	SD	Range	Sample size (n)
Head+body length	155 mm	6	145–165 mm	8
Tail length	213 mm	11	200–230 mm	8
Hindfoot length	57 mm	3	53–60 mm	7
Ear length	35 mm	2	33–38 mm	7

Table B. Measurements for live specimens of *Galagoides cocos*. These data derive from the following two sources: (1) Harcourt and Nash (1986b) for *G. cocos* at Gedi (*c*.100 km northeast of Mombasa) and Diani (30 km south of Mombasa) on the coast of Kenya; (2) A. Perkin (unpubl. data) for *G. cocos* at Arabuko-Sokoke Forest (*c*.100 km northeast of Mombasa, n = 2), Diani (n = 3), and East Usambara Mountains (*c*.150 km southwest of Mombasa (n = 1). Because adult male and adult female body linear measurements for *G. cocos* are not significantly different, the data for males and females are combined in this sample (Harcourt and Nash 1986b). Because body weights of adult male and adult (non-pregnant) female *G. cocos* are significantly different (Harcourt and Nash 1986b), the body weight data are presented separately for each sex.

Measurement	Mean	Range	Sample size (n)
Head + body length	159 mm	142–183 mm	38
Tail length	212 mm	182–230 mm	30
Hindfoot length	54 mm	40–57 mm	49
Ear length	30 mm	23–40 mm	32
Body weight (males)	150 g	135–167 g	36
Body weight (females)	138 g	117–172 g	42

Table C. Combined measurements for male and female *Galagoides zanzibaricus zanzibaricus* from Unguja Island, Zanzibar, Tanzania, the type locality for *G. zanzibaricus*. Measurements taken from one specimen captured and released by A. Perkin and from the tags of 10 specimens housed at the British Museum of Natural History. Nine of these collected by W. H. R. Lumsden (specimen numbers 1964.971, 1964.972, 1964.974, 1964.975, 1964.977, 1964.978, 1964.979, 1964.980, and 1964.981) and one obtained by an unknown collector (specimen number: 1955.331).

Measurement	Mean	SD	Range	Sample size (n)
Head+body length	143 mm	8	125–150 mm	11
Tail length	214 mm	12	198–235 mm	11
Hindfoot length	56 mm	3	51–59 mm	11
Ear length	32 mm	2	30–35 mm	11
Body weight	127 g	20	104–172 g	10

Table D. Combined measurements for male and female *Galagoides zanzibaricus udzungwensis* obtained from the following sites in Tanzania; two from Matundu Forest Reserve (Honess 1996); two from Kissarawe (housed at the British Museum of Natural History); two from Pugu Forest Reserve, three from Pande Game Reserve (A. Perkin, unpubl. data); four from Bagilo, Uluguru Mountains; and four from Amboni, near Tanga. These last eight specimens were collected by A. Loveridge and are housed at the Museum of Comparative Zoology, Harvard University.

Measurement	Mean	SD	Range	Sample size (n)
Head+body length	162 mm	11	139–180 mm	17
Tail length	222 mm	16	202–270 mm	17
Hindfoot length	58 mm	6	50–70 mm	17
Ear length	31 mm	3	25–37 mm	17
Body weight	145 g	27	118–195 g	6

Table E. Combined measurements for male and female *Galagoides granti* collected at Coguno (type locality) and Tambarara, Mozambique, by C. H. B. Grant during the Rudd Expedition. Coguno is the type locality. Measurements taken from specimen tags. All 12 specimens housed at the British Museum of Natural History (specimen numbers: 906.11.8.5, 1906.11.8.6, 1906.11.8.7, 1906.11.8.8, 1906.11.8.9, 1906.11.8.10, 1908.1.1.12, 1908.1.1.13, 1908.1.1.14, 1908.1.1.15, 1908.1.1.16, and 1908.1.1.129).

Measurement	Mean	SD	Range	Sample size (n)
Head+body length	153 mm	6	140–160 mm	12
Tail length	230 mm	6	216–237 mm	12
Hindfoot length	58 mm	3	54–63 mm	12
Ear length	38 mm	2	36–43 mm	12

Table F. Combined measurements for male and female *Galagoides granti* from eastern Zimbabwe (Smithers & Wilson 1979).

Measurement	Mean	Range	Sample size (n)
Head+body length	162 mm	Not provided	10
Tail length	232 mm	214–254 mm	10
Hindfoot length	62 mm	59–63 mm	10
Ear length	40 mm	38–41 mm	9
Weight	165 g	139–178 mm	6

Table G. Combined measurements for two male and one female *Galagoides granti* from Tanzania, two from Kichi Hills Forest Reserve, and one from Lulunda, Udzungwa Mountains (A. Perkin unpubl. data).

Measurement	Mean	SD	Range	Sample size (n)
Head+body length	164 mm	15	154–181 mm	3
Tail length	214 mm	7	208–222 mm	3
Hindfoot length	58 mm	1	58–59 mm	3
Ear length	38 mm	1	37–38 mm	2
Body weight	136 g	25	110–160 g	3

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The Recently Described Highland Mangabey, *Lophocebus kipunji* (Cercopithecoidea, Cercopithecinae): Current Knowledge and Conservation Assessment

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Abstract: The highland mangabey (*Lophocebus kipunji*), described and named in 2005, is the first monkey to be discovered in Africa since 1984. This species, endemic to Tanzania, was independently discovered by two research groups, one working in Ndundulu Forest in the Udzungwa Mountains, the other ~350 km to the southwest in the Rungwe-Livingstone Forest in the Southern Highlands. *Lophocebus kipunji* is an arboreal omnivore with a morphology and vocal repertoire distinct from other mangabeys (*Lophocebus* spp. and *Cercocebus* spp.). Although few data are available, studies of its molecular biology, ecology, behavior, and conservation status are underway. *Lophocebus kipunji* is Critically Endangered as a result of hunting and loss of habitat, which have produced small and fragmented populations. Efforts to improve the conservation status of both Ndundulu Forest and Rungwe-Livingstone Forest are ongoing, as well as augmentation of community-based conservation programs with expanded law enforcement. Research, long-term monitoring, effective law enforcement, and additional conservation projects are all essential to the long-term survival of *L. kipunji*.

Résumé: Le mangabé des montagnes (*Lophocebus kipunji*), recensé et nommé en 2005, est la première espèce de singe découverte en Afrique depuis 1983. Cette espèce endémique de la Tanzanie a été découverte par deux groupes indépendants de chercheurs, l'un travaillant dans la forêt Ndundulu des montagnes de l'Udzungwa, et l'autre à environ 350 km au sud-est de là, dans la forêt Rungwe-Livingstone située dans les montagnes méridionales. Le *L. kipunji* est un omnivore arboricole caractérisé par une morphologie et un repertoire vocal distincts de ceux des autres mangabés (*Lophocebus* spp. et *Cercocebus* spp.). Même s'il n'existe que peu de données pour l'instant, des études sont actuellement en cours concernant la biologie moléculaire, l'écologie, le comportement et l'état de conservation de cette espèce. Le *L. kipunji* est en Danger Critique d'Extinction du à la chasse et la perte d'habitat, qui ont produit des populations peu nombreuses et fragmentées. Des efforts sont en cours visant à améliorer le statut de conservation des forêts Ndundulu et Rungwe-Livingstone, ainsi qu'à augmenter les programmes communautaires de conservation et le respect des lois. La recherche, le suivi à long-terme, l'application des lois et d'avantages de projets de conservations constituent des éléments essentiels à la survie du *L. kipunji.*

Key Words: Highland mangabey, *Lophocebus kipunji*, Tanzania, conservation, Udzungwas, Southern Highlands

Introduction

Two decades spanned the interval between the discovery of the sun-tailed monkey (*Cercopithecus solatus*), in Gabon in 1984 (Harrison 1988), and the discovery in 2004 of the next new species of African monkey, the highland mangabey, in two widely separated forests of Tanzania: Ndundulu Forest in the Udzungwa Mountains, and Rungwe-Livingstone Forest in the Southern Highlands. The highland mangabey has since been described and named *Lophocebus kipunji* Ehardt, Butynski, Jones and Davenport, 2005 (in Jones *et al.* 2005), and is now the subject of research and conservation attention. *Lophocebus kipunji* (Fig. 1) joins Tanzania's other endemic mangabey, the Sanje mangabey (*Cercocebus sanjei*) (Ehardt *et al.* 2005, Ehardt and Butynski 2006), as one of the world's most threatened primates.

Davenport *et al.* (2006) reported that molecular data from a subadult male *L. kipunji* (killed by a farmer's trap while crop-raiding in Mount Rungwe, Southern Highlands) support the reclassification of this monkey as '*Rungwecebus kipunji*'. We, and several experts in primate taxonomy and molecular biology, are not in agreement with this reclassification into a new genus at present (Disotell *et al.* in prep.), and the original

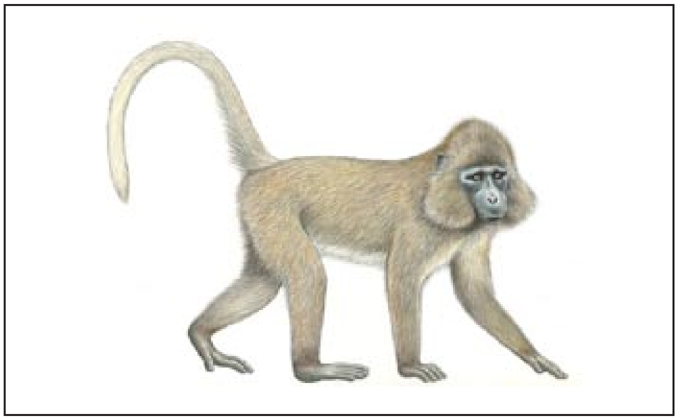

Figure 1. The highland mangabey, *Lophocebus kipunji*. Drawing by Stephen D. Nash.

taxonomic designation as *Lophocebus kipunji* is, therefore, maintained for this report.

This paper (1) reviews our current knowledge of *L. kipunji*, (2) summarizes present and planned research and conservation efforts, (3) assesses the conservation status of *L. kipunji*, and (4) presents recommendations for conservation action.

Species Description

The original description of *L. kipunji* is based on observational and photographic data (Jones *et al.* 2005). Acquisition of the dead subadult male by Davenport and colleagues in the type locality of Mount Rungwe has permitted a more detailed description of the morphology of this taxon (Davenport *et al.* 2006). The following is a composite of these descriptive data.

Lophocebus kipunji is an arboreal, medium-sized, mainly brown monkey with a black face, high crest of hair on the crown, and long tail. Muzzle is bare, elongated, and black. Maxillary suborbital fossae are pronounced. Cheek-whiskers are long, extending laterally and curving downward. Eyelids are black, eyes are brown. A very prominent, long, broad, erect crest of hair on crown; rises to a point in some individuals. Elongated shoulder pelage (cape or mantle) occurs in some adult males. Head, dorsum and limbs are medium to dark grey-brown or rufous-brown. Center of ventrum and distal half of tail are white to off-white. Forearms are dark grey-brown. Hind limbs are dark rufous-brown. Hands and feet are black. The tail is smooth, with a slight tuft at the tip in some adults. The tail is typically held up and curved backward when standing, sometimes also during locomotion; otherwise it is carried loosely and extends parallel to the body; seldom held vertical or arched forward over the back. Hairs are long and straight, without banding or speckling. There is no adult sexual dichromatism; adult males are moderately larger than females. Pink ischial callosities are fused in males, unfused in females.

No adult specimens are yet available. The length of the head plus body is estimated to be 85–90 cm in adults. Tail length of a subadult male is ~57% of total length (Davenport *et al*. 2006). Adult male body weight is estimated at 10–16 kg. Skull and scapula of subadult male examined by Davenport *et al*. (2006) have features characteristic of *Lophocebus* (Groves 1978; Fleagle and McGraw 1999, 2002).

Phenotypic differences between the two *L. kipunji* populations appear to be few. The degree of offset in color on the ventrum (white/brown) may be sharper in individuals at Ndundulu, and some Rungwe-Livingstone animals have a small, off-white patch on the upper chest.

Lophocebus kipunji is readily distinguished from the other two species of *Lophocebus* mangabeys (grey-cheeked mangabey, *L. albigena,* and black mangabey, *L. aterrimus*) (Grubb *et al.* 2003) by its coloration and by the shape of the crown pelage (Groves 2001). *Lophocebus kipunji* differs from all *Cercocebus* mangabeys in lacking the pale eyelid skin (i.e., pinkish, off-white, or flesh-colored) that contrasts with the color of the face. In addition, *L. kipunji* is arboreal, whereas all *Cercocebus* spp. are semi-terrestrial (Groves 1978, 2001; Harris and Disotell 1998; Fleagle and McGraw 1999, 2002).

Perhaps the most distinctive characteristic of *L. kipunji* is that, in contrast with all other *Lophocebus* spp., and all *Cercocebus* spp., it lacks the "whoop-gobble" loud call emitted by adult males (Waser 1982; Range and Fischer 2004). Comparison of a sonogram of a low-pitched loud-call of adult *L. kipunji*, termed the "honk-bark," with loud calls of other studied mangabey species indicates that the "honk-bark" is qualitatively and quantifiably dissimilar (Jones *et al.* 2005). According to Davenport *et al.* (2006), the call exhibits some structural congruence to the "roar-grunt" of *Papio* (Byrne 1981).

As mentioned above, the basis of the original description of *L. kipunji*, establishing its taxonomic status and name, was observational and photographic data (Jones *et al.* 2005). Subsequent to publication of the description, concern was expressed by Timm *et al.* (2005) and Landry (2005) that this procedure was not in accordance with the *International Code of Zoological Nomenclature* (ICZN 1999). Their primary concern was that, because no physical voucher specimen was available and used for the description, the name was "not available." In fact, we consulted extensively with A. Polaszek, the President of the International Commission on Zoological Nomenclature (ICZN), as well as with several eminent primate taxonomists, to ensure ICZN-compliance before publishing the description and assigning the name solely on the basis of observations and photographs. These consultations were motivated by our concern that there not be any requirement for a dead physical specimen, because our observations indicated that both populations of *L. kipunji* were very small and, therefore, highly threatened. As discussed in the published response (Polaszek *et al*. 2005) to Timm *et al*. (2005) and Landry (2005), the Code does indeed permit holotypes to be "illustrations" such as *individuals in photographs*:

"Designation of an illustration of a single specimen as a holotype is to be treated as designation of the specimen illustrated; the fact that the specimen no longer exists or cannot be traced does not of itself invalidate the designation" (4th edition, ICZN 1999; Article 73.1.4).

As such, dead specimens are *not* required. Wakeham-Dawson *et al*. (2002) fully discussed the unavailability of dead physical specimens in relation to the description and validity of assigned names.

We reiterate here the full code-compliance of such descriptions of threatened taxa, or of those for which the collection of specimens is otherwise impractical, impossible, or unethical, to reinforce the fact that description and classification of newly discovered taxa need not be delayed until voucher specimens are obtained. Description and taxonomic designation of threatened taxa are important at all levels in assisting with the prioritization and implementation of conservation actions, and with garnering support for these actions. Given that newly discovered taxa are likely to be threatened, conservation scientists need to be cognizant of allowance under the code for designation of surviving specimens as holotypes. The authors and their colleagues are currently carrying out research to supplement the current evidence related to the taxonomic status of *L. kipunji.* This involves the collection of molecular data (from feces and hair obtained through non-invasive sampling methods) and acoustic data (from recordings of species-specific vocalizations). Such data can contribute to further validation of newly described taxa, especially when no physical specimens are available.

Distribution, Abundance, and Habitat

Lophocebus kipunji occurs in two populations separated by about 350 km of largely non-forested land (Fig. 2) (Jones *et al*. 2005; Davenport *et al.* 2006). One population occurs in submontane forest from about 1,300–1,750 m a.s.l. in the southern part of Ndundulu Forest (7°39′–7°51′S, 36°27′–36°42′E; about 180 km² of closed forest) in the Udzungwa Mountains of south-central Tanzania (07º40′–08º40′S, 35º10′–36º50′E, about 10,000 km², Burgess *et al.* 1998). The other population occurs in degraded submontane and montane forest from about 1,750 m a.s.l. to at least 2,450 m a.s.l. in the Southern Highlands of southwestern Tanzania. This population occupies two forested areas: Mount Rungwe and Livingstone (designated Rungwe-Livingstone) (09º07′–09º11′S, 33º36′–33º55′E, about 562 km², including Kitulo Plateau).

Some *L. kipunji* on Mount Rungwe are living at a higher elevation (2,450 m a.s.l.) than reported for other populations of *Lophocebus* spp. The low temperature at 2,450 m a.s.l. in Rungwe-Livingstone can reach –3ºC, and rainfall can total 2,900 mm annually, the highest in Tanzania. Both Ndundulu and Rungwe-Livingstone experience distinct wet and dry seasons, with the driest months from June through October.

Only three groups of *L. kipunji* have been confirmed in Ndundulu, and these occur in an area of about 3 km². The total geographic range of *L. kipunji* at Ndundulu is unlikely to be more than 50 km². Sixteen groups of *L. kipunji* have been located in Rungwe-Livingstone (Davenport *et al*. 2006), spread over an area of about 70 km². The range in Rungwe-Livingstone is fragmented, with the two main areas connected by the narrow Bujingijila Forest Corridor, which is being degraded. The subpopulations in Livingstone are separated by as much as 20 km (Fig. 2). Neither the Ndundulu population nor the Rungwe-Livingstone population is likely to consist of more than 500 animals each. The world population of *L. kipunji* is, therefore, very likely far fewer than 1,000 individuals (Jones *et al.* 2005).

At Ndundulu, the submontane forest is pristine, with trees often reaching a height of 30 m, some over 40 m. The dominant tree is *Parinari excelsa.* Other trees (and shrubs) present include *Bersama abyssinica*, *Cassipourea gummiflua*, *Cola stelecantha*, *Craterospermum longipedunculatum*, *Dicranolepis usambarica*, *Ixora scheffleri*, *Myrianthus* sp., *Oxyanthus speciosus*, *Piper capense*, *Psychotria* sp., *Strombosia scheffleri*, *Strychnos* sp., *Tarenna pavettoides*, *Tarenna quadrangularis*, *Uvariopsis* sp., *Vitex amaniensis*, and *Zanthoxylum gilletii.*

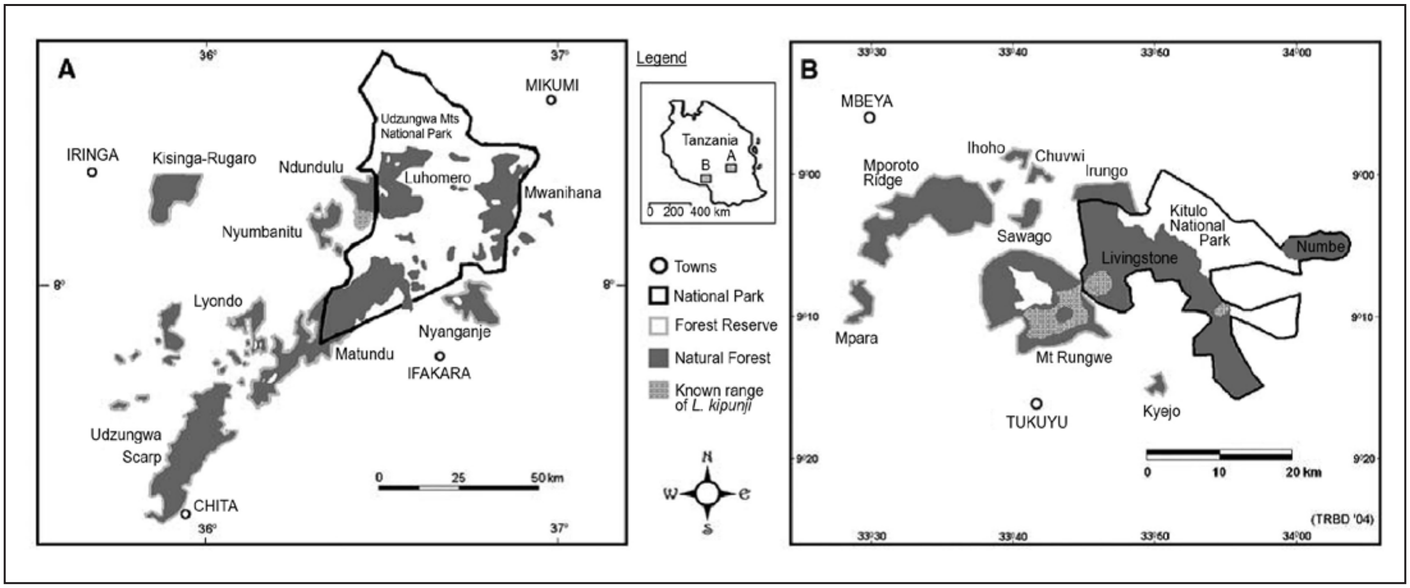

Figure 2. Maps of the known range of the highland mangabey, *Lophocebus kipunji*, in Ndundulu Forest, Udzungwa Mountains (A), and Rungwe-Livingstone Forest in the Southern Highlands, Tanzania (B). *Science* journal provided permission to reprint the maps, first published in Jones *et al.* (2005)

The submontane and montane forest habitat of *L. kipunji* in Rungwe-Livingstone is severely degraded, with significant areas of broken canopy and secondary forest, thick undergrowth, and few tall trees. Here, some of the more common trees are *Agauria salicifolia*, *Albizia gummifera*, *Aphloia theiformis*, *Bersama abyssinica*, *Chrysophyllum gorungosanum*, *Ficalhoa laurifolia*, *Ficus thonningii*, *Ilex mitis*, *Macaranga kilimandscharica*, *Maesa lanceolata*, *Myrianthus holstii*, *Myrica salicifolia*, *Neoboutonia macrocalyx*, *Nuxia congesta*, *Parinari excelsa*, *Pittosporum viridiflorum*, *Podocarpus latifolius*, *Polyscias fulva*, *Prunus africana*, *Syzygium guineense*, and *Trichocladus ellipticus* (see McKone and Walzem 1994).

Survey work to more precisely determine the distribution and abundance of *L. kipunji* is continuing both at Ndundulu (T. Jones pers. comm.) and Rungwe-Livingstone (T. Davenport pers. comm.).

The forest of the Udzungwas and the Southern Highlands are rich in endemic and threatened species of plants and animals. Within the Udzungwas, Ndundulu is especially important for the long-term survival of the Udzungwas' two endemic birds — the Udzungwa forest partridge (*Xenoperdix udzungwensis*, an Endangered species of a monospecific genus) and the rufous-winged sunbird (*Cinnyris rufipennis*), Vulnerable. At least seven other globally threatened species of birds are also present (Dinesen *et al.* 2001; Baker and Baker 2002).

Ecology and Behavior

Lophocebus kipunji is predominantly arboreal, only rarely going to the ground. It occupies mid- and upper-canopy, retreating to the high canopy and becoming still and quiet when disturbed from the ground. The highland mangabey may be substantially frugivorous in diet, eating both ripe and unripe fruit. Preliminary observations in both Ndundulu and Rungwe-Livingstone indicate that *L. kipunji* also feeds on shoots, leaves, flowers, bark, moss, lichen, and invertebrates (Jones *et al.* 2005; Davenport *et al.* 2006). In Rungwe-Livingstone, where there is significant encroachment by agriculture, the mangabeys also raid crops such as maize, beans, and sweet potatoes (Davenport *et al.* 2006).

Social structure is multimale. Group size is not well known for Ndundulu; rough counts of two groups in this forest produced estimates of 12 and 17 animals (C. Ehardt unpubl. data). Davenport *et al.* (2006) reported group sizes of 30–36 individuals (mean = 32.3, n = 3) for Rungwe-Livingstone. If the observed group size differences between the Ndundulu and Rungwe-Livingstone populations are eventually confirmed, they may be related to the effects of severe habitat degradation and loss in Rungwe-Livingstone. Results of a preliminary study indicate that the mean home range size for five groups in Rungwe-Livingstone is 54 ha (range = 24–99 ha) (Davenport *et al*. 2006).

In Ndundulu, *L. kipunji* associates with three other diurnal, arboreal monkeys: Peter's Angola colobus (*Colobus angolensis palliatus*), Moloney's white-collared monkey (*Cercopithecus mitis moloneyi*), and Udzungwa red colobus (*Procolobus gordonorum*, Vulnerable, IUCN 2006) (C. Ehardt unpubl. data). Sympatric, diurnal, arboreal monkeys in Rungwe-Livingstone include *C. a. palliatus* and *C. m. moloneyi*; *L. kipunji* forms associations with these species, including sleeping in neighboring trees (Davenport *et al.* 2006).

Lophocebus kipunji has a number of vocalizations, including the "honk-bark" loud call given by adults when they meet conspecific groups. This suggests that the "honk-bark" is functionally similar to the "whoop-gobble" of other mangabeys in facilitating group spacing (Waser 1982; Range and Fischer 2004). In Ndundulu, *L. kipunji* also emits a high-pitched, sharply abbreviated "chirp," possibly an alarm call, heard, as it is, when crowned eagles (*Stephanoatus coronatus*) call or soar above (C. Ehardt unpubl. data). The crowned eagle — Africa's 'monkey-eating eagle' — is common in the Udzungwas, being heard or seen virtually daily. Crowned eagles are probably the most significant predator of arboreal monkeys in Africa, including *L. kipunji* in the Udzungwas and the Southern Highlands. Other vocalizations include "screams" given during intragroup agonistic encounters, "chutters" given within groups when foraging, and "squeals" (C. Ehardt unpubl. data). A prolonged series of continuous, high-pitched squeals was given by an adolescent mangabey as it moved rapidly through the trees and bridged a river in pursuit of the rest of its group, which had already crossed and moved about 100 m distance onto a ridge (C. Ehardt unpubl. data).

Conservation Assessment and Recommendations

Assessment of the conservation status and the development of conservation activities are guided by full taxonomic designation, as well as by knowledge of the ecological factors impacting the viability of recognized taxa. The taxonomy and conservation status of African primates (Grubb *et al.* 2003) was reassessed during a workshop, *Primate Taxonomy for the New Millennium*, held in Orlando, Florida, in 2005. The workshop was organized by the IUCN/SSC Primate Specialist Group and sponsored by the Disney Institute. Through the workshop assessments the mangabeys emerged as one of two groups of African monkeys that are broadly and significantly threatened, as well as characterized by considerable debate about their taxonomic distinctions. With funding from the Critical Ecosystem Partnership Fund, the authors are compiling two sets of data that will contribute to further resolution of mangabey taxonomy: fecal samples are being collected for molecular analyses (phylogenetic and population, in collaboration with Todd Disotell at New York University and Jeffrey Rogers at the Southwest National Primate Research Center), and recordings of vocalization are being obtained for sonographic analyses (in collaboration with Jean-Pierre Gautier of Université de Rennes, Station Biologique). These data will be correlated with the existing morphometric data (Groves 2001; Fleagle and McGraw 1999, 2002) in an effort to bring greater resolution to mangabey taxonomy, including that of *L. kipunji*. Not only are these studies important for addressing debates about generic and species designations for the mangabeys overall, and for identifying novel patterns of genetic diversity important to conservation policy, they will also address the complex phylogenetic, phylogeographic, and theoretical issues surrounding the *Lophocebus-Papio-Theropithecus* and *Cercocebus-Mandrillus* clades.

Irrespective of its final taxonomic designation, *L. kipunji* is classified as Critically Endangered under criteria B1ab(iii) (IUCN 2006). The extent of occurrence (both populations combined) is believed to be less than 100 km² (B1); the species is fragmented (B1a) into two populations that are about 350 km apart, and one of these is further fragmented into subpopulations; and the extent and quality of habitat continues to decline (B1b(iii)), significantly so in Rungwe-Livingstone.

The most significant threat to *L. kipunji* is the destruction of its forest habitat, a process that has proceeded virtually unabated in Rungwe-Livingstone for many years. Agricultural encroachment coupled with illegal logging, charcoal production, and hunting, continue to degrade and destroy the forests of the Southern Highlands. Forest loss is also such that the narrow Bujingijila Forest Corridor that joins Mount Rungwe to Livingstone is on the verge of disappearing, and links between sites in Livingstone are also threatened. Loss of these connections will further fragment the Rungwe-Livingstone population, making it increasingly unlikely to survive over the long term (Davenport *et al.* 2006). One result of the degradation and loss of habitat is probably an increase in the rate of crop-raiding by *L. kipunji*. This will further exacerbate the threat as farmers attempt to protect their crops using traps and other means. As the habitat declines, hunting pressure will also increase, as poachers focus on the few large mammals that remain.

Mount Rungwe is designated a Forest Reserve by Tanzania, although the level of protection is not congruent with even this official status. Either the protected status of Rungwe must be elevated and enforced immediately, or other means must be found to effectively manage the Mount Rungwe Forest. The Livingstone Forest is now within the recently gazetted Kitulo National Park. The main impetus for establishing this park, however, was protection of the Kitulo Plateau, not the Livingstone Forest. It is essential for the Tanzania National Parks (TANAPA) to rapidly and effectively address the ongoing pressures in Livingstone Forest in order to prevent extirpation of *L. kipunji*. A critical component of protection should be the initiation of systematic, long-term monitoring of the Rungwe-Livingstone Forest. This must, however, be preceded, with great haste, by effective law enforcement to remove the most immediate and significant threats.

The situation in Ndundulu is not as critical as it is in Rungwe-Livingstone, although the *L. kipunji* population in this forest reserve is already extremely small. The Danish ornithologists who conducted extensive bird surveys in Ndundulu in the early 1990s (Dinesen *et al.* 1994, 2001) had only three chance sightings of *L. kipunji* over the many months they spent camping and intensively working in the forest. (Our Danish colleagues were the first to discover *L. kipunji,* in Ndundulu, although their ornithological expertise did not permit recognition that this was a new species of primate. It also was the precise locations of their sightings of what they presumed to be the Sanje mangabey, provided to us by Lars Dinesen and Thomas Lehmberg, that were directly responsible for the subsequent location and identification of the new species in Ndundulu.) Although ongoing survey work (by T. Jones and C. Ehardt) may locate additional groups beyond the three currently confirmed in Ndundulu, it is likely that the population will be found to comprise far fewer than 500 individuals, and quite possibly fewer than 100.

The habitat destruction and hunting that are seriously affecting the Rungwe-Livingstone population are not significant in Ndundulu, although Wahehe people from the village nearest to the forest (Udekwa) have hunted and used forest resources in the northern and western areas of Ndundulu. We have encountered poachers during fieldwork in other forest reserves in the Udzungwas, and even in the adjacent forest (Mt. Luhombero) within the Udzungwa Mountains National Park (UMNP). There is concern that if Ndundulu's protective status is not upgraded, the risks to the already small population of *L. kipunji* will remain, or increase. TANAPA has indicated willingness to extend the boundaries of UMNP and officially take responsibility for protecting Ndundulu. TANAPA is currently sending rangers to patrol Ndundulu, with sanction from the Division of Forestry and Beekeeping. The regional and district forestry offices are also working closely with the people in Udekwa village who now have official responsibility for community-based management of Ndundulu. Fees to enter Ndundulu for research or tourism are collected by the Village and deposited in a bank account designated for this purpose by the district forestry office in Iringa. The village chairman and committees propose how these funds might be used for community activities. These proposals are subject to approval by forestry officials.

Tanzania requires that communities responsible for management of forest resources consider and approve any change in protective status of the forests, such as incorporation into national parks that are managed and controlled by TANAPA. Although we and others working in the Udzungwas have been encouraging the Ministry of Natural Resources and Tourism to further ensure effective and long-term protection of Ndundulu's flora and fauna (including a number of endemic species) by incorporating it into UMNP, the newly expanded efforts at community-based conservation may work against this proposal. What will be required in this new context are sufficient monitoring data, vigilance, and oversight to assess the policy's efficacy and to ensure sustainability of Ndundulu's biodiversity.

Lophocebus kipunji is Critically Endangered. Its existence is threatened by continued and severe degradation and loss of its forest habitat, by habitat fragmentation, and by hunting. In efforts to reverse these threats, the research and conservation activities outlined above will continue with, we hope, the sustained support of donor organizations and that of the Tanzanian people.

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New Northwestern Range Limit of the Northern Talapoin, Mbam et Djerem National Park, Cameroon

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Abstract: Recent surveys carried out in the Mbam Djerem National Park, Cameroon, have recorded the presence of talapoin monkeys (*Miopithecus ogouensis*). This area, at about 6°N, is in the transition zone between the Central African forest block and the Guinea-Congolia/Sudania savannas. These observations, plus those from similar habitat in the Central African Republic to the east, suggest that the distribution of the northern talapoin may be much more extensive than previously thought. Its small size and choice of habitat may have precluded it from being noticed by wildlife surveys in the past, as these monkeys tend to occur in swampy areas with thick vegetation. Future survey teams are encouraged to be on the lookout for talapoins both north and south of the Equator in savanna gallery forests.

Résumé: Les recensements récents dans le parc National de Mbam et Djerem au Cameroun montraient la présence des talapoins (*Miopithecus ogouensis*). Le milieu de cette région, qui se situe vers 6°N, est la zone de transition entre le bloc de foret d'Afrique Centrale et les savanes Guinée-Congolia/Soudanienne. Ces observations, plus ceux des habitats similaires dans le République Centrafricaine, située a l'est, suggèrent que la distribution du talapoin du nord est peut-être plus étendu qu'on a cru auparavant. Il est possible que sa petite taille et sa choix du milieu l'ont cachée de l'attention des recensements dans le passé; ces singes préfèrent les zones marécageuses avec une végétation très touffue. Nous encouragent les équipes de sondage futur de chercher activement pour cette espèce, aussi bien au nord qu'au sud de l'équateur dans les forets galeries dans les savanes.

Key Words: *Miopithecus*, talapoin monkeys, biogeography, distribution, Cameroon

Introduction

Two species of talapoin monkey are currently recognized: the northern talapoin, *Miopithecus ogouensis*, north of the Congo River; and the southern talapoin, *M. talapoin*, to the south of the Congo River (Oates 1996; Kingdon 1997). They are a very small, inconspicuous, strictly riparian species. Their preferred habitat is inundated forest, but they also occur in dense riparian vegetation throughout woodland and areas dominated by agriculture (Gautier-Hion 1973; Kingdon 1997). The distribution of the northern talapoin is centered on the riparian forests of Gabon (Fig. 1) but they also occur in Cameroon, Equatorial Guinea, Republic of Congo, and Cabinda, an exclave of Angola. The known east-west limits of the major block of its distribution are from about 8°36′ (the Atlantic Ocean coast) to 16°E, and its north-south distribution from about 4°10′ N (in Cameroon) to 5°40′ S (in Cabinda) (IEA 1998; Kingdon 1997; Lernould 1988) (Fig. 1). Records from Blancou (1958) and Tello (A. Gautier pers. comm.) also suggest that they occur almost to 8°N along riparian forests in the savannas, along the Ouaka River in the Central African Republic. This is 600 km east and 400 km north of the edge of the main distribution block (Fig. 1). Stephen Gartlan (in Wolfheim 1983) suggested that they occurred north of the Sanaga River, but this has yet to be confirmed.

Observations

A new national park, Mbam et Djerem, was created in 2000 in central Cameroon. This park, of about 5,000 km², lies on the Guinea-Congolia/Sudania regional transition zone (White 1983) between the main forest block and the Guinean savannas to the north. Its southern and northern limits are about 5°30'N to 6°12'N, respectively (Fig. 1). The Djerem River, in fact the upper reaches of the Sanaga, runs north-south through this park, and is lined by a broad band of riparian forest. The southeastern part of the park is lowland, tropical, semideciduous forest; the northwestern part is wooded and

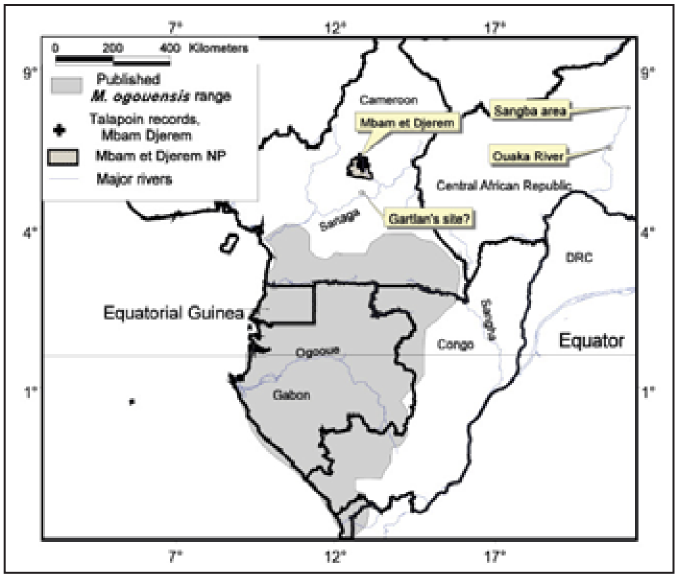

Figure 1. Range of *Miopithecus ogouensis*, after Kingdon (1997) and IEA (1988), the two areas in Central African Republic cited by Tello (A. Gautier pers. comm.), Blancou (1958), and S. Gartlan (in Wolfheim 1983), and the recent records from Mbam et Djerem National Park, Cameroon.

bush savannah with gallery forests lining the watercourses. The transition between the forest and the savannah has a relatively high biodiversity because of the interlacing of the two main habitats. The forest has been slowly creeping north since the 1950s (evidenced by the old maps of the region and present conditions, which show the contrast between savannah in the past and young colonizing woodland today).

A series of wildlife and vegetation surveys were carried out in the park between 2000–2005 (detailed in Maisels 2005). At the end of 2005, a comprehensive program was set up to cover the entire protected area with a series of survey lines, crossing all habitats throughout the park. This was to be the baseline for monitoring ecological parameters and human impacts in the park.

Talapoin monkeys were recorded along the Djerem River at about 6°N during one of the pilot surveys in 2003, and again, twice, during a comprehensive survey in 2005–2006. They were seen in gallery forests of the Djerem and a tributary in the northern third of the park. We also asked local hunters about the monkey species present in the area, and all described a very tiny monkey that lives in large groups next to water; the local name in Gbaya is *dikiti* and in Vouté it is *djane*.

Discussion

The observations detailed here confirm the most north-westerly limit of the distribution of northern talapoin recorded to date. The records are 200 km north of the distribution cited in Kingdon (1997) and IEA (1998), and 100 km north of the area suggested as a possible locality by S. Gartlan in Wolfheim (1983). It has probably been overlooked during wildlife surveys due to its small size (0.8–1.9 kg; Kingdon 1997), its preference for swampy or inundated areas that are difficult to reach, and its habit of keeping to the thickest, most lianescent vegetation. Although talapoins call when disturbed (Gautier-Hion 1988), the vocalizations are bird-like (refer to Gautier-Hion *et al.* 1999 for recordings) and possibly difficult to identify by survey teams unfamiliar with the species.

We recommend that the wildlife survey staff in Cameroon and Central African Republic working in areas up to 8°N and about 21°E bear in mind that this species could be present in suitable habitats, and look for it during fieldwork and question local hunters about it. Faunal survey teams working in the possible area of occurrence of the southern species, *M. talapoin*, should also be aware of its possible presence in gallery forest mosaic habitats. All records should be georeferenced in order to improve our understanding of these species' use of habitat and their geographical distribution.

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A Note on the Distribution of Allen's Swamp Monkey, *Allenopithecus nigroviridis*, in Northwestern Congo

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Abstract: Allen's swamp monkey, *Allenopithecus nigroviridis*, is confined to the swamp and riparian forests of the Central African region. It occurs along the Congo River and its tributaries. Recent data show that it occupies suitable habitat at least 100 km to the northwest of its previously known distribution, in an area to the west of the Nouabalé-Ndoki National Park, in the northern Republic of Congo. The apparent absence of the swamp monkey from most of the interior of the Nouabalé-Ndoki National Park itself suggests that the species probably reached northwest Congo along the Sangha and Ndoki Rivers, rather than by dispersing across the watersheds from the Oubangui. Hunters find the species easy to shoot from canoes at night, as these monkeys like to sleep in overhanging vegetation beside the rivers. More details on its distribution in the region and of its conservation status are required.

Résumé: Le singe des marais, *Allenopithecus nigroviridis*, est une espèce inféodée aux marécages et aux forêts ripicoles de la région d'Afrique Centrale. Ils se trouvent le long du fleuve Congo et ses tributaires. Les observations récentes montrent qu'il occupe l'habitat convenable au moins 100 km au nord-ouest de sa distribution auparavant connue, dans une zone à l'ouest du Parc National de Nouabalé-Ndoki, dans le nord du République de Congo. L'absence apparente du singe de marais du Parc National de Nouabalé-Ndoki lui-même suggère que l'espèce a probablement arrivée dans la région par les fleuves Sangha et Ndoki, plutôt que à travers les interfleuves de l'Oubangui. Les riverains du fleuve Congo trouvent cette espèce facile à chasser en pirogue, la nuit, parce que ces singes dorment dans la végétation aux bords des fleuves. Plus des détailles sur sa distribution dans la région et de son statut de conservation sont nécessaire.

Key Words: *Allenopithecus*, Allen's swamp monkey, biogeography, distribution, conservation, Congo

Introduction

The distribution of Allen's swamp monkey, *Allenopithecus nigroviridis*, is centered on the lowland forests of the central Congolian basin. The known limits of its east-west distribution are from about 16°E to about 26º–27°E, and its north-south distribution from about 3°N to 6°30′S (Gautier 1985; Colyn 1988; Lernould 1988; Kingdon 1997, IEA 1998) (Fig. 1). The known distribution includes an area to the northwest of the Congo River, which comprises the lower courses of the Oubangui, Likouala-aux-Herbes, and Sangha rivers (Fig. 1). These watercourses are typically bordered by wide bands of swamp and riparian forest, the habitat favored by this monkey (Gautier 1985; Colyn 1987, 1988; Lee *et al.* 1988; Lernould 1988; McGraw 1994; Kingdon 1997).

In the 1990s, rumors of the occurrence of Allen's swamp monkey on the upper Sangha River came to the attention of the personnel of a Wildlife Conservation Society project (the Nouabalé-Ndoki Project) based in the Nouabalé-Ndoki National Park, Republic of Congo (Fig. 1). This area is at least 100 km to the northwest of the previously known distribution of the species. This paper provides details of the sightings of this species in the area, besides some information on its local conservation status.

Observations

The village of Bomassa, on the Sangha River, lies 20 km to the east of the Ndoki River, and is outside the Nouabalé-Ndoki National Park. Makao is about 40 km to the east of the Park, and more than 120 km from Bomassa. No traditional villages exist along the Ndoki nor above Makao on the Motaba, and there is little or no communication or exchange of local people between the two areas because they are separated by completely uninhabited forest lacking any roads.

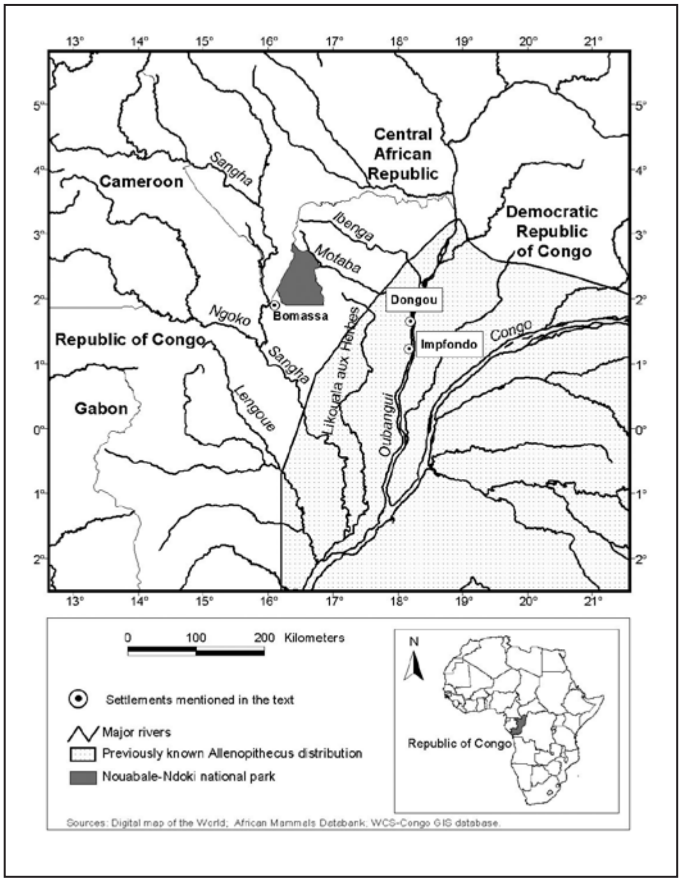

Figure 1. Previously known northwestern limits of the distribution of *Allenopithecus nigroviridis,* plus the new sighting locations mentioned in the text. The major rivers of the region, and the settlements of Bomassa, Boha, Makao, Dongou, Impfondo are shown.

Allen's swamp monkeys were seen on two islands in the Sangha River near the village of Bomassa (Fig. 1), the headquarters of the Nouabalé-Ndoki National Park. The islands where Allen's swamp monkey has been observed are small — about 0.5 km² and 0.08 km², respectively. Both islands are near to the banks of the Sangha River: 120 m from the west bank and about 70 m from the east bank, respectively. There are no connections to the mainland either via the canopy or dry season land bridges. The monkeys must therefore swim between the islands and the mainland. They are known for their ability to escape from predators by plunging into water and swimming away (Rowe 1996; Gautier-Hion *et al*. 1999). De Brazza's monkeys (*Cercopithecus neglectus*) and moustached monkeys (*Cercopithecus cephus*) are also natural inhabitants of the islands — they have never been introduced by humans.

The species has also been seen on the Ndoki River, a tributary of the Sangha River, just inside the western limit of the Nouabalé-Ndoki National Park, due east of Bomassa at 1º13′N, 16º31′E (Fig. 1). Finally, they were seen on the Mbeli River, a tributary of the Ndoki River (Fig. 1). The Ndoki flows south and joins the Sangha about 80 km to the south of the sightings on the Ndoki and the Mbeli (Fig. 1). Group size on the islands appeared to be at least 15 individuals; the sightings on the Ndoki and Mbeli involved several individuals; minimum counts were about 10.

We were informed that Allen's swamp monkey did not occur in the vicinity of Makao, the village closest to the Nouabalé-Ndoki National Park, on the upper Motaba (Fig. 1). However, hunters in Bomassa could correctly imitate the call of the adult male swamp monkey, and described them and their behavior to one of the authors (FM) who was already familiar with the species from work in the Salonga National Park, Democratic Republic of Congo (Gautier-Hion and Maisels 1994). Behaviors mentioned by hunters in Bomassa were, specifically, descriptions of their semiterrestrial habits, feeding on "worms" by raking through leaf litter; and the habit of large groups sleeping on branches overhanging rivers. Hunters described males as being much larger than females. Valentin Yako is familiar with the species from observations near the villages of Dongou, on the Oubangui River in eastern Congo (Fig. 1), and Boha, just north of Lac Tele, confirming that the species occurs on the Likouaa-aux-Herbes, and the lower Motaba and Ibenga, as suggested by the IEA (1998) (Fig. 1). The local name for the species, *Simbi*, is consistent throughout northern Congo, from the Oubangui across to Bomassa, 200 km to the west.

Over the course of the last 10 years, at least 4,000 km of ecological foot surveys have been carried out throughout the area, including the Nouabalé-Ndoki National Park and its buffer zones, by two of the authors (SB and MF) (see Fig. 1 for the extent of these surveys). About 30% of the areas covered were in close proximity to swamp and riparian habitats. The surveys were designed to provide relative abundance data on all large mammal species, including monkeys. No evidence of Allen's swamp monkey was recorded during these surveys, either on the west or on the east, apart from on Bomassa Island.

Discussion

The observations detailed here confirm the most northwesterly limit of the distribution of Allen's swamp monkey recorded to date. The apparent absence of the swamp monkey from the central sectors of Nouabalé-Ndoki National Park itself suggests that the species probably reached northwest Congo along the Sangha and the Ndoki, rather than by dispersing across the watersheds from the Oubangui.

Allen's swamp monkey is listed in Annex II of CITES (Inskipp and Gillett 2005) and ranked as Lower Risk, Near Threatened on the IUCN Red List (IUCN 2006). Although it apparently has a wide geographic distribution, it occurs only near water bodies. About a third of the area within its range is considered to be ecologically unsuitable (as defined as >1 km from permanent water; IEA 1998). Due to its relatively small size (3.6 – 6.2 kg; Kingdon 1997), and apparent local scarcity, Allen's swamp monkey appears not to be an important target for hunters on the upper Sangha. In addition, work by the Nouabalé-Ndoki Conservation Project has resulted in fairly well respected agreements by local people that they do not export meat outside the village, but use it only for their own consumption (Ruggiero 1998). These monkeys, therefore, are in general not regularly hunted and the conservation status of Allen's swamp monkey appears stable at least in the immediate vicinity of Bomassa. The swamplands of the Likouala-aux-Herbes and the Congo rivers, on the other hand, are regularly, and in some areas intensively, hunted for the bushmeat trade (Blake 1993, pers. obs.; B. Djoni pers. comm.), which may present a serious problem for this species. Extensive ecological surveys and hunting studies are required on the major watercourses of northern Republic of Congo, southwestern Central African Republic, and southeastern Cameroon, before any firm conclusions on distribution, population sizes, and conservation status can be drawn for this population.

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Chimpanzees in the Ntakata and Kakungu Areas, Tanzania

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Abstract: Surveys were carried out for chimpanzees, *Pan troglodytes schweinfurthii*, in the areas of Ntakata (300 km² between the Mkamba River and the Lubalisi River, 05°45′–06°15′ S, 30°00′–30°15′ E), and Kakungu (200 km² between the Lubalisi River and the sources of the Rubufu River, 05°55′–06°15′ S, 30°00′–30°15′ E), Tanzania, during the dry seasons of 2001 and 2003. The predominant vegetation was savanna woodland with forest patches (mainly along watercourses and hillsides). Population information was obtained by sightings and sleeping-nest counts. In the Ntakata area, chimpanzees occur in Ntakata, Mlofwezi, Kapalagulu (05°52′ S, 30°02′ E), and Mpulumuka (5°58′ S, 30°11′ E) and in the Ntakata-Kapalagulu Hills (Fig. 1). No evidence was forthcoming for their existence in Ikubulu, Lunfampa, Kakundu, Kabufisa, and Kamafiga, nor the plains of north of Kapalagulu Hill and the entire Lugufu basin. In the Kakungu area, they occur at Kakungu itself (05°58′ S, 30°03′ E) and Kalobwa in the Kakungu-Kalobwa Hills. With evidently large home ranges, densities were found to be low in the 500-km² area between the Ntakata-Kapalagulu Hills and Kakungu-Kalobwa Hills — everywhere less than 0.05(0.048) individuals/km². Hunting (by immigrant farmers and refugees), besides habitat loss (logging, firewood, and clearing for agriculture) are believed be causing a steady decline of chimpanzee populations in the region.

Key Words: Chimpanzee, *Pan troglodytes schweinfurthii*, habitat, Kalobwa (Karobwa) area, Ntakata Forest, population density, distribution

Introduction

Chimpanzees (*Pan troglodytes*) are distributed in tropical rain forests and more open and dry savanna woodland areas in Africa (Kortlandt 1983; Teleki 1989). In savanna woodland areas they typically occur in low population densities and have large home ranges (Kano 1972; Moore 1992), when compared to chimpanzees in more forested areas (see, for example, Hashimoto 1995). It is important to study chimpanzees in these different habitats in order to (1) understand the variety and flexibility of chimpanzee adaptation, (2) facilitate and support their management and conservation in these contrasting environments, and (3) clarify models of early hominid behavioral ecology (Suzuki 1969; Kano 1972; Itani 1979; McGrew *et al*. 1981; Baldwin *et al.* 1982; Moore 1992).

The distribution of eastern chimpanzees (*Pan troglodytes schweinfurthii*) in western Tanzania was documented by Kano between 1965–1967 (Kano 1972). Since then, a number of surveys have been conducted outside of Mahale and Gombe National Parks, Tanzania (Itani 1979; Nishida 1989; Massawe 1992; Ogawa *et al*. 1997; Nakamura and Fukuda 1999). Zamma and colleagues surveyed the chimpanzee population in Ntakata (Ntakatta) and Kakungu later, in 2003 (Zamma *et al*. 2004), and here we report on the results of our surveys in the same areas in 2001 and 2003.

Methods

Study sites

Kano (1972) referred to one area of the chimpanzee's range in western Tanzania as 'the Karobwa area' — 900 km² surrounded by the Mkamba River in the north (05°51′ S), sources of the Rubufu River in the south (06°10′ S), Mt. Kakungu in the west (29°55′ E), and Mt. Ipumba in the east (30°31′ E). Here, we call the northwestern part of the Karobwa area 'the Ntakata area' — 300 km² between the Mkamba River and the Lubalisi River (05°45′–06°15′ S, 30°00′–30°15′ E) — and the southwestern part 'the Kakungu area' — 200 km² between the Lubalisi River and the sources of the Rubufu River (05°55′–06°15′ S, 30°00′–30°15′ E) (Fig. 1).

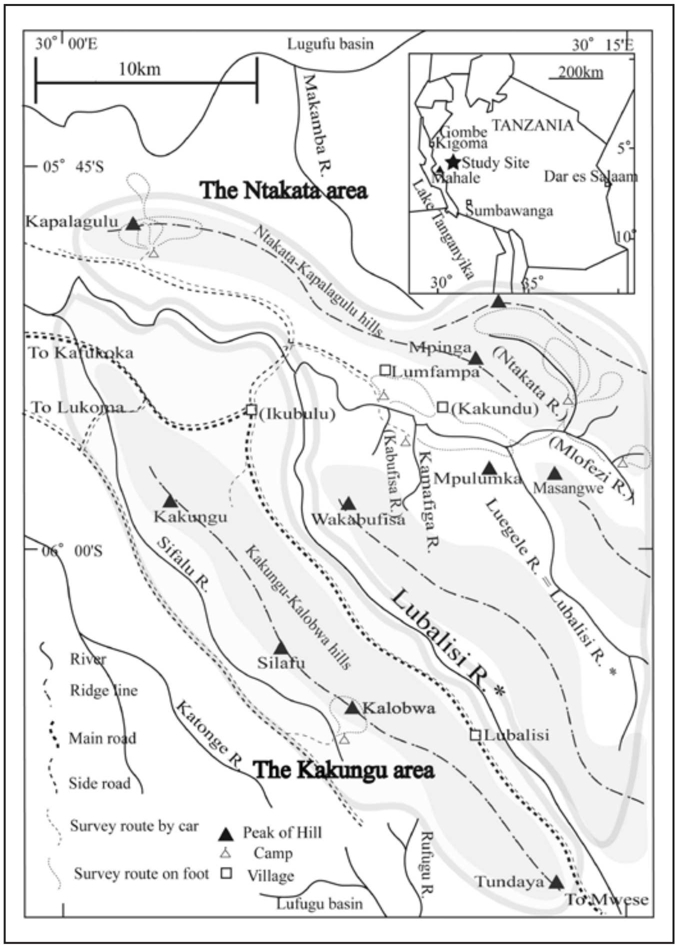

Figure 1. The Ntakata and Kakungu areas. Place names are taken from Series Y742 1:50,000 topographic maps of the region. Local names not shown on the topographic maps are shown in parenthesis. *Both of the tributaries are the Lubalisi Rivers on the topographic maps. In the text of this paper, the south tributary is referred to as the Lubalisi River, because the north tributary is locally called the Luegele River.

The dry season in the region extends from May to October, and the rainy season from November to April. There are a number of vegetation types in the two areas: savanna woodland, forest, bamboo thickets, open grassland, and cultivated fields.

Savanna woodland is comprised of deciduous ‘miombo’ trees scattered over Graminae-dominated grassland. Based on Ogawa’s two 2 km × 4 m line transect vegetation surveys from the ridge of Kapalagulu Hill southward to the plains below (August, 2003), 99.96% of the area was savanna woodland and the rest (0.04%) forest. In the 16,000 m^2 of the vegetation survey, there were 890 trees of >5cm in diameter at breast height (DBH) of 55 species. The total basal area, $\pi(\mathrm{DBH}/2)^2$, was 16.5 m^2 (0.10% of the area). The basal areas of the dominant trees were: 3.8 m^2 (23.2% of the total basal area) for *Brachystegia bussei*, 2.4 m^2 (14.6%) for *Isoberlinia angolensis*, 1.5 m^2 (9.0%) for *Pericopsis angolensis*, 1.1 m^2 (6.4%) for *Brachystegia manga*, and 0.9 m^2 (5.6%) for *Brachystegia boehmii*.

Forests were patchily distributed along streams. One of the largest such patches in the area was Ntakata Forest, 18 km^2 at 5°55′ S, 30°12′ E in the Ntakata River valley. No systematic vegetation survey was made, but Ntakata Forest was dominated by *Garcinia huillens*, *Albizia glaberrhima*, *Chionanthus africana*, *Julbernardia unijugata*, *Teclea* sp. and mizingati (local name in ki-Bende language). There were also evergreen forests on the of hill plateaus.

Bamboo of the genus (*Oxytenanthera*) occurred in scattered thickets on the plains and hillsides, and some areas along valley bottoms were open *grassland*. There were also places on the hillsides covered by grasses and only scattered trees.

Study periods and study methods

We carried out ecological surveys during the dry seasons of 2001 and 2003. Moore and Kamenya visited the Ntakata area from 17 to 22 July 2001 in conjunction with a film project. Ogawa carried out another survey in the Ntakata and the Kakungu areas from 11 to 31 August 2003. Ogawa recorded the perpendicular distance between a chimpanzee nest and the path, as well as the age of the nests. Population density of chimpanzees over three to four years old was estimated by the assumption that all nests within 35 m of each side of the walking routes were found, and that a nest would disappear in 260 days (as was found in the Ugalla area, Tanzania; Ogawa unpubl. data). Both teams recorded the number of nests in each nest cluster to estimate the size of a sleeping party. A nest cluster we defined as one or more nests, which appeared to have been made on the same day, were located within a circle of 50 m diameter and each of which was not more than 20 m from its neighboring nest.

Results

Sightings

Ogawa saw chimpanzees four times and heard calls on 14 occasions during the 21-day stay in the two areas (Table 1). He heard chimpanzees every day during the six days of his stay at Ntakata Forest (05°55′ S, 30°12′ E). On 16 August 2003, he saw chimpanzees walking on the slope in the savanna woodland close to the Ntakata River. There were two adult males, four adult females (one in estrus and one with a dependant infant on its back), and a juvenile. On 21 August, Ogawa saw an adult male with two adult females at the upper edge of a forest in the valley of the Mlofwezi River (05°58′ S, 30°14′ E). On 25 August, Ogawa’s local assistants saw four adult males (some possibly subadult), and two estrus females at Kalobwa Hill (06°03′ S, 30°08′ E). The average party size of the three groups was 5.3 (7+3+6) individuals over three to four years old. Moore and Kamenya also heard chimpanzees daily at Ntakata, including a meeting of at least three parties, totaling more than 10 calling individuals.

Nest trees and clusters

Ogawa recorded 154 chimpanzee nests in all. The mean size of the nest clusters was 2.52 (n = 61; range, 1–15) and the mean size of the clusters in which all leaves of the nests were

Table 1. Primates and large mammals said to inhabit the Ntakata and Kakungu areas by the local wa-Bende people.

		Evidence of presence[1]	Times encountered[2]
Proboscidea			
Loxodonta africana	Elephant	FE, P	
Tubulidentata			
Orycteropus afer	Aardvark	NE, P	
Artiodactyla			
Hippopotamus amphibius	Hippopatamus	P	
Potamochoerus aethiopicus	Warthog	P	
Potamochoerus porcus	Bushpig	P	
Syncerus caffer	Black buffalo	SF, FE, P	
Kobus defassa	Waterbuck	DE, P	2
Hippotragus equinus	Roan antelope	P	
Hippotragus niger	Sable antelope	P	
Alcelaphus lichtensteini	Lichtenstein hartbeest	P[3]	2
Tragelaphus scriptus	Bushbuck	DE, SF, P	
Tragelaphus spekei	Sitatunga	P[2]	
Oreotragus oreotragus	Klipspringer	SF, P	
Sylvicapra grimmia	Common duiker	P4	
Acepyceros melampus	Impala	P	
Giraffa camelopardalis	Giraffe	P	
Carnivora			
Panthera pardus	Leopard	P	
Crocuta crocuta	Spotted hyaena	P5	
Primates			
Galago senegalensis	Northern esser galago	P	
Otolemur crassicaudatus	Thick-tailed greater galago	P	
Cercopithecus aethiops pygerthrus	Vervet	P	
Cercopithecus mitis	Blue or Sykes's monkey	P	
Cercopithecus ascanius	Black-cheeked red-tailed monkey	DE, P	6
Papio cynocephalus	Yellow baboon	DE, P	3
Procolobus oustaleti	Oustalet's red colobus	DE, P	13
Pan troglodytes schweinfurthii	Eastern chimpanzee	DE, NE, P	4

[1] DE = direct encounter, SF = skeleton and/or fur, FE = feces, NE = nest, P = positive information by local people.

[2]Times encountered: The number shows the number of direct encounters during the 21 days, from 11 to 13 August 2003. The times we heard only their vocalizations were not included. 1: [3]Lichtenstein hartebeests inhabit only Lugufu basin only.

[4]Sitatungas might be confused with bushbucks. 3: Common duikers occur only downstream of this area.

[5]Spotted hyenas at very low density.

still green was 2.0 (n = 7; range, 1–5). The average height of the nests above the ground was 13.9 m (n = 136; range, 4–30), and the average height of the nest trees was 19.0 m (n = 136; range, 4–35). Chimpanzees made 36 (23.4%) nests in *Brachystegia bussei*, 30 (19.5%) in *Combretum molle*, 8 (5.2%) in *Pericopsis angolensis*, 7 (4.5%) in *Maesa lanceolata*, and 5 (3.2%) in *Brachystegia boehmii*. Moore and Kamenya recorded 28 nests, 18 of which were in one cluster two to three months old in 8–12 m tall 'miombo' trees.

Population density

The density of chimpanzees over three to four years old was estimated at 0.03 individuals/km^2 in the Ntakata area, based on 87 nests along 144.9 km that we walked. We recorded all nests along 99.7 km in the Ntakata-Kapalagulu Hills, which provided a density estimate there of 0.05 individuals/km^2. The density in Kakungu-Kalobwa Hills of the Kakungu area was 0.02 individuals/km^2, based on six nests along 13.5 km. Only two nests were found during a 25.3 km drive from Lukoma to the foot of Kalobwa Hill, in the southwest of the Kakungu-Kalobwa Hills. This yielded an estimate of <0.01(0.004) individuals/km^2. We believe that this not an underestimate due to the fact that we were driving in a car rather than walking because 13 nests were found on the slope of Kakungu Hill over a distance of 20.0 km. Excluding the Lufubu and Lugufu basins from the core area of chimpanzee habitat, therefore, the density in the 500 km^2 area between the Ntakata-Kapalagulu Hills and Kakungu-Kalobwa Hills was approximately 0.03(0.032) individuals/km^2 based on 93 nests along 158.4 km.

Distribution

In the Ntakata area, we found evidence of chimpanzees at Ntakata, Mlofwezi, Kapalagulu (05°52′ S, 30°02′ E), and Mpulumuka (5°58′ S, 30°11′ E) in the Ntakata-Kapalagulu Hills (Fig. 1). We failed to find any evidence of chimpanzees at Ikubulu, Lunfampa, Kakundu, Kabufisa, and Kamafiga (Fig. 1), and no trace of them in the plains of north of Kapalagulu Hill. Local people informed us that chimpanzees do not inhabit the Lugufu basin (Fig. 1).

In the Kakungu area, Ogawa found evidence of chimpanzees at Kakungu (05°58′ S, 30°03′ E) and Kalobwa in the Kakungu-Kalobwa Hills (Fig. 1). Little evidence was found in the plains southwest of these hills, where there were only bamboo thickets, cultivated fields, and savanna woodlands in which trees were no more than 15 m in height. Local people told us that chimpanzees inhabit Mt. Ipumba (05°59′ S, 30°28′ E), but neither team was able to visit the region.

Human activity

Some of the region's farmers immigrated into this area through the rural colonization program (*ujamaa vijijini*) of the Tanzania government in the 1960–70's. Since then, an increasing number of immigrant farmers have been cultivating fields in the low-lying areas as a result the agricultural reform policies and economic liberalization of the 1980's. Trees are cut down for commercial timber, for firewood, and to clear land for agriculture. There has been mineral prospecting in the area since at least 2001. While mining itself currently has minimal impact on wildlife, the potential threat is clearly great if the resulting development fails to consider conservation needs.

The wa-Benbe people in Congo have moved to this area (even though the shore of Lake Tanganyika was patrolled to prevent invasion) and there are Burundi refugees at the Mishamo settlement, who hunt, using snares — more than 20 snares were counted along a 200 m path in Ntakata Forest. Most traps are aimed at bushbuck (*Tragelaphus scriptus*) and the common duiker (*Sylvicapra grimmia*), and some are also set for buffalos (*Syncerus caffer*) and leopards (*Panthera pardus*). Moore and Kamenya did not encounter snares, but found the remains of a young elephant that had been butchered just outside Ntakata Forest in 2001. Ogawa was told that chimpanzees were hunted on the northeast slope of Kakungu-Kolobwa Hills in 2003.

Discussion

We encountered chimpanzees frequently between Ntakata and Mlofwezi. They evidently foraged in the forested areas around the Ntakata River and other streams. Because we heard vocalizations from four different directions at a time, and the mean party size was 5.3 chimpanzees, and because the size of the largest nest cluster was 18, at least one group (community) was evidently made up of more than 20 individuals. If our density estimate is correct (0.05 individuals/km²), their home range should be about 400 km². If this unit group occupied the entire area between the Lubalisi River and Ntakata-Kapalagulu Hills, the range would almost certainly exceed 30 km along a northwest-southeast axis. In addition, if all chimpanzees in the three parties observed from 16 to 25 August belonged to the same unit group, their home range would be more than 400 km² and including both the Ntakata and Kakungu areas. However, the six chimpanzees observed on 25 August in the Kakungu-Kalobwa Hills might belong to another group. Because the traffic on the Mpanda-Mwese-Lukoma Road was heavy in the dry season, it may well have been a barrier between the Ntakata area and the Kakungu area, although the Lubalisi River and the Luegele River were neither wide nor deep in the dry season.

Like chimpanzees in other savanna woodland areas, those in this area had a large home range and low population density, compared to those in tropical rain forests (Kano, 1972; Moore 1992; Hashimoto 1995). The low population density might be due to sparse and widely distributed foods, but may also result from recent human activities in this area. Kano (1972) estimated that 8–9 unit groups inhabited the 900 km² of the Karobwa area in 1960's: 320–360 chimpanzees, indicating a density of 0.38 individuals/km² (assuming the average size of one unit group was 40 individuals as in Kasakati, Tanzania). The density of 0.03 individuals/km² estimated in this study is much lower, although our survey did not include Mt. Ipumba. However, because the census methods were different, they are not directly comparable, and the frequent encounters at Ntakata may indicate that chimpanzees are in fact more abundant. Further studies, especially in the rainy season, are needed to document and understand the ecology of chimpanzees in this area and to confirm whether densities in this area have decreased since the 1960's.

The chimpanzees in this area formed small sleeping parties, perhaps because the risk of predation is low. The chimpanzees encountered at Kalobwa did not flee from Ogawa's local assistants, but instead threatened them. This naive attitude to humans may expose themselves to the danger of poaching. More patrols and management of the Burundi refugee camp at Mishamo are needed to protect the chimpanzees and other wild animals in this area. Besides the depredation of poaching, the habitats and the overall number of chimpanzees have, under any circumstances, been reduced through deforestation for cultivation and logging. Proper land-use planning is needed to conserve the remaining chimpanzee habitat in the Ntakata and Kakungu areas of Tanzania.

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Gibbon (Hylobatidae) Species Identification Recommended for Rescue or Breeding Centers

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Abstract: Gibbons, Family Hylobatidae Gray, 1870, are small, arboreal apes of the tropical and semi-deciduous forests of southeast Asia and parts of south and east Asia. Four genera and about 14 species are currently recognized; a number of them threatened with extinction. Two of the reasons for breeding gibbons in captivity are to retain species and subspecies diversity and to create a viable gene pool, with the ultimate goal of releasing animals into protected native habitat. Accurate taxonomic identification may be complicated for *some* gibbon species due to (1) variation in coat color, (2) sexual dichromatism, and (3) the occurrence of coat color changes from infancy through sexual maturity, and for *all* species because of (4) the impacts of such as malnutrition and housing on coloration (for example, their maintenance indoors only or in full sunlight), (5) the ease with which the vocalizations of the different species can be confused, (6) the difficulties in distinguishing some gibbon subspecies from each other, and (7) errors in, or the lack of, information concerning the origin of confiscated gibbons. Given these problems, it is not surprising that rescue and breeding centers encounter difficulties in identifying the gibbons they receive. I review the characteristics and identifying features of the species and subspecies of gibbons, including information from museum specimens, live gibbons housed at the Gibbon Conservation Center, Santa Clarita, California, and a number of zoos worldwide.

Key Words: Primates, gibbons, Hylobatidae, conservation breeding, taxonomy

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Introduction

Gibbons, Family Hylobatidae Gray, 1870, are small, arboreal apes, inhabiting the tropical and semideciduous forests of southeast Asia, and a small section of south and east Asia. They occur in northeast India and eastern Bangladesh through south China, Laos, Vietnam, Cambodia, Thailand, the Malay Peninsula, Sumatra, to Java and Borneo. Many of the species go through pelage color changes. These may be during infancy and before adulthood, from infancy through subadulthood, or from infancy through adulthood. There are also certain color variations in some of the wider-ranging gibbon species or subspecies that can be identified by their geographic distribution. Pelage color changes in gibbons may also be attributed to environmental factors such as malnutrition, pregnancy, age, nursing, staining from urine or sweat glands in light pelage (Fig. 1) or bleaching of hair in dark pelage, and housing (for example, indoors only or in full sunlight). Inexperienced taxonomists may have difficulties distinguishing different gibbon species through their vocalizations, which are nevertheless distinct and consistent. Gibbon taxonomy at the subspecific level has been difficult and controversial to comprehend. Some taxonomists use different names to describe the same coloration or species. In some cases, English names used to describe a color might not translate into another language. Many taxonomic studies of the number and names of gibbon genera, species, and subspecies have been conducted over the years (Elliot 1913; Fooden 1969; Groves 1972, 2001; Marshall and Sugardjito 1986; Geissmann 1995; Roos and Geissmann 2001; Brandon-Jones *et al.* 2004; Mootnick and Groves 2005). Current taxonomies indicate that there may be 12–14 gibbon species (Groves 2001; Brandon-Jones *et al.* 2004), four genera (see Mootnick and Groves 2005) and 25 or more species and subspecies.

There are a number of issues and, in some cases, complications with regard to our understanding of gibbon variation and taxonomy. The formal descriptions of many of the gibbons are based on museum specimens. Some species or subspecies hybridize in their native habitat in areas where they overlap in distribution, generally at the headwaters of the rivers that divide them (Groves 1967; Marshall and Brockelman 1986; Marshall and Sugardjito 1986; Geissmann *et al.* 2000). In some cases, the pelage color of museum specimens can be faded from exposure to sunlight and treatments with certain preservatives (Downing 1945). Incorrect labeling is also a factor which confuses our attempts to understand the geographic basis of their taxonomy. A few museum specimens were listed as adults, but the pelage and dentition revealed that they were subadults in a color transition. Some published taxonomic descriptions have been incomplete or ambiguous. A few manuscripts that provided the coordinates for localities where gibbons occur were in error by 1 or 2 degrees on a few localities. Confiscated live gibbons can provide a plethora of information, including an understanding of their occurrence in parts of their geographical range where they are now locally extinct. In many cases the information on their origin, however, is lacking, incomplete or incorrect.

Given these variables, it is not surprising that rescue and breeding centers may encounter difficulties in the species identification of gibbons. Besides this, genetic, vocalization, behavioral, or skeletal analysis may be beyond the capabilities for some facilities to use as a means of species identification. It is extremely important not to hybridize species or subspecies through captive breeding programs if the progeny of those gibbons will possibly be released into an area where gibbons coexist. Thus, before releasing gibbons back into a secure habitat it is important to confirm what subspecies already exists in those areas. It is of the utmost importance, therefore, to be able to determine what species or subspecies of gibbon is housed in all facilities before they are placed in any type of conservation or reintroduction program.

Methods

This study was based on observations of gibbons housed at the Gibbon Conservation Center (GCC) between 1976–2006, some gibbons in zoos or rescue centers in Asia and the USA, and skins at the following museums: American Museum of Natural History, New York (AMNH); British Museum (Natural History), London (BMNH); Field Museum of Natural History, Chicago (FMNH); Institute of Ecology and Biological Resources, Hanoi (IEBR); Harvard Museum of Comparative Zoology, Cambridge (MCZ); Muséum national d'Histoire Naturelle, Paris (MNHN); Museum Zoologicum Borgoriense, Bogor (MZB); National Museum of Natural History, Washington, DC (USNM); Zoological Museum, Vietnam National University, Hanoi (ZMVNU); Zoological Reference Collection, National University of Singapore, Singapore (ZRC). Additional criteria for determining taxonomic status followed Groves (1972, 2001), Marshall and Sugardjito (1986), and Geissmann (1995). Specimens examined are listed in Appendix I. Vocalizations of live specimens were compared to Marshall *et al.* (1972, 1984), Marshall and Marshall (1978), Marshall (1981) and Marshall and Sugardjito (1986).

Genus *Symphalangus* Gloger, 1841

Symphalangus syndactylus (Raffles, 1821) Siamang

Siamangs are the largest of the gibbons. They are stocky and black, with a large inflatable throat sac (Fig. 2), long hair on their upper body, and a broad chest (Fig. 3). The female's skull is intermediate in size between male siamangs and other gibbons (Hooijer 1952). The crown hair lies flat and swirls laterally above the brow. The second and third toes are webbed (Schultz 1933) up to the second phalanx (Raffles 1821). The extent of the webbing is individually variable but typically goes as far as the proximal interphalangeal joint (Fig. 4), although in some individuals it may reach as far as the distal interphalangeal joint (Fig. 5). A few instances of webbing can be found between the proximal phalanges of the fourth and fifth toes (A. Mootnick and L. Theisen-Watt pers. obs.) (Figs. 5 and 6), and in one individual (GCC Rumi) this was observed on only one foot. Males have a very long genital tuft (Groves 1972), up to 135 mm long (Marshall and Sugardjito 1986) directed downwards. Immatures are the same color as the parents and also have a visible throat sac. As they mature they may obtain creamy hair around the chin and brow (Geissmann 2003). In one adult male siamang, the pelage had a silverish golden streak running down both sides of the abdomen and along the front of the thighs (GCC Montgomery). No distinguishing features have been reported between the two subspecies in C-banding, G-banding or silver staining of their chromosomes (vanTuinen and Ledbetter 1983). Siamangs are placed in their own genus *Symphalangus* by Groves (2005) and Mootnick and Groves (2005), which is characterized by a diploid chromosome number of 50 (Klinger 1963). The single species has two subspecies, but there are few visual features that reliably distinguish them.

Symphalangus syndactylus syndactylus (Raffles, 1821) Sumatran siamang

Mountains and swamp forests of Sumatra

Symphalangus s. syndactylus appears to have a larger cranium, tooth row, and body than the mainland subspecies (Groves 1972). A shallow medial sagittal groove reaches nearly into the tip of the nose. The nose, although of course variable, has a long tapering point over the nostrils (A. Mootnick prelim. obs.) (Figs. 7 and 8).

Symphalangus syndactylus continentis Thomas, 1908 Malayan siamang

Northwest and central Malay Peninsula

The upper portion of the nose appears slightly bulbous, with an abbreviated midsagittal groove. The rounded internarial septum is separated dorsally by a slight constriction, and with a central latero-lateral depression, with a wide connection to the area above the lip. The lower half of the nose has a gradual tapering of the outer sides above the nostrils, with an increased tapering closer to the tip, giving the nose a slightly wider appearance on the lower portion than is observed in *Symphalangus s. syndactylus* (A. Mootnick prelim. obs.) (Fig. 9).

Genus *Nomascus* Miller, 1933

Crested gibbons are characterized by shorter dense hair compared to other gibbon genera. Adult males and immatures of both sexes have blackish pelage. Adult females are buff to gold to gray-tan. Adult females have a black crown patch or streak of various sizes and may have a faint white face ring. Depending on the humidity levels, female *Nomascus* can obtain a more orangey hair color resulting from their water soluble sweat (Fig. 10). The crown hair of adult males and immatures of both sexes stands erect and longer in some species, with the hair being longer in the center of the crown. The nose is long and slender (Groves 1972) with a groove running lengthwise down the center. Females have an elongated clitoris and males have a long baculum (Groves 1984). External genitalia of the two sexes appear similar which has caused confusion in identifying the sex when females are in their immature black pelage. Infants are pale at birth (Fig. 11), but begin their gradual change to a black phase at approximately six months of age, starting at the fingers, toes, and face ring (Fig. 12). The color change to black may be completed as early as 1.5 years of age (Fig. 13). The scrotal sac is easily observed at birth, through all stages of development, and throughout adulthood. Females change back to the light color phase near the age of sexual maturity, but males remain black (Pocock 1905; Delacour 1951; Deputte and Lecierc-Cassan 1981; Liu *et al*. 1989; Couturier and Lernould 1991). With the exception of *Nomascus gabriellae* (buff-cheeked gibbon), males have a small throat sac. Pelage description of each black-crested gibbon species and subspecies was based only on the examination of a few museum specimens and photographs or video of live specimens, either in captivity or their native habitat. This genus is characterized by a diploid chromosome number of 52 (Wurster and Benirschke 1969).

In the past, 52-chromosome gibbons were referred to as *concolor* gibbons or as belonging to the *concolor* group (Groves 1972; Marshall and Sugardjito 1986; Geissmann 1995). With the elevation of some subspecies to species in *Nomascus* (Geissmann 1995; Groves 2001) and the elevation of four subgenera to full genera (Mootnick and Groves 2005), I suggest that reference to *Nomascus* as the *concolor* group is confusing, because *concolor* refers to just one species in the genus. Common names such as crested gibbons or crested gibbon group would take in both the black crested gibbons and the light-cheeked gibbons and be more appropriate.

Nomascus concolor concolor (Harlan, 1826) Tonkin black-crested gibbon
Northern Vietnam, between the Black and Red rivers, central Yunnan

Adult males, immature males and females have blackish hair. They have long body hair for *Nomascus*, and a few white hairs at the corner of the mouth (Fig. 14) (MCZ 38114–16). The hair of the adult females can range from buffish to a light tawny; they have a black-brown or black crown streak (Ma *et al*. 1988; Geissmann 1989). They have dark hair on the ventrum, that forms an inverted triangle (Geissmann 1995) (Fig. 15) and a small white patch of hair above the mouth and below the eyes. Adult females can also have black on the first digits, and chin, with a few black hairs on the genitals, pelvis, and legs, and around the ears. Individuals I have observed had a creamy-buff throat. Groves (2001, 2005) listed four subspecies of *N. concolor*. Besides the nominate subspecies and *lu* (see below), he included two forms from China, *N. c. furvogaster* (Menglai, Cangyan, Yunnan) and *N. c. jingdongensis* (Wenbu, Jingdong, central Yunnan) described by Ma and Wang (1986) but not dealt with in this review.

Nomascus concolor lu (Delacour, 1951) Laotian black-crested gibbon
Northwestern Laos

Delacour (1951), with the help of J. Greenway and F. Edmond-Blanc, collected six specimens of *N. concolor lu* on 7 January 1939, at Ban Nam Khueng, northwestern Laos (20°23′N, 100°15′E; coordinates from Jenkins 1990). The exact collection date of the adult male holotype BMNH ZD1952.142 and an adult female paratype BMNH ZD1952.143 is confused in that the date on the specimen labels is 17, not 7, January 1939 (P. D. Jenkins pers. comm.). I am assuming that the error is with the specimen labels, since Delacour (1951) described all of the six specimens as being collected on 7 January 1939, which included the holotype.

Delacour (1951) provided the following description of two adult females. One female (MCZ 46288) has a black crown, with the overall pelage a vivid tawny ("fauve assez vif"), but strongly mixed with black hairs on the chest and abdomen. The second female, the paratype BMNH ZD1952.143, he described as having a black crown, with the overall pelage being a vivid tawny, but mixed with black hairs, perhaps due to a color transition (Delacour 1951).

There is some controversy concerning the description of *Nomascus concolor lu*, and even whether it still exists in its native habitat. During 2004–2006, however, I received correspondence from J.-F. Reumaux stating that 11 families of *N. concolor lu* had been located in the Bokeo Nature Reserve, northwestern Laos. There were also credible reports of a further seven families there. The existence of *N. concolor lu* in this reserve was confirmed through DNA extracted from feces (C. Roos pers. comm.), as well as by tape recordings, video footage, and photographs (Figs. 16 and 17). A video of a pair and infant in the reserve (Figs. 18 and 19) showed that they were very similar to two adult specimens at the MCZ (Figs. 20 and 21) that Delacour, Greenway, and Edmond-Blanc had collected on (I presume) 7 January 1939 at Ban Nam Khueng.

From my inspection of the adult female MCZ 46288, it is tawny-buff with a small black crown (Fig. 22), similar to that of the adult female with an infant in the video that was taken at the Bokeo Nature Reserve (Fig. 23). The upper chest is buff with a few black hairs, gradually darkening, with a black grizzling on the lower chest, abdomen, and genital region (Fig. 21), again similar to the adult female of the Bokeo Nature Reserve (Fig. 19). There is a brownish orange color in the center of the chest of MCZ 46288, possibly from her sternal gland (Fig. 21). There are a few black hairs on the fingers and toes. The chin is black (Fig. 21), with a few black hairs on the throat and above the ears. The face ring is slightly lighter than the surrounding hair. There are no long guard hairs. The female BMNH ZD1952.143 is much grayer in color than the female at the MCZ (P. D. Jenkins pers. comm.).

Delacour's adult male MCZ 46289 is entirely black, with no white hairs at the corners of the mouth. It has short black body hair, mixed with longer black guard hairs. This contrasts with *N. c. concolor* males (MCZ 3811416) which have longer hair than *N. concolor lu* (MCZ 46289). The adult male co-type MNHN CG 1952-543 that Delacour collected on 7 January 1939 is also entirely black (C. Callou pers. comm.). Delacour's descriptions differ in that MCZ 46289 and MNHN CG 1952-543 are entirely black. Delacour indicated that all the males have at least a trace of gray on the cheeks.

With only a few museum specimens to examine, Groves (1972), Dao Van Tien (1983), and Marshall and Sugardjito (1986) described *N. concolor lu* as black, with a trace of silver along the side of the head. The adult male holotype BMNH ZD1952.142 has a trace of gray (or buff) on the cheeks and a small trace of gray on either side of the crown (P. D. Jenkins pers. comm.). The skin of a juvenile female USNM 296921 was collected by R. Elbel on 26 February 1953 at Khao Tham Phra. It had numerous incisions across the face (to remove the skull), which made it difficult to interpret. Rearrangement of the facial skin, however, showed that the juvenile, in black pelage, has a moderate amount of blackish hairs mixed throughout a narrow whitish-gray cheek patch, giving it an overall grizzled appearance. The narrow cheek patch begins below the ear, but not touching the ear, and ends above the chin, but not touching the lip. There are a few grayish white hairs throughout the pelage, including a few whitish hairs under the lip, and a few buff hairs in the genital region.

A topotype, AMNH 148262 labeled male, collected on 7 January 1939 at Ban Nam Khueng, is somewhat similar to the juvenile female USNM 296921. It has, however, a slight trace of a silver streak by the temples, and less silver hair on the facial cheeks. The genital area is blackish, with slight grayish grizzling on the rump. Although labeled as a male, AMNH 148262 has a very short pubertal tuft. As an adult male, the tuft should be longer, and the scrotal sack should be visible. An X-ray of the skull of this gibbon showed that the canines and lower third molars had not yet erupted (Fig. 24), and it is similar in this respect to a 4.9 yr old female *Nomascus* (GCC Parker). The nipples of AMNH 148262 are small, which is typical of immature male and female *Nomascus* (GCC Dexter and Parker). Geissmann (1989) also concluded that AMNH 148262 was a subadult female in the early stages of her color transition.

Delacour (1951) wrote that the *N. concolor lu* holotype (BMNH ZD1952.142) male was overall black with a gray stripe over the eye to the ear. Delacour (1951) described three other males (MCZ 46289, MNHN CG 1952-543, and AMNH 148262) as having a slightly different appearance. Two of the

Delacour's (1951, p.121) description of *Hylobates concolor lu.*

"3. Hylobates concolor lu subsp.nov.
Mâle noir, avec une bande allant de l'oeil à l' oreille, et un peu au delà, d'un noir mélangé de gris argenté; fourrure longue, épaisse et grossière.

Type mâle adulte au British Museum of Natural History, collecté à Ban Nam-Khueng, Province du Haut Mékong, Laos, le 7 Janvier 1939, par J. Delacour, J. Greenway et F. Edmond-Blanc. Longueur totale: 520 mm.; oreille: 35 mm.; pied: 152 mm. Trois autres mâles et deux femelles adultes ont été obtenus au même endroit et à la même date.

Nommé d'après la tribu des *Lu* qui habite la région de Nam-Khueng. Les trois autres mâles diffèrent quelque peu; deux sont presque entièrement noirs, avec seulement des traces de gris aux joues et aux reins; le troisième a du gris à la face, comme le type, et aussi aux joues, au menton, aux épaules, aux cuisses et au bas du dos. Les deux femelles sont d'un fauve assez vif, avec la couronne noire; l' une a le fauve de la poitrine et du ventre fortement mélangé de noir; l'autre a tout le pelage mélangé de noir, ce qui n'est peut-être qu'une livrée de transition.

Distribution: L'extrême ouest du Laos, le long du Mékong, près des frontières du Siam et des Etats Shans. Il est curieux qu'une forme de *H. concolor* sans joues blanches, et extrêmement voisine de *H. c. nasutus*, ait été trouvée aussi loin de cette dernière, dont elle est séparée par le domaine très étendu de la sous-espèce à joues blanches, *H. c. leucogenys*."

English translation of Delacour (1951), page 121.

3. Hylobates concolor lu new subspecies
Male black, with a stripe going from the eye to the ear, and a little beyond it, of a black mixed with silver gray; long, thick and robust hair.

Type adult male in the British Museum of Natural History, collected in Ban Nam-Khueng, Province of Haut Mekong, Laos, on 7 January 1939, by J. Delacour, J. Greenway and F. Edmond-Blanc. Total length: 520 mm.; ear: 35 mm.; foot: 152 mm. Three other males and two adult females were obtained in the same area and on the same date.

Named after the Lu tribe that inhabits the region of Nam-Khueng. The three other males are a little different; two of them are almost entirely black with only some traces of gray at the cheeks and in the [area of] the kidneys; the third one has gray on his face, like the type, and also at the cheeks, the chin, the shoulders, the thigh and at the base of his back. The two females are a fairly vivid tawny color, with a black crown; one has the tawny color on the chest and the belly strongly mixed with black; the entire pelage of the the other is completely mixed with black, which may only be a transition coat.

Distribution: The extreme west of Laos, along the Mekong, close to the frontier with Siam and the Shans States. It is curious that such a form of *H. concolor* without white cheeks, and extremely similar to *H. c. nasutus*, can be found far away from the latter, from which it is separated by the large range of the subspecies with white cheeks, *H. c. leucogenys*.

three male *N. concolor lu* that he collected were in a black color phase, had a trace of gray on the cheeks, and a trace of gray on the loins. The third male (AMNH 148262 which appears to be a female) had a similar pattern of gray on the face as the holotype, but also a trace of gray on the cheeks, chin, and shoulders, upper thigh, and lumbar area (Delacour 1951). A somewhat similar description was given by Hill (1970) of an imported black juvenile gibbon (SDZ 024368) housed at the San Diego Zoo. It had large, white cheek-patches and white eye-patches. By 1971, the white eye-patches had faded into black (M. Jones pers. comm.). This, in some cases, is the final stage of the first color transition in *Nomascus* (Fig. 25). Hill's (1970) description was that of *N. l. leucogenys* (northern white-cheeked gibbon). Since *N. l. leucogenys* and *N. concolor lu* are found in bordering areas in northern Laos, some of the *N. concolor lu* museum specimens could be hybrids. Specimens may also be immatures undergoing color transitions, and even misidentified in their sex. DNA analysis is necessary to confirm their identity.

Nomascus nasutus nasutus (Kunkel d'Herculais, 1884) Cao Vit black-crested gibbon
Northestern Vietnam, east of the Red River

Adult males, immature males and females have blackish hair with slightly brownish hair on the chest, extending sometimes from the throat to the abdomen (Figs. 26 and 27). It is difficult to interpret from the numerous photographs in Fischer (1965; see Fig. 26), whether "Patzi" had lighter-colored chest hair when in black pelage, or if her chest hair was sparse on pale skin. Adult females are buffish to buffish gray in color, which can be mixed with few longer blackish hairs. They have a long, wide, black crown streak that can extend past the nape, to the brow, tapering to a thin face ring, and becoming thicker at the chin (Fig. 28). The rectal hair is brownish. There are some black hairs above the ear. The vocalizations of an adult female (Patzi) in the Tierpark Berlin were similar to those of *N. n. nasutus*, but her pelage differed in that she had a very long, broad, black crown streak that went past the nape, and extended to the brow, tapering to a thin face ring and becoming thicker at the chin (Geissmann *et al*. 2000; Mootnick *et al.* 2006). This female had a narrow, blackish-brown chest plate slightly wider than the face, beginning at the throat and tapering at the top of the abdomen (Fig. 29).

Nomascus nasutus hainanus (Thomas, 1892) Hainan black-crested gibbon
Hainan Island, China

Adult males have short black hair, and the crown hair is not as obvious as in other species of *Nomascus* (Fig. 30) (Pocock 1905; Groves 1972; Ma *et al*. 1988; Geissmann *et al*. 2000). Adult females have a black crown patch, brownish buff body hair, no black hairs on the limbs (Ma *et al*. 1988), and a small white patch of hair above the mouth and below the eyes (Fig. 31). Adult females have a thin, white face ring that is thicker above the mouth and below the orbital ridge (Mootnick *et al*. 2006). Comparison of the DNA of *N. nasutus hainanus* and *N. n. nasutus* may result in these two subspecies being elevated to species. Groves (2005) lists *hainanus* as a distinct species, and *nasutus* as a subspecies of *N. concolor*.

Nomascus leucogenys leucogenys (Ogilby, 1840) Northern white-cheeked gibbon
Southern Yunnan, northern Laos, and northwestern Vietnam

The cheek patches of the adult male and immature connect under a black chin and can extend up to the top of the ear (Fig. 32). Adult females range in color from dark to light buff to creamy orange often diffused with tan, gray, or black hairs. They have a white face ring, and a small to medium-length black crown patch (Figs. 11, 12, and 32). Adult females can have reddish brown to brown-black hair in the genital region; black hairs on the tips of the fingers and toes; and white hairs below the eye and above the mouth. A trace of the crown patch can extend between the scapulae. The female has few black hairs around the ears**.** Females are sometimes larger than males.

Nomascus leucogenys siki (Delacour, 1951) Southern white-cheeked gibbon
Central Vietnam and southern Laos

Nomascus l. leucogenys and *N. leucogenys siki* differ by a reciprocal translocation between chromosomes 1 and 22 not present in the former (Couturier and Lernould 1991). Groves (2001) pointed out that there is some difference of opinion as to whether the form *siki* was a subspecies of *N. leucogenys* or *N. gabriellae*. Two mtDNA studies placed it in a clade with *leucogenys* (Garza and Woodruff 1992; Zhang 1997), although it also evidently interbreeds with *N. gabriellae* in central Vietnam (see below). Following the suggestion of Zhang (1997), Groves (2001, 2005) considered it to be a distinct species. It is my opinion, however, that this conclusion is premature, since the evidence was based on only a few specimens: Until additional evidence is reported, *Nomascus l. siki* should be considered a subspecies. Adult males have small, white cheek-patches that extend as far up as the corners of the eyes, and thin, white hair partially encircles the upper lip and totally encircles the lower lip, connecting on the upper portion of the throat, and terminating at a black chin which can have a few white hairs (Fig. 33). Adult females have few black hairs above the ear, and appear to be more similar in appearance to adult female *N. l. leucogenys* than to *N. gabriellae* females (Geissmann 1995), with a thin white face-ring that is wider above the mouth and below the eye, which gives them an older appearance (Fig. 25).

Nomascus gabriellae × *Nomascus leucogenys siki* Light-cheeked gibbon hybrid
Central Vietnam

These two forms have a natural hybrid zone in central Vietnam. Adult and immature males and immature female hybrids look more like *N. gabriellae* than *N. leucogenys siki* (Fig. 34), and adult female hybrids have features similar to both *N. gabriellae* and *N. leucogenys siki* (Fig. 35). The hybrids can easily be identified by karyotyping (P. vanTuinen pers. comm.).

Nomascus gabriellae Thomas, 1909 Buff-cheeked gibbon
Southern Vietnam, southern Laos, and eastern Cambodia

Nomascus gabriellae has been referred to as the buff-cheeked gibbon (Osgood 1932), red-cheeked gibbon (Groves 1972, 2001, 2005), yellow-cheeked gibbon (Geissmann 1995), and golden-cheeked gibbon (Varsik 2000). Adult males are mainly blackish but generally have dark brown to buffish brown on the upper chest, and can be lighter in color around the nipples. They have small, light buffish white cheek patches that extend to the bottom of the orbital ridge and can be slightly separated at the throat, with black hair under the eyes (Fig. 36). Adult females can be smaller than adult males and *Nomascus l. leucogenys* females. Adult females are generally buff to strawberry-buff and can have a very slight grizzling of darker hairs on the chest, on the edges and tips of the fingers and toes, and on the outer forearm. Their blackish crown patch can taper down the nape of the neck and sometimes has a few black hairs extending to the center of the scapulae. There is black hair under the eyes, and a black fringe around the ears. Adult females may have slightly red-brown to black genital hairs, with a few slightly red-brown to black hairs surrounding the anus, and usually there is a trace of a white fringe encircling the face.

Genus *Hoolock* Mootnick and Groves, 2005 Hoolock or white-browed gibbon

Mootnick and Groves (2005) suggested that the two known hoolock gibbons, western and eastern, be considered as separate species. Although there is compelling evidence for this, I do not consider it conclusive. In a comparative study of the two, there was a 2.5–3% difference in the mitochondrial cytochrome b gene, a separation nearly comparable with those seen between *Nomascus gabriellae* and *N. leucogenys* (C. Roos pers. comm.). There is a greater difference in the pelage of the two forms than that observed between *N. gabriellae* and *N. leucogenys*. However, a comparative study of *Hoolock* vocalizations would also be of great interest in determining the degree of difference between them, and further karyological and molecular genetic studies, using a larger sample size, are needed.

Adult males have blackish hair with a thick white brow, and a thin tuft of hair at the chin. Adult female pelage is varying shades of buff, tan to copper-tan with different shades of brown hair on the sides of the face, throat, chest, and inner thighs. As observed in *Nomascus*, adult female *Hoolock* also have a slight color variation in the same individual resulting from their sweat that can give them a copper-tan appearance. Shorter hairs on the sides of the neck give this gibbon's face a triangular appearance. The tooth row is wider compared to *Hylobates* and *Nomascus*, and the chest region is narrow. Ischial callosities are heavily furred. The coats of young infants are gray-white with a yellow tinge (McCann 1933) (Fig. 37) and contrast more strongly in color to the pelage of the mother than is observed in most other gibbon species. They go through a fast color change to mainly black with a white brow and a trace of a face ring. They lose most of the grizzling throughout the coat at approximately 1.5 years old. At puberty, the female's entire pelage is mostly light in color, while males remain black throughout adult life. Adult and immature hoolock gibbons are the only gibbon species to produce a guttural growl during their vocalization (Mootnick and Groves 2005). Captive *Hylobates agilis* (agile gibbon) and *Hylobates muelleri* (Müller's gibbon) have occasionally been misidentified as hoolock gibbons, and this is probably the case of Chu and Bender (1961). The genus is characterized by a diploid chromosome number of 38 (Prouty *et al*. 1983a, 1983b).

Hoolock hoolock (Harlan, 1834) Western hoolock gibbon
Myanmar west of the Chindwin River, northeastern India, and northeastern and southeastern Bangladesh

Juvenile through adult males, and juvenile through the beginning stages of subadulthood females are black with a thick, white brow of varying heights that grows upwards, that flicks up at the ends and generally not separated in the middle (Figs. 38 and 39). They have a black chin tuft. The black genital tuft of the adult males grows dorsally to about 52 mm in length, and parts in the middle lengthwise. Some males have slightly longer black hair under and toward the center of the brow, giving the appearance of a separated brow. The infant's white brow is large, with a trace of white along the sides of the head by the end of the first color transition and afterwards, and the chin tuft is pale (Fig. 40). The thick, white brow of the adult female turns upwards at the ends, is narrower as it travels down the orbital ridge and the muzzle, and then connects with the white chin tuft. White hair encircles the bridge of the nose and extends around the muzzle to connect with the chin tuft creating a face ring like a figure of eight. The throat and chest of the adult female is generally darker than the adult female *Hoolock leuconedys* (eastern hoolock gibbon) (Fig. 41). The hair on the hands and feet of the adult female is generally the same color as the body hair, but there is a black fringe on the fingers, the edge of the hands, and toes (Groves 1972; Mootnick *et al*. 1987) that encircles the foot, and there is some blackish brown in the genital region (Mootnick and Groves 2005) (Fig. 42) and around the anus.

Hoolock leuconedys (Groves, 1967) Eastern hoolock gibbon
Myanmar east of the Chindwin River, south western Yunnan, and Lohit District, Arunachal Pradesh, northeast India

Recent surveys confirmed that *H. leuconedys* also occurs between the Lohit River and the mountains in the Dafa Bum, Arunachal Pradesh, in northeast India in a continuous range into Myanmar (Das *et al.* 2006). The adult males are black, with a long silvery testicle tuft that parts in the middle lengthwise and is approximately 75 mm long, directed dorsally. The chest of the adult male is grizzled with silverish hair (Fig. 43) that can be seen first when approximately nine years old

(GCC HHL304). By the time the adult male has a grizzled, silver chest and the female is completing her final color change, there are two parallel white lines of hair connecting to the medial aspect of the thick, white brow where it is separated in the middle, which descend then diverge to encircle the muzzle and connect with the chin tuft (Figs. 44 and 45). Starting at the outer aspect of the thick, white brow of the adult female, there is white hair encircling the orbital ridge that runs just above the diverging white line of hair above the bridge of the nose that then connects at the medial aspect of the brow. This gives the female the appearance of a double figure of eight face ring (Fig. 45). The hands and feet of the adult female are slightly paler than the limbs, and may have a trace of white (Groves 1972) (Fig. 44). The adult female sometimes has a lighter coloration running through the center of the light brown chest hair (Fig. 43); the digits may have a trace of black on them; and the crown hair is lighter and grows slightly upwards and toward the nape of the neck and is slightly directed toward the sides of the head (Fig. 46) (Mootnick *et al*. 1987). The adult female's genital region is generally lighter in color compared to the surrounding area, whereas the hair surrounding the anus is brown. Some females from Yunnan and the east of the Chindwin River have been observed to have brown hair on the genital region. At subadulthood, the male begins to acquire a brownish color to the hair on the chest, and the testicle tuft is beginning to lengthen with silverish hair. Before the chest turns brown, the thin, face-ring slowly decreases on the sides of the face, and white hairs begin to encircle the bridge of the nose, and eventually connect with the white hairs under the chin. At this time the white brow is beginning to thicken above the orbital ridge. Immatures in the black color phase have white chin hairs and a large, white brow separated in the middle, with white hair along the lateral aspect of the orbital ridge, giving the appearance of a face ring (Fig. 45).

Genus *Hylobates* Illiger, 1811

The remaining gibbon species are classified in the genus *Hylobates*. This genus is characterized by a diploid chromosome number of 44 (Chu and Bender 1961; Chiarelli 1962). Referring to *Hylobates* as the *lar* group is now misleading, and a new name should be given to the 44-chromosome gibbons — the *Hylobates* group or the 44-chromosome gibbon group.

Female genital swelling is very prominent in this genus, and most obvious in *Hylobates moloch* (Javan gibbon), *H. muelleri*, *H. agilis*, *H. albibarbis* (Bornean white-bearded gibbon), and *H. lar* (lar gibbon). The genital swelling is not as pronounced in *H. pileatus* (pileated gibbon) (A. Mootnick pers. obs.). I reserve judgment on *H. klossii* in this respect as my observations are limited to just two adult females.

Hylobates klossii (Miller, 1903) Kloss' gibbon
Mentawai Islands, Indonesia

Both sexes have short, black hair, and are known to remain this color at all life stages. *Hylobates klossii* has a broad chest and long legs, thumbs, and big toes (Groves 1972) (Fig. 47). The hair forming the genital tuft is short. There is inter-digital webbing on the feet (Groves 1972), but it only extends approximately one-third of the way along the proximal phalange between the second and third digits (Fig. 48). Adults have the most compact skull, smallest jaw, and teeth in comparison to other gibbons (Marshall and Sugardjito 1986). The hair on top of the head is flat. Immature crown hair stands erect (Fig. 49). The spectacular great call of the adult female *H. klossii* is more similar to those of female *H. pileatus* and *H. muelleri* than it is to female *H. lar*, *H. albibarbis* and *H. agilis*. No subspecies have been described, but there are some variations in hair length, the direction of hair grown on the outer side of the forearm, and in body size on different islands (Groves 1972, 1984). Of the four captive females observed, two were in transition from juvenile to adulthood (A. Mootnick pers. obs.). When one of the females became a young adult she had a slight tawny-colored grizzling on the chest (Fig. 50).

Hylobates pileatus Gray, 1861 Pileated or capped gibbon
Western Cambodia, southeastern Thailand, and southwestern Laos

Hylobates pileatus is the most sexually dichromatic of the gibbons in the *Hylobates* group. Adult males have short, black hair with a thick, white brow band that becomes thinner as it encircles the face. The fingers and toes of the adult males are white, with a slight fringe running halfway up the sides of the hands and feet (Fig. 51). There is a white prepubertal patch. The crown cap is encircled by a grizzled, light, sliverish streak on the sides of the head that becomes faint on the back of the head, with a few white hairs on the nape, shoulder and upper back. Adult males may have a faint, gray grizzling on the lower back and lower legs. Subadult and adult females are silver-buff with a black, heavily furred throat, and an inverted triangle on the ventrum that branches off to the underarm area but stops short of the genital region (Figs. 1 and 52). This black coloration extends upwards to the bottom of the ears and narrows in front of the ear to connect with the cap. The cap of the female is large and black, with long, silver-buff hair curved over the temples. Subadult and adult females have a white brow (which becomes thinner depending on age, physical condition or pregnancy) (Figs. 52, 53, 54 and 55) that sometimes extends laterally around the orbital ridge; there can be a trace of a white facial ring (Fig. 52). Since infants do not have bi-colored hair (darker hair at the base), they are lighter buff than subadults and adult females (Figs. 1, 53 and 55). Infants, as in all hylobatids, initially have some light creamy-pink skin (Fig. 54) that turns various darker colors depending on the species and parts of the body. During infancy the palms, soles and face turn to a tawny gray (Fig. 1) and, depending on age and amount of sunlight exposure, they end up having a charcoal-gray pigmentation.

Hylobates pileatus is the only species in the genus in which males undergo a complete color change from infancy to adulthood (buff to black). Both males and females begin their color change at about 10–12 months old. The change starts at either the center of the chest or the crown (Figs. 53 and 56). At 9.5 months old, black hair was noticeable on the crown of one female (GCC Jitka) but not on the chest. The first signs of black on the center of the throat closest to the chest plate were observed for a male at 37 months old, and the white brow and a partial face ring became evident (GCC Truman). The females can complete their color change at 4 years of age (Fig. 52), whereas the process is still ongoing in males when 4.5 years old (Fig. 57). Both sexes have a lateral tuft along the sides of the crown. By seven years of age, the female's crown hair has lengthened to the point that it hangs over the temples (Figs. 53 and 54), which Marshall and Sugardjito (1986) referred to as Dagwood tufts. In some females the tuft curls upwards (Fig. 55). Males complete their color change by 6.5 years of age (GCC Kokopelli, Mateus Binti); the lower back and lower limbs are the last areas where the color change is noticeable (Fig. 58).

Hylobates moloch (Audebert, 1797) Javan, silvery, or moloch gibbon
Western and central Java

Both sexes are silvery gray, and generally have long, dense hair at the neck, sides of the head, upper arms, and on the shoulders. The hair length between the shoulders ranges from 50 mm to 70 mm (Groves 1968). The outer hair coloration can turn a mouse gray in harsh sunlight. Either sex may have a distinct light-to-blackish gray cap depending on whether they are from central or western Java, and the same dark coloration as the cap is occasionally seen under the whitish brow. There is charcoal-gray hair in the genital region and surrounding the anus. The female's chest is sometimes charcoal-gray colored (Fig. 59) (Geissmann 1995). The transition from a gray chest to a dark chest plate can begin as early as 5 years old at the center of the chest, and can eventually resemble a wide, inverted triangle that tapers towards the abdomen and becomes a line as it gets closer to the groin (GCC Chloe) or observed only on the upper chest (GCC Khusus). An adult male from central Java (MZB 3320) has a thin charcoal-gray colored vertical streak running down the center of the chest. Immature chest coloration darkens from a light, silverish gray to silver gray, or gray by the time they are mature. Both sexes have white to white-gray hair on the brow and surrounding the chin; this hair usually connects to slightly darker hair on the side of the face to form a face ring (Fig. 60). Hair under the chin grows upward, giving the appearance of a "goatee". Infants are lighter in color than adults and change to silvery gray shortly after birth (Figs. 59 and 61) (Groves 1972) and their cap darkens as they mature (Figs. 61 and 62). *Hylobates moloch* is sometimes confused with *H. muelleri* because of similarities in coat color. However, the great call of the female *H. moloch* is more similar to those of female *H. agilis*, *H. albibarbis*, and *H. lar* than it is to *H. muelleri*.

Following the suggestion of Andayani *et al.* (2001; see also Supriatna *et al.* 1999; Supriatna 2006), Brandon-Jones *et al*. (2004) listed two subspecies of *H. moloch*: *H. m. moloch*, the west Javan silvery gibbon, and *H. m. pongoalsoni* Sody, 1949, the central Javan silvery gibbon. I do not consider them here, and they are not recognized by Groves (2001, 2005) or Geissmann *et al*. (2002). *Hylobates m. pongoalsoni* has a lighter cap than the gibbons of western Java. Research on their vocalizations, and additional molecular genetic and chromosome studies may shed further light on this (Geissmann *et al*. 2002).

Hylobates muelleri Martin, 1841 Müller's, Bornean, or gray gibbon
Borneo, except for the southwest

Adult male and female *Hylobates muelleri* are similar in their coat color, which varies from gray to gray-brown, or blackish. The hair of the adult male's genital tuft is 25 mm long (Marshall and Sugardjito 1986) and is typically darker than the body hair. Infant coat color is lighter than the parents (Fig. 63). This species lacks a uniform appearance in areas of geographic overlap with other Müller's gibbon subspecies. The great call of the female is somewhat similar to that of female *H. pileatus*.

Marshall and Sugardjito (1986) recognized three subspecies (see Groves 2001, 2005), which we list here. Some people have difficulties distinguishing two of them, *H. m. muelleri* (Eastern Müller's gibbon), and *H. m. abbotti* (Abbott's gray gibbon) from *H. moloch* because of similarities in coat color. *Hylobates m. funereus* (northern Müller's gibbon) is occasionally misidentified as *H. albibarbis* for the same reason.

Hylobates muelleri muelleri Martin, 1841 Eastern Müller's gibbon
Southeastern Borneo

Hylobates m. muelleri is pale gray or gray-brown, with a thick, white brow that is wider at the center. The cap is blackish, and can grow slightly down the nape with black grizzling through the gray hair as it approaches the center of the back. The ventrum, abdomen, genitals, hands or just the fingers, and toes are blackish (Fig. 63). The outer portion of the legs and arms are gray to gray-brown, and the inner aspects of the limbs are darker in color (Figs. 63 and 64), and vary between individuals.

Hylobates muelleri funereus I. Geoffroy St. Hilaire, 1850 Northern Müller's gibbon
Northern Borneo

Hylobates m. funereus is dark gray or gray-brown with a blackish to blackish-brown cap, ventrum, throat, inner aspects of the limbs (which can vary between individuals), anus, and genitals (Fig. 65). The outer area of the lower limbs, elbow, and tips of the fingers, toes, and in some individuals the back, can be paler in color. They have a large, white brow that is wider at the center. Toes and fingers are black on specimens from southern regions where the subspecies overlaps geographically with *H. m. muelleri*. There is a report of a very large *Hylobates m. funereus* and a blackish color phase in the Kinabatangan Wildlife Sanctuary (Ancrenaz 2001).

Hylobates muelleri abbotti Kloss, 1929 Abbott's gray gibbon
Western Borneo

Hylobates m. abbotti has short, mouse-gray body hair, and can have dark hair in the genital region (Fig. 66), while the lumbar region can be slightly lighter than the upper back. The brow is slightly paler than the head hair and it can have blackish hair below the brow and above the eyes. Populations closer to the bordering area of *H. m. funereus* sometimes have blackish hair on the throat, fingers, and toes, and a slightly darker cap (Fig. 67), and upper chest and inner aspects of the limbs, reflecting a possible subspecific hybridization in areas of overlap. The *H. muelleri* that were found in Sarawak 4th Division, Ulu Selio at an elevation of 3,500 feet (FMNH 88551-60) somewhat resembles both *H. m. abbotti* and *H. m. funereus.*

Hylobates agilis F. Cuvier, 1821 Agile or dark-handed gibbon
Sumatra, south from Lake Toba, and Malay Peninsula between the Perak and Mudah rivers

Marshall and Sugardjito (1986) and Brandon-Jones *et al.* (2004) list three subspecies of *H. agilis*: *H. a. agilis* (the mountain agile gibbon); *H. a. unko* (lowland agile gibbon); and *H. a. albibarbis*. Groves (2001, 2005) lists *albibarbis* as a full species on the basis of morphological and pelage differences. Hirai *et al.* (2003, 2005) reinforce this view and I follow Groves' (2001) recommendation in this case. Based on similarities in the vocalization and some aspects of the pelage, J. T. Marshall maintains the view that the form *albibarbis* is a subspecies of *H. agilis*; an arrangement suggested earlier in Marshall and Marshall (1976) (J. T. Marshall pers. comm. 2005-06). Groves (2001, 2005) listed *unko* as a junior synonym of *H. agilis*.

With a captive weight of as little as 5.8 kg (GCC Mumma), some adult *Hylobates agilis* can be considered the smallest of the gibbons.. Males and females have very prominent orbital ridges (Griffith 1827), can be either buffish, buffish with darker underparts, brownish, reddish, blackish, or with a lighter colored lumbar region (Fig. 68). Immature through adult males and immature females have whitish brows and cheek patches, which resemble a beard (Fig. 69). The hair of the adult male's genital tuft is 50 mm long, and is generally the same color as, or slightly paler than, the body hair (Marshall and Sugardjito 1986). Starting at the chin, females begin to lose their cheek patches at approximately 6 years old, and finish their color change between 7 and 14 years old (Fig. 70). Adult females who have been housed in low light conditions, who are pregnant or lactating, or who have nutritional deficiencies, may lack the white brow and if in black pelage they could resemble *H. klossii*. The lumbar region and rump of young infants are mixed with slightly lighter coloration. *H. agilis* can have webbing between the second and third toe on the proximal phalanges (Elliot 1913) (Fig. 71). The female's great call is similar to female *H. albibarbis* and somewhat similar to the female *H. lar*.

Marshall and Sugardjito (1986) concurred with Wilson and Wilson (1977) that there is a high percentage of *Hylobates agilis* in black pelage east of the Barisan Mountains, in the swamp forests and eastern lowlands of Sumatra, and in west Malaysia, and that there is a high percentage of light-colored phase *Hylobates agilis* in the mountainous range of the Barisan Mountains, which is the native habitat of the robust black *Symphalangus syndactylus*. For this reason Marshall and Sugardjito (1986) confirmed that *Hylobates agilis unko* is located east of Barisan Mountains and west Malaysia, and *H. a. agilis* occurred in the mountainous range of west Sumatra. It is possible that sympatry with *S. syndactylus* in west Sumatra, is the reason for the occurrence of the lighter form, *H. a. agilis*.

I have also found a small but observable difference between the facial pelage of *H. agilis* in the mountains and lowlands of Sumatra and Malay Peninsula (Mootnick *et al.* 1996, A. Mootnick, in prep.). Distinct differences exist in the color and amount of white surrounding the face or on the brow in museum specimens from Sumatra and Malay Peninsula, when compared with live specimens. My preliminary notes on museum specimens indicate that elevation plays a role in the amount of white on the brow and/or cheek patches, or shade of white on the cheek patches, an aspect which has led to me to give the common names for the *Hylobates a. agilis* (mountain agile gibbon) and *H. agilis unko* (lowland agile gibbon) (Mootnick *et al.* 1996). *H. agilis* is easily determined through G-banding when compared with the chromosomes of other *Hylobates* gibbons (vanTuinen *et al.* 1999) and in C-banding analysis (Hirai *et al.* 2003).

Hylobates agilis agilis F. Cuvier, 1821 Mountain agile gibbon
Highlands of northern Malay Peninsula and western Sumatra south of Lake Toba

The pelage of *H. a. agilis* is buff, reddish-orange, reddish-brown, brown or blackish. My observations indicate that the adult males and immature males and females have white cheek patches that generally connect under the chin and brow (Fig. 72). The adult female's brow is wide and white, tapering towards the ends, and not divided in the middle (Fig. 73).

Hylobates agilis unko Lesson, 1829 Lowland agile gibbon
Lowlands of northern Malay Peninsula and eastern Sumatra south of Lake Toba

Hylobates agilis unko possesses few characteristics that reliably distinguish it from *H. a. agilis*. Based on a preliminary study, the cheek patches are creamy-white to a grizzled white, sparser than *Hylobates a. agilis*, and do not connect under the chin or brow (Fig. 74). The adult female's brow marking is thin and short and can be separated in the middle. The lumbar region is paler than the rest of the body in some *Hylobates a. unko*.

Hylobates albibarbis Lyon, 1911 Bornean white-bearded gibbon
Southwestern Borneo

First described as a subspecies of *H. muelleri* (Lyon 1911), Marshall and Sugardjito (1986) and Brandon-Jones *et al.* (2004) listed this gibbon as a subspecies of *H. agilis* (see above). Overall, *H. albibarbis* varies in shades of light brown with a large, dark brown cap and darker brown under parts, with the lower back being buffish in color (Lyons 1911). The description that follows was compiled from museum specimens. The hands and feet vary from brown to blackish brown with darker fingers and toes. The brow is whitish and can be separated. Immature and adult males have white to creamy-white cheek patches. The chest and abdomen are dark-brown. The lower back is buff (Fig. 75). The shoulders, upper back, and from the nape to the back of the ear, vary in shades of tawny. The front portion of the sides of the face up to the front of the ear is brown. The throat varies from light to dark brown. The rump and hips vary from brown to tawny. The outer portion of the legs are tawny, and are generally darker on the inner portion. The outer portion of the arm varies from tawny to brown, and the inside of the arm is generally darker. The hair surrounding the anus is brown. The hair surrounding the female's genitals is dark brown, whereas the male's genital tuft is tawny. Because there is so much color variation in this species and since, historically, it has been misidentified with *Hylobates muelleri funereus* it would be important to confirm the species identification through its vocalizations, karyotype or DNA. The female's song has longer and slower notes when compared with the *H. a. agilis* and *H. a. unko*. Karyotyping wild-born, or captive-born individuals whose parents have been confirmed to be *H. albibarbis*, can easily distinguish this form from *H. a. agilis* and *H. a. unko* (vanTuinen *et al.* 1999; Hirai *et al.* 2003, 2005).

Hylobates lar (Linnaeus, 1771) Lar or white-handed gibbon

Marshall and Sugardjito (1986) recognized four subspecies of *Hylobates lar*: *H. lar lar* (Malayan lar gibbon); *H. lar carpenteri* (Carpenter's lar gibbon); *H. lar entelloides* (mainland lar gibbon); and *H. lar vestitus* (Sumatran lar gibbon). Ma and Wang (1986) described a fifth subspecies, *H. lar yunnanensis* (Yunnan lar gibbon). This arrangement follows Groves (2001, 2005). Adults of both sexes have white hands and feet and a complete face ring. Males and females can be dark or light in color, ranging from creamy-buff to brown to blackish. Depending on the subspecies, the hair on the head lies flat or points upward, and hair texture ranges from straight to frizzy. The great call of the female *H. lar* is somewhat similar to those of female *H. agilis* or *H. albibarbis*. The pelage of the lumbar region, rump, and outer thigh of infants are mixed with light coloration, and lighter than that of young infant *H. agilis* (Fig. 76). Some infants have been observed with a pale abdomen and chest (Fig. 77).

Hylobates lar lar (Linnaeus, 1771) Malayan lar gibbon
Central and southern Malay Peninsula and southern Thailand

Both sexes are generally dark chocolate brown in color, but approximately one-third of the population is creamy-buff (Fig. 78) (Marshall and Sugardjito 1986). The darker hair base ranges from 50–66% of the length of the hair (Groves 1972). The hair length between the shoulders ranges from 36 mm to 55 mm (Groves 1972). The genital region is darker than the body hair. The white hair on the hands and feet extends slightly past the wrist and ankle. The face ring is thin above and on the outer sides of the eyes. It widens at the bottom of the ears, and remains wider as far as the chin. A partial face ring has been observed in some specimens (Blyth 1847; Gulik 1967; Groves 1972), but without genetic testing it is difficult to determine if they are descendents of *H. agilis* or if this is a phenomenon of this subspecies.

Hylobates lar carpenteri Groves, 1968 Carpenter's lar gibbon
Northern Thailand

This subspecies has long hair, and can have more facial hair than the mainland lar gibbon (*H. l. entelloides*). Silvery base hairs give it a brownish charcoal or white-buff appearance depending on the color phase. These base hairs are deeper in color in the darker color phase, and base hairs are up to 50% of the hair length (Groves 1972). *Hylobates l. carpenteri* has a white face ring. The pubic region is similar in color to the rest of the body, with few white hairs. The white on the hands and feet can extend up to the wrists and ankles (Groves 1968). Hair length between the shoulders varies from 79 mm to103 mm (Groves 1968).

Hylobates lar entelloides I. Geoffroy St. Hilaire, 1842 Mainland lar gibbon
Central and southern Thailand, and southeastern Myanmar

Hylobates l. entelloides can be blackish, tawny, or blackish brown with a brownish chest and a trace of white hairs on the nape, with brownish buff with slight grizzling of black hairs on body, or overall buff in coloration (Fig. 79). The hair base extends to about one-third up the hair shaft (Groves 1972). Hair length between the shoulders varies from 29 mm to 56 mm (Groves 1968). The white face ring can vary in width depending on the geographical location, and is wider on the sides of the face and chin. The hands and feet are whitish and can be grizzled with the color of the body hair. A trace of the body hair color on the back of the wrist can also taper (almost forming a triangle) towards the knuckles. The black color phase of this subspecies is darker than the dark phase of *H. l. lar* or *H. lar carpenteri*. Some black color phase males have grizzled white hair in the genital tuft.

Hylobates lar vestitus Miller, 1942 Sumatran lar gibbon
Northern Sumatra, north of Lake Toba

Unlike the other lar gibbons, *H. l. vestitus* lacks a dark color phase. The Sumatran lar gibbon varies in color from red-buff, to red-brown, to light-brown, with a slightly darker crown, scapular, genital region, forearm, calf, and throat, and a paler lumbar region (Fig. 80) (Marshall and Sugardjito 1986), or white grizzling through the body. The hair length between the shoulders range from 44 mm to 60 mm (Groves 1972). The white on hands and feet has a slight grizzling of the body hair, and was observed to have the white not extending up to the wrist or the ankle, or extending past the wrist. The face ring is white and medium in size.

Hylobates lar yunnanensis Ma and Wang, 1986 Yunnan lar gibbon
South western Yunnan

Hylobates l. yunnanensis differs from the other subspecies in having the lighter base hairs extend only to 10–20% of the hair length (Ma and Wang 1986). The pelage of the pale phase is creamy in color and can have a darker tone ranging from buff to tawny buff to brownish buff on the cap, chest, legs, and outer aspects of the arms. There is a trace of brown to reddish brown hair in the genital region. The hair is longer on the scapular and shoulders. Hands and feet are white. Hair length on the upper back is 120–150 mm (Ma and Wang 1986). Brandon-Jones *et al.* (2004) point out that *H. l. yunnanensis* may be a synonym of *H. l. carpenteri.* This, one would hope, can be resolved by a comparative morphological and DNA study.

Discussion

Museum specimens provide ample material for a comparative study on species identification. Pelage coloration is genetically determined and can vary according to age, sex, or color phase. My findings indicate four genera and 14 species of gibbon. The highest diversity can be found in Yunnan, China, where there are three genera and five species. Further studies may well argue for the elevation of some subspecies to species, and there remains the possibility that new subspecies will be discovered. *Hylobates lar entelloides*, for example, has a wide distribution, from Thailand to southeastern Myanmar, and, with so much pelage variation, future studies on genetics, morphology, and vocalization may identify additional subspecies.

The *Hoolock leuconedys* and *Hylobates lar* that were observed in more northern localities had longer hair on the upper body, which could serve to protect them in the colder environment. *Nomascus c. concolor* and *N. l. leucogenys* did have slightly longer hair than has been observed in other *Nomascus* species or subspecies, but still the hair length in the upper body (especially the upper arms) is very short in comparison to the other three genera of hylobatids. Since the distribution of *Nomascus* is from southern China to southern Vietnam, one would expect to see more variation in hair length within the species in *Nomascus*. The short dense hair could be more advantageous in the higher altitudes where it could snow or in the southern region where it is hot, and at the same time protect them from mosquitoes.

Delacour (1951) described the adult male holotype of *Nomascus concolor lu* as mainly black with a gray stripe over the eye to the ear, and that the other three males that he collected were similar but also had at least a trace of gray on the cheeks. After the inspection of these four black specimens that Delacour (1951) collected, it was revealed that two of the adult males were entirely black, and one of the males was actually a subadult female going through a color transition. The photos and video of the *N. concolor lu* that I observed from the Bokeo Nature Reserve in black pelage were black without any gray on the face. In addition, since there is a hybrid zone of *N. concolor lu* and *N. l. leucogenys*, I would then suggest that the description of the adult male *N. concolor lu* needs to be revised to entirely black.

A color chart is necessary when describing the pelage of gibbons. I attempted to use color guidebooks (Smithe 1974, 1975; Munsell 1994) whenever possible, but shades varied so much even these were inadequate. If feasible, it would seem expedient to create a universal color guide specifically for the hylobatids to facilitate future comparisons.

Depending on the species, the status in the wild ranges from Critically Endangered to Least Concern, although some taxa remain Data Deficient (Eudey 1987; IUCN 2006). Some of the species and subspecies rank among the most threatened primates in the world (see Mootnick *et al*. 2006). International captive breeding and rehabilitation programs have been established to preserve the gene pool of some gibbon species (for example, for *H. moloch*: Supriatna and Manullang 1999; Supriatna 2006); unfortunately, some have proved difficult to maintain in captivity. Factors contributing to the decline of some captive gibbons include hybridization, a monogamous mating system, few population founders from the rarer species, stress (Mootnick *et al.* 2006), and behavioral abnormalities attendant with human-rearing (Mootnick and Nadler 1997).

Gibbon systematics traditionally has been controversial and confusing. One of the many purposes of rescue and breeding centers is to provide for the reproduction of gibbons, whether in captivity or once released, so that species and subspecies diversity is retained. If mentally and physically healthy gibbons are to be released into their native habitat, it is very important that they are released in the proper location with the same subspecies, and not in the range of other gibbon taxa.

Accurate visual identification of an individual gibbon may be complicated by the existence of different colors for the two sexes in some gibbon species, and the different colors within some gibbon species according to age and color phase. If our intentions are to save species from becoming extinct, it is of the utmost importance to make sure hybridization at the subspecific level does not occur in conservation programs. It is hoped that this description of gibbon coat colors will properly assist in the identification of captive and wild species and subspecies to prevent hybridization and maintain their diversity.

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Appendix I. Specimens Examined

The gibbons that were examined are listed consecutively under the localities alphabetically, and identification numbers or house name. Museum specimens are listed first.

AMNH = American Museum of Natural History, New York, USA
BMNH. ZD = Zoology Department, British Museum (Natural History), London, UK
FMNH = Field Museum of Natural History, Chicago, Illinois, USA
GCC = Gibbon Conservation Center, Santa Clarita, California, USA
IEBR = Institute of Ecology and Biological Resources, Hanoi, Vietnam
MCZ = Museum of Comparative Zoology, Harvard University, Cambridge Massachusetts, USA
MZB = Museum Zoologicum Bogoriense, Bogor, Java, Indonesia
USNM = National Museum of Natural History, Washington, DC, USA
ZMVNU = Zoological Museum, Vietnam National University, Hanoi, Vietnam
ZRC = Zoological Reference Collection, Department of Zoology, University of Singapore, Singapore. (Formerly National Museum and formerly Raffles Museum)

Symphalangus s. syndactylus, Sumatra: Alur Purba: MZB 3107; Bukit Dulu: AMNH 102187–88, 102190; Bukit Sanggul: MZB 6455, AMNH 106582–83; Gunung Dempo: MZB 6454, 6467, AMNH 106581; Lubuk Linggau: MZB 6465, AMNH 102186, 102193–97; Muara Beliti: AMNH 10292; Muara Dua AMNH 102720–21, 102725–27 102729; Teluk Aru: USNM 143577–81; Teluk Tapanuli: ZRC 4-711. GCC: Karenina, Olive-Oyl, Rumi, Saphire.

Symphalangus s. continentis, Malay Peninsula: Kledang Hill: 4-701-2; Kuala Tahan: ZRC 4-704; Selangor Pass: USNM 171981; Wray's Camp: ZRC 4-703. GCC: Ella, Fatima, Kino.

Symphalangus syndactylus, Range unknown: FMNH 60340, 60555, 95842, 99366; GCC: Amos, Holly, Marlow, Montgomery, Raub.

Nomascus concolor concolor, Vietnam: Chapa, Tonkin FMNH 39149-50, MCZ 38114–16.

Nomascus concolor lu, Laos: Ban Nam Kaueng: AMNH 148262, MCZ 46288–89; Khao Tham Phra: USNM 296921.

Nomascus n. nasutus, Vietnam: Tam Dao District: ZMVNU 3.101.5; Thai Nguyen Province ZMVNU 3.55.0, 3.56.0; Trung Khanh District: IEBR 48, 50, 51.

Nomascus l. leucogenys, Laos: Lao Fou Tahai: FMNH 31760; Muong Yo: FMNH 31769–70; Phong Saly: USNM 240490–92. Vietnam: Bai Thuong Thanh Hoa: ZMVNU 3.53.2; Chi Ne District: ZMVNU 3.100.4; Dung Tan Ky Nghi: IEBR 563; Ho- Xuan: USNM 39151; Lai Chau: FMNH 31761, 31768, IEBR D2, K53; Muong Moun: USNM 31771; Tenky District: IEBR 528, 564, 736; Vuon Ma Trang: ZMVNU 3.102.0. GCC: Asia, Dexter, Jane, Parker, Ricky, Sasha, St. Paddy, Vok. Moorpark College: Samantha.

Nomascus leucogenys siki, Laos: Nakai: AMNH 87251; Vietnam: Quy Chau District: IEBR 503, 695-96.

Nomascus gabriellae × *Nomascus leucogenys siki*, natural hybrid: GCC: Kim Khi.

Nomascus gabriellae, Laos: Plateau Bolovens: AMNH 87252. Vietnam: Ban Methuot: FMNH 46495, 46497, 46499–501, 46503, 46505–06, 46508; Dalat: USNM 320789; Gialai Kontum: ZMVNU 733–35. GCC: Lulu, Alfalfa. Los Angeles Zoo: Andrea, China, Enik, Robin, Tina, Victor, Yang.

Hoolock hoolock, India: Bara Hapjan: USNM 257987; Changchang: AMNH 83419, 83425–26; Khasi Hills: AMNH 171169; Lushai Hills: FMNH 75881. Myanmar: Chenga Hka: AMNH 112690; Dagung Hka: AMNH 112954; Haibum: AMNH 112385–86, 112694, 112698–99, 112701, 112707; Hkamti: AMNH 112704; Linhpa West: AMNH 112709; Mt. Victoria: AMNH 163633. Bangladesh: Natural History Museum Dhaka Zoological Gardens: Mounted specimen; one adult male and female. GCC: Alfa, Beta

Hoolock leuconedys, Myanmar: Dalu: AMNH 112983; Gokteik: USNM 257988; Gora: AMNH 112982; Limpa east bank: 112708; Mansun: AMNH 112678; AMNH 25 miles west of Myithyina 279146; N'bunghku: AMNH 112680–81; Phawzaw, east bank: AMNH 112713; Tawman: AMNH 112673; Yunnan: Homushu Pass: AMNH 43065, 43068. Range unknown: GCC: Arthur, Betty, Chester, Drew, Fia, Gelson, U Maung Manug.

Hylobates klossii, Mentawei Islands: north Pagai 121675–77; south Pagai: USNM 121689, 121679, FMNH 43333; Siberut: USNM 252308–11; Sipora: USNM 252307. Gibbon Foundation, Indonesia: Nanam. Taman Safari, Indonesia: Ani; Pusat Primata Schmutzer: December 2003. One adult female and two immatures.

Hylobates pileatus, Thailand: Khlong Yai: ZRC 4-665, USNM 257686; Laem Ngop: USNM 201555; Nongkhor: ZRC 4-661, 4-662, USNM 241018–19; Cambodia: Kiri Rom Plateau: USNM: 321549. Distribution unknown: FMNH 53750; GCC: Anasazi, Birute, Cambio, Chewy, Geebone, Harry, Ila, Jitka, Josh, JR, Kanako, Kokopelli, Louis, Lula, Maggie, Mateus-Binti. Truman, Tuk, Valentina.

Hylobates moloch, Java: Gunung Salak: MZB 3349, 6416–17; Karang Gardang: MZB 2453; Purwakarta: MZB 6418; Slamet: MZB 3320–22; Sumedang: AMNH 101807. MZB Location unknown: 6419–20, 6429, 11140, 11145. GCC: Chilibi, Chloe, Isaac, Isabella, Ivan, Khusus, Leon, Ling, Lionel, Medena, Reg, Shelby, Ushko.

Hylobates muelleri muelleri, Borneo: Klumpang Bay: FMNH 41514; GCC: Bob.

Hylobates muelleri funereus, Borneo: Bukit Selidang (Sarawak 3rd Division 4000'): FMNH 88567; Kalabakan, Sungai Tibas Camp: FMNH 85925; Kinabalu: FMNH 8370; Pa Barang: FMNH 88263, 88266; Sandakan, 8 miles west: 33542–44; Sandakan, 5 miles north: FMNH 68681; Sungai Kretam Kecil: FMNH 68674–80; Ulu Selio (Sarawak 4th Division 3500'): FMNH 88552–54, 88556–57, 88559–60; Usun Apau Padang: FMNH 88566. Distribution unknown: GCC: Abbey.

Hylobates muelleri abbotti, Borneo: Perbuah: MZB 6570–71, AMNH 106766, 106779, 107102; Poch Mountain: FMNH 8369; Sarawak: FMNH 1171;

Hylobates a. agilis, (elevation 455–1,500 m) Malay Peninsula: Batu Tugoh: BMNH ZD.1955.1484, ZRC 4-554–56. Maxwell's Hill: BMNH ZD.1955.1487. Tea Garden, Larut Hills: BMNH ZD.1955.1485. Sumatra: Bukit Sanggul: AMNH 106570–76, 106578–80, 106672, 106675–79, 18836. Distribution unknown: GCC: Mumma, Sonny, Shorty.

Hylobates agilis, Since the seconds were not given for the coordinates, the elevations could vary from 21–568 m for some of the below listed gibbons. These locations were next to river basins and mountainous areas, or mountainous areas near a bay. Sumatra: Lampung: MZB 6438 (facial pelage coloration resembles *H. agilis unko)*; Muara Dua: AMNH 102470–74, 102771–79 (facial pelage coloration varies considerably within this location; AMNH catalog lists Muara Dua at 100 m. Muara Dua has a river basin next to a mountainous area); Tapanuli Bay: USNM 114499–501 (facial pelage coloration resembles *H. agilis unko)*; Teluk Betong: FMNH 14804 (brow was difficult to detect, next to the buff pelage).

Hylobates agilis unko, (7–200 m) Malay Peninsula: Tandjong Autu: BMNH ZD.1955.1486; Ulu Ijok: BMNH ZD.1934.7.18.9, 1934.7.18.11; Ulu Selama: ZRC 4-557. Sumatra: Babat: MZB 6435, 6437, 6441; Kluang: MZB 6434, 6436; Kota Pinang: ZRC 4-558–60; Kayutanam, Palembang: MZB 6440; Muara Beliti: AMNH 102161–62, 102199; USNM 102161–62, 102199; Muara Enim: ZRC 191 (facial pelage coloration resembles *H. a. agilis)*; Muara Lakitan: AMNH 102198; Pan Ji, Teluk: ZRC 4-562191 (facial pelage coloration resembles *H. a. agilis)*; Sekayu: MZB 6439; Selat Rupat: USNM 143572–76; Siak Kecil (6 miles up): USNM 144089, 144091–92; Siak Kecil (30 miles up): USNM 144090; Sungei Inderagiri: USNM 113176–80; Sungei Kateman: USNM 123151–55; Teluk Tarisan: USNM 141157–59. Distribution unknown: GCC: Kingfisher, Homer, Lulu, Elaine.

Hylobates albibarbis, Borneo: Batu Jurong: USNM 153797–99, Matan River: USNM 145328–29, Parit, Sungei Cempaga: AMNH 103441–46, 103449–56. Riam: AMNH 106053,106130, Sukadana: USNM 145326; Sungei Kendawangan: USNM 153800–01. GCC: Jackie.

Hylobates lar lar, West Malaysia, Jambu Luang: USNM 112710–11; Johore, Jambu Luang: USNM 112711; Pahang State including Labatuah, Rurpin River: USNM 115501–02; Selangor: USNM 171982.

Hylobates lar carpenteri, Thailand, Chiang Mai: Ban Mae Lamao: 99754–56; Ban Na Muang: USNM 307751; Dansai: USNM 307754; Mae Sariang: FMNH 99763–64;

Hylobates lar entelloides, Myanmar: Tenassarim, Balik River: USNM 111988; Bankachon: FMNH 828821–22; Toak Plateau: AMNH 54663, 54671. Thailand, Kampaengphet: Ban Nam Lai Tai:

FMNH 99759; Ban Kerng Chada: FMNH 99743; Katataek: FMNH 99746–49; Khlong Suan Mak: FMNH 99760–62; Khlong Tawai: FMNH 99750–51; Ko Kaew: 99752–53; Sisawat District (Baw Ngam): FMNH 99736, 99739–41; Wang Phato: FMNH 99744–45. GCC: Chan Chan, Judy.

Hylobates lar vestitus, Sumatra: Alur Purba: MZB 3106; Kungke: USNM 271047; Pulau Munteh-Pendeng: MZB 6448; Teluk Aru: USNM 143569–70.

Hylobates lar yunnanensis, Yunnan: Nam Ting River: FMNH 39382; AMNH 43063–64.

Hylobates lar, Distribution unknown: FMNH: 44740; GCC: Ayellette, Blonde, Dagwood, Hazel Nut, Mandalay, Number 2, Spanky.

Figure 1. *Hylobates pileatus* (pileated gibbon) adult female “JR” and 6.5 week old female “Jitka”, GCC. Photo by Erin Bell.

Figure 2. *Symphalangus syndactylus continentis* (Malaysian siamang) adult male “Kino”, Gibbon Conservation Center (GCC), California. Photo by Alan Mootnick.

Figure 3. *Symphalangus syndactylus continentis* (Malaysian siamang) adult male “Kino”, GCC. Photo by Clare Cunningham.

Figure 4. *Symphalangus syndactylus continentis* (Malaysian siamang) adult male “Kino”, GCC. Syndactyly of the second and third toes. Photo by John Williams.

Figure 5. *Symphalangus syndactylus continentis* (Malaysian siamang) immature male "Valentino", Cleveland Amory's Black Beauty Ranch. Syndactyly of the second and third toes extending up to the distal interphalangeal joint. Photo by Lee Theisen-Watt.

Figure 6. *Symphalangus s. syndactylus* (Sumatran siamang) adult female "Rumi", GCC. Webbing between fourth and fifth toes. Photo by John Williams.

Figure 7. *Symphalangus s. syndactylus* (Sumatran siamang) adult female "Ebony", Twycross Zoo, England. Photo by Rod Williams.

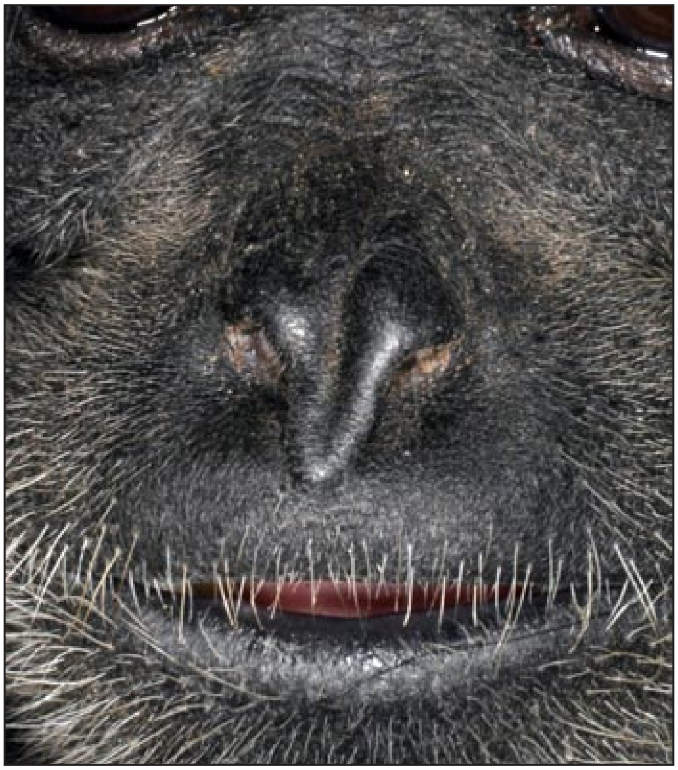

Figure 8. *Symphalangus s. syndactylus* (Sumatran siamang) adult female "Karenina", GCC. Tapering of nose and medial sagittal groove. Photo by John Williams.

Figure 9. *Symphalangus syndactylus continentis* (Malaysian siamang) adult male “Kino”, Close-up of the nose. Compare with Fig. 8. GCC. Photo by John Williams.

Figure 11. *Nomascus l. leucogenys* (northern white-cheeked gibbon) adult female “Ricky”, 3 week old female “Parker”, GCC. Photo by Alan Mootnick.

Figure 10. *Nomascus l. leucogenys* (northern white-cheeked gibbon) adult female “Ricky”, GCC. Photo by Alan Mootnick.

Figure 12. *Nomascus l. leucogenys* (northern white-cheeked gibbon) adult female “Ricky”, 7 month old male “Dexter”, GCC. Photo by Jim Zuckerman.

Figure 13. *Nomascus l. leucogenys* (northern white-cheeked gibbon) adult female "Ricky", 18 month old male "Dexter", GCC. Photo by Alan Mootnick.

Figure 15. *Nomascus c. concolor* (Tonkin black-crested gibbon) adult female "Hong-Hong", Gejiu Zoo, China. 3 September 1990. Photo by Thomas Geissmann.

Figure 14. *Nomascus c. concolor* (Tonkin black-crested gibbon) adult male "Zombie", Twycross Zoo, England. Photo by Elliott Haimoff.

Figure 16. *Nomascus concolor lu* (Laotian black-crested gibbon) adult female, Bokeo Nature Reserve. Photo permission: Jean-Francois Reumaux.

Figure 17. *Nomascus concolor lu* (Laotian black-crested gibbon) immature, Bokeo Nature Reserve. Photo permission: Jean-Francois Reumaux.

Figure 18. *Nomascus concolor lu* (Laotian black-crested gibbon) adult male, photo was reproduced from a video taken in the Bokeo Nature Reserve. Photo permission: Jean-Francois Reumaux.

Figure 19. *Nomascus concolor lu* (Laotian black-crested gibbon) adult female and infant, photo was reproduced from a video taken in the Bokeo Nature Reserve. Photo permission: Jean-Francois Reumaux.

Figure 20. *Nomascus concolor lu* (Laotian black-crested gibbon) adult male, MCZ 46289. Photo by Annie Lussier and Peter Weinberg, Museum of Comparative Zoology and Harvard University.

Figure 21. *Nomascus concolor lu* (Laotian black-crested gibbon) adult female, MCZ 46288. Photo by Annie Lussier and Peter Weinberg, Museum of Comparative Zoology and Harvard University.

Figure 22. *Nomascus concolor lu* (Laotian black-crested gibbon) adult female, MCZ 46288. Photo by Annie Lussier and Peter Weinberg, Museum of Comparative Zoology and Harvard University.

Figure 23. *Nomascus concolor lu* (Laotian black-crested gibbon) adult female and infant, photo was reproduced from a video taken in the Bokeo Nature Reserve. Photo permission: Jean-Francois Reumaux.

Figure 24. *Nomascus concolor lu* (Laotian black-crested gibbon) subadult, AMNH 148262. Photo permission: Jean Spence, American Museum of Natural History.

Figure 25. *Nomascus leucogenys siki* (southern white-cheeked gibbon) adult female “Fany”, 1 year 10 month old male “Tai Chi”, Zoo Mulhouse. June 2004. Photo by David Gomis.

Figure 26. *Nomascus n. nasutus* (Cao Vit black-crested gibbon) juvenile female “Patzi” and juvenile male *Nomascus leucogenys siki* “Mohle”, Berlin Tierpark, Germany. 1963. Photo from archive of Tierpark Berlin.

Figure 27. *Nomascus n. nasutus* (Cao Vit black-crested gibbon) infant female “Patzi”, Berlin Tierpark. 1962. Photo from archive of Tierpark Berlin.

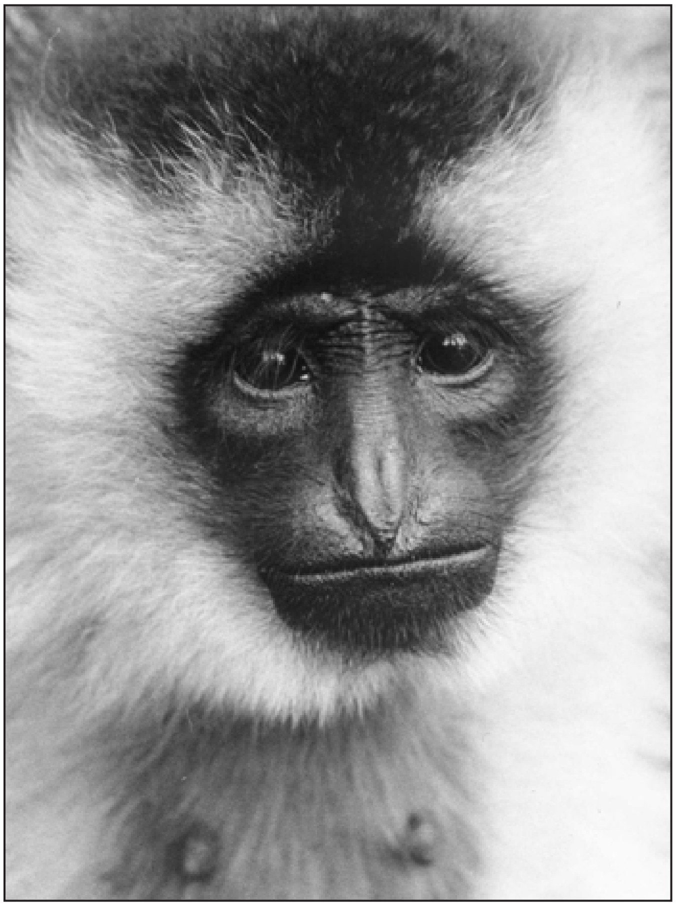

Figure 28. *Nomascus n. nasutus* (Cao Vit black-crested gibbon) adult female “Patzi”, Berlin Tierpark. August 1970. Photo from archive of Tierpark Berlin.

Figure 29. *Nomascus n. nasutus* (Cao Vit black-crested gibbon) adult female “Patzi”, Berlin Tierpark. 1972. Photo from archive of Tierpark Berlin.

Figure 31. *Nomascus nasutus hainanus* (Hainan black-crested gibbon) adult female and infant. Hainan. Photo by Bawangling National Nature Reserve staff.

Figure 30. *Nomascus nasutus hainanus* (Hainan black-crested gibbon) adult male, Hainan, China. Photo by Bawangling National Nature Reserve staff.

Figure 32. *Nomascus l. leucogenys* (northern white-cheeked gibbon) female left “Ricky”, male right “Vok”, GCC. Photo by Jim Zuckerman.

Figure 33. *Nomascus leucogenys siki* (southern white-cheeked gibbon) subadult male “Pimkie”, Zoo Mulhouse, France. Photo by Aline Drouin.

Figure 35. *Nomascus leucogenys siki* × *Nomascus gabriellae* (natural hybrid) adult female “Demi”, Zoo Mulhouse. Photo by Aline Drouin.

Figure 34. *Nomascus leucogenys siki* × *Nomascus gabriellae* (wild-born hybrid) juvenile female “Kim Khi”, GCC. Photo by Alan Mootnick.

Figure 36. *Nomascus gabriellae* (buff-cheeked gibbon) adult female left “Bahmetoo”, adult male right “Koo”, Los Angeles Zoo, California. Photo by Alan Mootnick.

Figure 37. *Hoolock hoolock* (western hoolock) neonate. Borajan Reserve Forest, Assam. Photo by Kashmira Kakati.

Figure 39. *Hoolock hoolock* (western hoolock) adult male "Turja" Dhaka Zoo. Bangladesh. Photo by Alan Mootnick.

Figure 38. *Hoolock hoolock* (western hoolock) subadult Alipore Zoo. India. Photo by Mike Dee.

Figure 40. *Hoolock hoolock* (western hoolock) adult female "Lucky" and 14 month old male "Sugrib" Dhaka Zoo. Bangladesh. Photo by Alan Mootnick.

Figure 41. *Hoolock hoolock* (western hoolock) adult female “Alfa”,GCC. Photo by Alan Mootnick.

Figure 42. *Hoolock hoolock* (western hoolock) adult female “Alfa”, GCC. Photo by Alan Mootnick.

Figure 43. *Hoolock leuconedys* (eastern hoolock) adult male “Arthur” and adult female “Betty”, GCC. Photo by Erin Bell.

Figure 44. *Hoolock leuconedys* (eastern hoolock) adult male “Arthur” and adult female “Betty”, GCC. Photo by Erin Bell.

Figure 45. *Hoolock leuconedys* (eastern hoolock) adult female “Drew”, GCC. Photo by Erin Bell.

Figure 46. *Hoolock leuconedys* (eastern hoolock) juvenile female left “Drew”, juvenile male right “Chester”, GCC. Photo by Alan Mootnick.

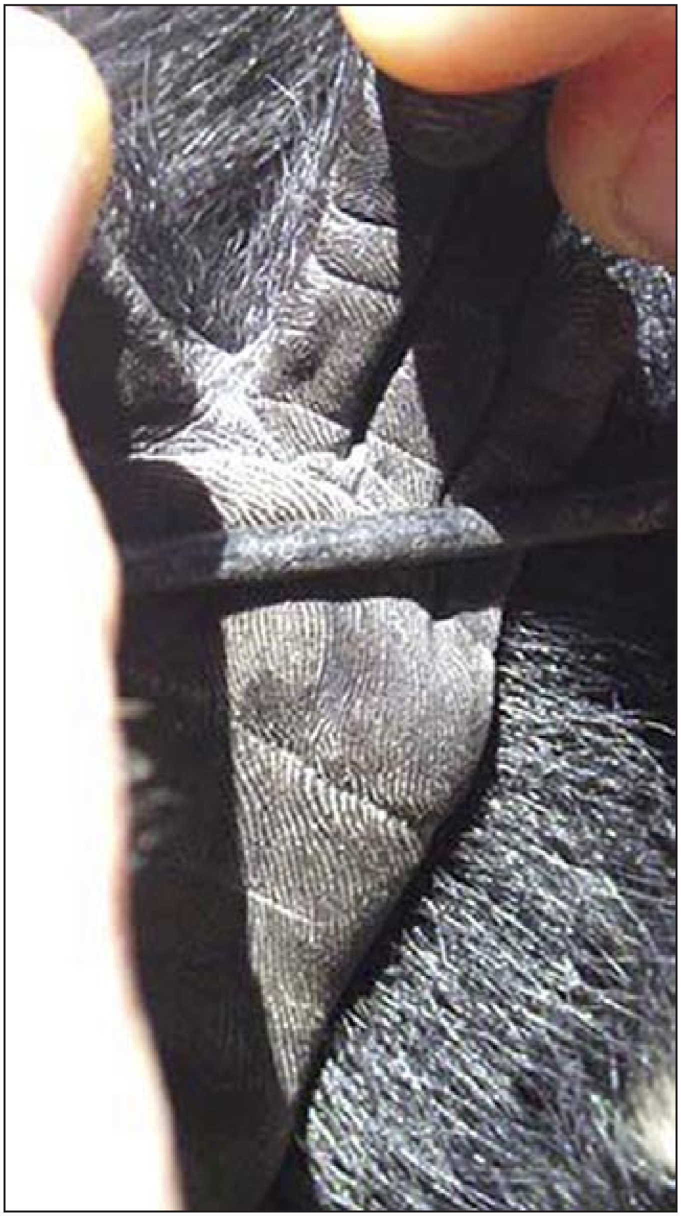

Figure 48. *Hylobates klossii* (Kloss’ gibbon) female “Nanam”, Gibbon Foundation, Indonesia. Slight interdigital webbing between the second and third digits. Photo by David Broadhurst.

Figure 47. *Hylobates klossii* (Kloss’ gibbon) adult female, Lion County Safari, California. Photo by staff photographer.

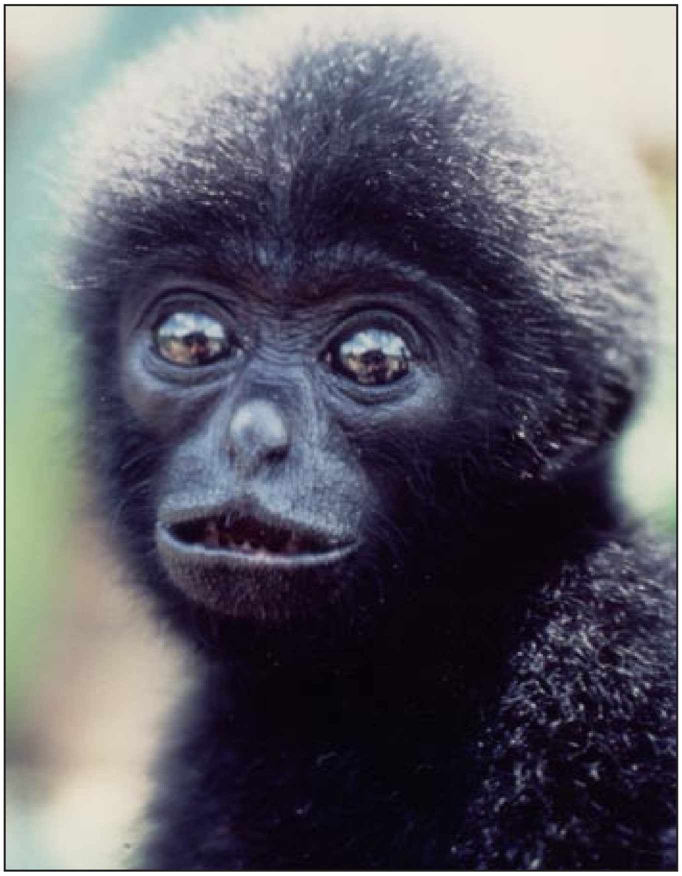

Figure 49. *Hylobates klossii* (Kloss' gibbon) infant, South Pagai. Photo by Richard Tenaza.

Figure 51. *Hylobates pileatus* (pileated gibbon) adult male "Birute", GCC. Photo by Alan Mootnick.

Figure 50. *Hylobates klossii* (Kloss' gibbon) 8 yr old female "Nanam", Gibbon Foundation, Indonesia. Photo by Micca Rogers.

Figure 52. *Hylobates pileatus* (pileated gibbon) 52 month old female "Kanako", GCC. Photo by Erin Bell.

Figure 53. *Hylobates pileatus* (pileated gibbon) adult female "JR" in first trimester, 23 month old male "Truman", GCC. Photo by Erin Bell.

Figure 55. *Hylobates pileatus* (pileated gibbon) adult female "Tuk", GCC. Photo by Erin Bell.

Figure 54. *Hylobates pileatus* (pileated gibbon) adult female "JR", 1 day old female "Jitka", GCC. Photo by Erin Bell.

Figure 56. *Hylobates pileatus* (pileated gibbon) adult female "JR", 32 month old male "Truman", GCC. Photo by Erin Bell.

Figure 57. *Hylobates pileatus* (pileated gibbon) 4 yr 6 mo male “Kokopelli”, GCC. Photo by Alan Mootnick.

Figure 58. *Hylobates pileatus* (pileated gibbon) 5 year 7 month old male “Mateas Binti”, GCC. Photo by Erin Bell.

Figure 59. *Hylobates moloch* (Javan gibbon) adult female “Chloe”, 1 day old male “Lionel”, GCC. Photo by Alan Mootnick.

Figure 60. *Hylobates moloch* (Javan gibbon) adult male “Chilibi”, GCC. Photo by Suzanne Kokel.

Figure 61. *Hylobates moloch* (Javan gibbon) adult female "Chloe", 6 month old male "Reg", GCC. Photo by Alan Mootnick.

Figure 62. *Hylobates moloch* (Javan gibbon) 3 yr old male "Lionel", 6 year 10 month old male "Isaac", GCC. Photo by Clare Cunningham.

Figure 63. *Hylobates m. muelleri* (eastern Müller's gibbon) adult female "Dongkey", 1.5 month old infant, Kalaweit. Photo by Wandy.

Figure 64. *Hylobates m. muelleri* (eastern Müller's gibbon) subadult male, Taman Safari, Indonesia. Photo by Alan Mootnick.

Figure 65. *Hylobates muelleri funereus* (northern Müller's gibbon) adult female "Abbey", GCC. Photo by Alan Mootnick.

Figure 66. *Hylobates muelleri abbotti* (Abbott's Müller's gibbon) adult female and infant, Singapore Zoo. Photo by Roland Wirth.

Figure 67. *Hylobates muelleri abbotti* (Abbott's Müller's gibbon) adult male "Hylo", Edinburgh Zoo, Great Britain. Photo by Elliott Haimoff.

Figure 68. *Hylobates agilis* (agile gibbon) adult female and infant, Singapore Zoo. Photo by staff photographer.

Figure 69. *Hylobates a. agilis* (mountain agile gibbon) juvenile female "Ruby Baby", GCC. Photo by Alan Mootnick.

Figure 70. *Hylobates a. agilis* (mountain agile gibbon) 12 year 4 month old female "Ruby Baby" and 6 day old male "Milton", GCC. Photo by Donald Johanson.

Figure 71. *Hylobates a. agilis* (mountain agile gibbon) adult male "Bebopen Baby", GCC. Photo by John Williams.

Figure 72. *Hylobates a. agilis* (mountain agile gibbon) adult male "Sonny", GCC. Photo by Suzanne Kokel.

Figure 73. *Hylobates a. agilis* (mountain agile gibbon) adult female "Mumma" and infant male "Albert", GCC. Photo by Shawn Tanaka.

Figure 74. *Hylobates agilis unko* (lowland agile gibbon) adult male “Homer”, GCC. Photo by Alan Mootnick.

Figure 76. *Hylobates lar* (lar gibbon) (brown color phase) 15 month old female “Princess”, Cleveland Amory’s Black Beauty Ranch, Texas. Photo by Lee Theisen-Watt.

Figure 75. *Hylobates albibarbis* (white-bearded gibbon) adult female “Jackie”, Valley Zoo, Canada. Photo by staff photographer.

Figure 77. *Hylobates lar* (lar gibbon) (brown color phase) 15 month old female “Princess”, Cleveland Amory’s Black Beauty Ranch. Photo by Lee Theisen-Watt.

Figure 78. *Hylobates l. lar* (Malaysian lar gibbon) subadult male, Zoo Negara, Malaysia. Photo by staff photographer.

Figure 79. *Hylobates lar entelloides* (Thai lar gibbon) (born in northeast Thailand) adult female "Judy", GCC. Photo by Alan Mootnick.

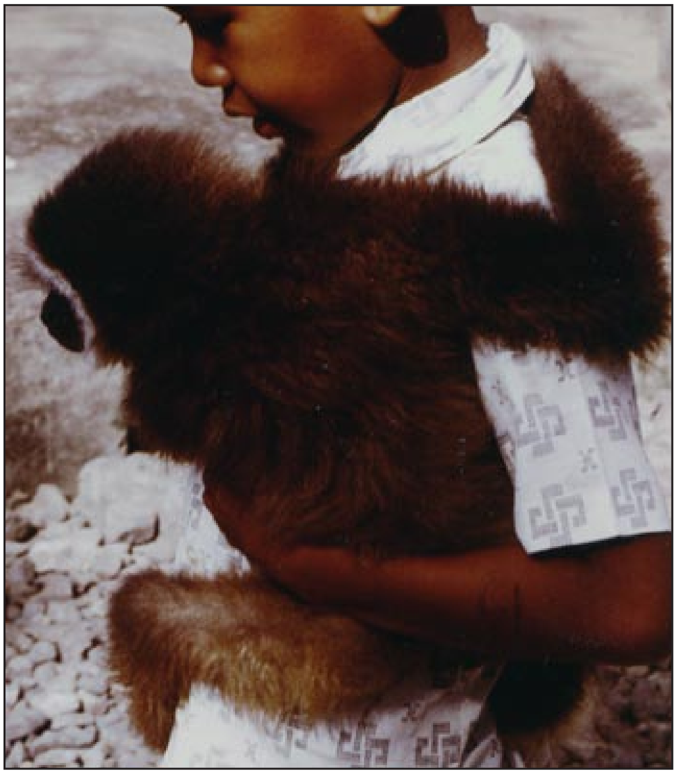

Figure 80. *Hylobates lar vestitus* (Sumatran lar gibbon) juvenile, Tapaktuan, Indonesia. Photo by Elsie Marshall.

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Song Activity of the Pileated Gibbon, *Hylobates pileatus*, in Cambodia

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Abstract: The song structure of pileated gibbons (*Hylobates pileatus*) was studied in eight locations in southwestern Cambodia. Male and female vocalizations were recorded daily between 07:00 and 13:00 for five consecutive days at each. The results showed that peak calling activity occurs around 10:00, with slight variation between different locations. A female's song is typically made up of approximately seven to eight phrases of great calls (average = 7.63 ±2.36), each lasting an average of 13.25 ±6.09 seconds. Matching male call phrases are relatively stable at 11.55 ±3.82 seconds and are positively correlated with the duration of matching female songs, whereas solo male call phrases are shorter, 10.66 ±9.16 with no correlation to female songs. The number of great call phrases, the sequences, and duration in female songs varied significantly between individuals from different localities. This suggests that gibbon develop local dialects and that songs constitutes an important parameter in pair formation and social structures.

Key words: Gibbon, *Hylobates pileatus*, song activity, Cambodia

Introduction

Gibbons (Hylobatidae) occur in most of eastern Asia, from northwest India in the west, to China in the east and Java (Indonesia) in the south. They generally exhibit monogamous social structures with well-defined territories (Mackinnon and Mackinnon 1977; Chivers 1984; Leighton 1987; Brockelman *et al*. 1998) and distinguish themselves from other primates by producing long and loud song bouts (Haimoff 1984; Brockelman *et al*. 1998; Geissmann 1999, 2002). Gibbon duets are well-timed and complex vocal interactions that influence pair-bonding behavior (Chivers 1976; Brockelman and Srikosamatara 1984; Raemakers *et al*. 1984; Palombit 1994; Geissmann 1995, 1999, 2000, 2002). Most of the duets and individual calls are distinctly different from each other; so much so that a trained listener can easily distinguish between, for example, two different vocalizing couples (Geissmann pers. comm.). Some species, for example siamang (*Hylobates syndactylus*), exhibit particularly complex vocal structures, and it is consequently considerably more difficult to distinguish between two different songs without help from an audiogram (Geissmannn 1999, 2000).

Maples *et al.* (1989) and Geissmann (1999, 2000) provided evidence that the duet of siamangs (*H. syndactylus*) plays an important role in pair bonding. Such duets are the result of learned behavior, primarily through intensive adaptive vocal interaction between a male and a female (Maples *et al.* 1989; Geissmann 1999, 2000). This suggests that gibbons have a larger song repertoire than normally recorded in the field and that song activity can be adapted to a new partner. Although it is well known that two or more groups of gibbons can be distinguished from their songs alone, it is possible that even individuals differ in their song composition on different days. It has been suggested that it is possible to build a phylogenetic relationship on the basis of acoustic repertoire (Geissman 2002; Konrad 2004). Takacs *et al*. (2005) revealed that a phylogenetic relationship based on acoustic repertoire alone does not necessarily match that of a phylogenetic relationship using DNA sequences. Nevertheless, differences in female great calls can be easily detected in an audiogram, and differences — if any — in song composition, duration, time, and structure should be possible to record directly in the field.

The pileated gibbon, *Hylobates pileatus*, is found in Thailand, Cambodia, and Laos west of the Mekong River (Lekagul and McNeely 1988; Corbet and Hill 1992; Traeholt *et al*. 2005). It is abundant in both logged and virgin forests of western Cambodia, and duets usually in the mornings (Traeholt *et al*. 2005). This study was undertaken in conjunction with Fauna and Flora International's Cambodia Primate

Programme and examines the differences in the song structure of pileated gibbons in a number of sites in Cambodia.

Methods

Gibbon songs were recorded from eight locations (Table 1) for five consecutive days at each. All locations were in heavily logged, evergreen forest, although Plot 1 in Chipat was significantly more degraded than the others.

We recorded gibbon duets between 07:00 and 13:00 from three different listening posts forming an equilateral triangle of 1 km on each side. For each duet we recorded time started and ended, duration, date, temperature, weather condition, and location (using a global positioning system) of both males and females. When a female was silent for 15 minutes we considered her great call as terminated (i.e., when the female started another great call in the 16th minute following termination of the previous call we considered it a new song). A male call that was part of a duet was a matching call. Male calls that were not part of a duet we refer to as non-matching calls. We defined a song as consisting of a number of call phrases (i.e., a female's great call is repeated several times in the space of a complete song). Among the gibbons in Chipat and Botum Sakor we recorded the number of phrases by one-zero sampling with 1-minute intervals. An example is given in Table 2. The duration of each female and male call phrases was measured in seconds. We used the t-test (two-sample, unequal variance: *p* value of 0.05 to accept a null hypothesis) to test for any statistical differences in song duration, number of call phrases, and duration.

Results

The pileated gibbon exhibits clear diurnal calling activity (Fig. 1). Peak calling occurred at 10:00 (sample size = 101 recorded songs; Fig. 1). There was, however, a slight difference in calling activity among the Chipat gibbons, who called equally frequently between 10:00 and 11:00 (Fig. 1).

Although all the females' great calls were typical of the species, the number of call phrases in each song, their sequences, and duration varied considerably (Table 3). This was apparent not only between different individuals, but also in the day-to-day activity for the same individual. The sequences of call phrases of the song of female BS1, for example, differed considerably (Table 3). She could produce eight great calls over 11 minutes in one song (sequence 7 in Table 3), and two single phrases over 11 minutes in another (sequence 5 in Table 3).

A female pileated gibbon's song is made up of approximately 7–8 phrases of great calls (Table 4; average = 7.63 ±2.36). Each phrase lasts for an average of 13.25 ±6.09 seconds (Fig. 2a). The length of matching male call phrases is relatively stable at 11.55 ±3.82 seconds (Fig. 2a; high = 24

Table 1. The eight survey locations in Cambodia.

Location	Coordinates	Habitat
Samling 1	103°52′16.13″E, 11°16′19.75”N	Secondary tall evergreen forest
Samling 2	103°49′19.84″E, 11°17′13.81″N	Secondary tall evergreen forest
Chipat 1	103°28′27.31″E, 11°29′44.23″N	Secondary evergreen, low and open canopy
Chipat 2	103°29′37.63″E, 11°29′31.81″N	Secondary tall evergreen forest
Kirirom	104°02′26.80″E, 11°18′52.03″N	Secondary tall evergreen and sporadic grassland
Phnom Prom	103°58′10.98″E, 11°23′25.66″N	Secondary evergreen forest
Botum Sakor 1	103°20′38.81″E, 11°14′28.89″N	Secondary tall evergreen forest
Botum Sakor 2	103°22′14.77″E, 11°10′11.91″N	Secondary tall evergreen forest

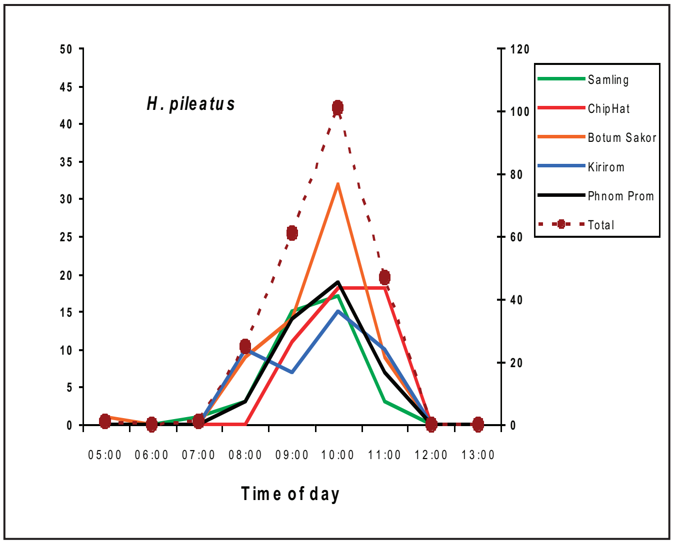

Figure 1. The diurnal calling activity of pileated gibbons from eight different localities in western Cambodia. We did not record any song activity after 12:00.

Table 2. An illustration of the one-zero sampling of three different pileated gibbon songs from western Cambodia. To save space the table is incomplete (i.e., it only contains a number of zeros after the last recorded phrase of each respective gibbon song). In reality, each song was considered terminated after 15 minutes (15 × 0) of silence by the female.

Gibbon																	No of phrases	Duration (min.)
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	7	7
2	1	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	6	11
3	1	1	0	1	1	0	1	1	0	1	0	0	0	0	0	0	7	10
Minute	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		

Table 3. An example of one-zero sampling of gibbon songs from Chipat (CHP) and Botum Sakor (BS). CHP3 = gibbon #3 from Chipat, BS1 = gibbon #1 from Botum Sakor. *) The duration of this song exceeded the number of columns available in this table. Hence the number of phrases (7) does not match the counted number in Table 4.

	Gibbon																				No. of Phrases	Duration (min.)
1	CHP1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	7	7
2	CHP3	1	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	6	11
3	BS1	1	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	5	9
4	BS1	1	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	6	10
5	BS1*)	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	7*)	32*)
6	BS1	1	0	1	1	1	1	0	1	0	0	1	0	0	1	0	0	1	0	1	10	19
7	BS1	1	1	1	0	1	0	1	1	1	0	1	0	1	0	0	1	0	0	0	10	16
8	BS4	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	4	9
	Minute	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		

Table 4. The number of call phrases and total song duration of three female *H. pileatus* songs in Chipat and five individuals in Botum Sakor, Cambodia. Numbers in parentheses refer to the number of recorded songs assigned to the respective individual. For example, BS1 (5) denotes that we recorded five songs from Botum Sakor Gibbon Number 1.

Location	Gibbon	No. of phrases	Average	Average/min	Song duration (min)	Average song duration (min)
Chipat	CHP1 (1)	7		1.00	7.00	7.00
	CHP2 (1)	10		0.77	13.00	13.00
	CHP3 (1)	6		0.46	13.00	13.00
	Average/song	7.67 ±1.70			Average (N = 3)	11.00 ±2.83
Botum Sakor	BS1 (5)	38	7.6	0.44	86.00	17.20
	BS2 (1)	8		0.73	11.00	11.00
	BS3 (2)	19	9.5	0.83	23.00	11.50
	BS4 (4)	26	6.5	0.52	50.00	12.50
	BS5 (1)	8		0.89	9.00	9.00
	Average/song	7.62 ±2.50			Average (N = 13)	13.77 ±6.55

seconds, low = 7 seconds), whereas male call phrases that are not part of a duet song are relatively shorter, 10.66 ±9.16 seconds but with much higher fluctuation (Fig. 2a; high = 73 seconds, low = 2 seconds). There are no significant differences in the phrase duration of matched and unmatched male calls, although two phrases of unmatched calls lasted for 45 and 73 seconds, respectively. These appear to be uncharacteristic song activity, and omitting these two calls from the statistical analysis results in a significant difference in the phrase length of matched and unmatched male calls ($p<0.005$, t-test). Furthermore, the lengths of matched phrases were positively correlated with those of female call phrases (Fig. 4; $k = 0.1568$), whereas the length of unmatched call phrases were negatively correlated with the length of female call phrases ($k = –0.0303$). The sequences of call phrases in a complete female song differed between individuals irrespective of their location (Table 4). Differences were also recorded within inter-day call activity of the same female (Fig. 2b), however, there were no significant differences in average number of phrases per song and the total song duration between groups from different localities (Table 4, Fig 2c). Botum Sakor gibbons, however, used significantly longer call phrases in their songs than their conspecifics in Chipat ($p<0.001$, t-test) (Fig. 3). Within the Botum Sakor population there is also a significant difference between the longest and shortest female phrase duration ($p<0.005$, t-test).

Discussion

Communication within and between couples of pileated gibbons consist of complex structures of call phrases of different duration, frequency, and number. There is no doubt that frequent calling plays an important role in the social structure of gibbons but it is not yet clear to what extent such songs play a role in pair formation. It has been suggested that songs play a crucial role in pair formation of siamangs, *Symphalangus syndactylus*, and that couples often adjust their calling to each other (Maples *et al.* 1989; Geissman 1999, 2000, 2002). This could suggest that there is a continuous evolution of song patterns among Hylobatidae, and that gibbon groups that become isolated for a period of time will develop distinctly different song patterns. Although differences in individual female great calls can easily be detected in an audiogram and even be noted by an experienced listener in the field, it is less clear if there are any structural differences in songs of gibbon groups from one locality compared with another.

Our findings revealed that the number of great call phrases per female song was relatively constant throughout the study area (Table 4); however, this does not exclude the possibility that differences in number of call phrases can be found between groups of gibbons much farther apart. For example, pileated gibbons in Thailand may use significantly more phrases than pileated gibbons in southern Laos. The cur-

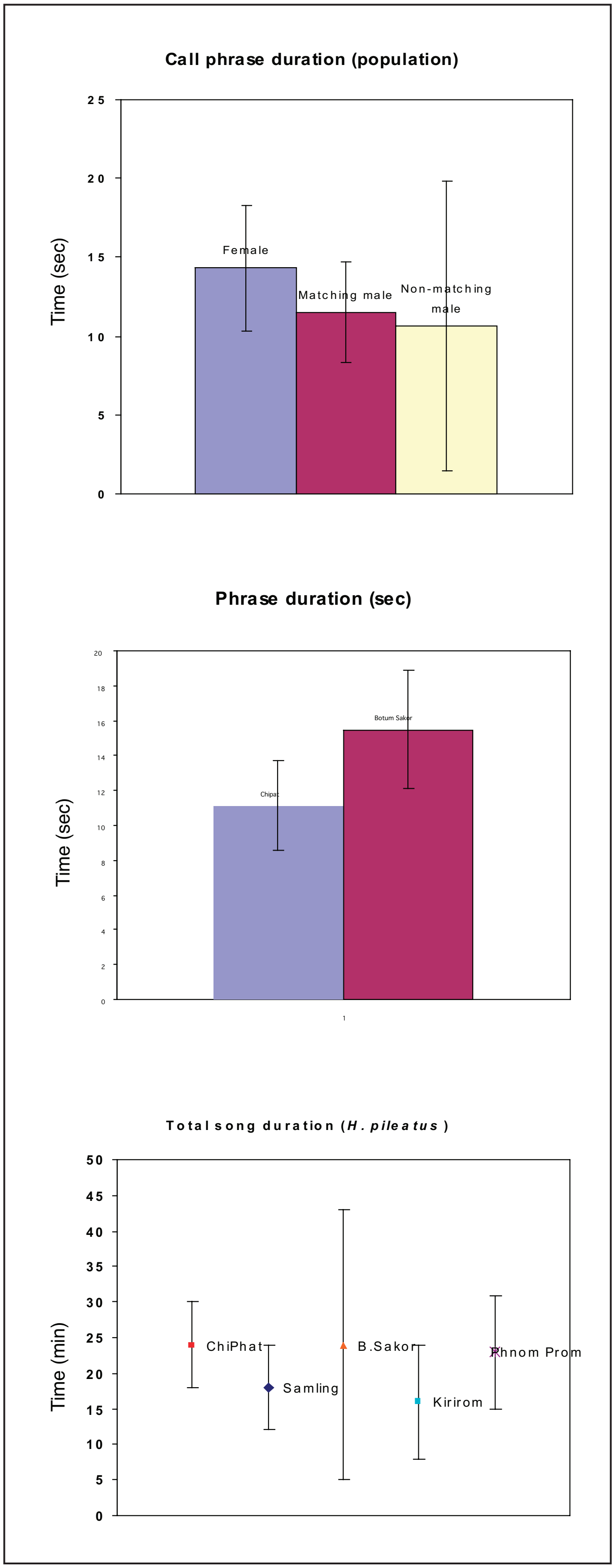

Figure 2a–c. Call phrases and song durations of female and male *Hylobates pileatus* in western Cambodia. The average phrase duration of females, matching male's phrases and un-matching male's phrases are illustrated in Figure 2a, the inter-day call activity of a single female is illustrated in Figure 2b, and the total female song duration from each survey location is illustrated in Figure 2c.

rent data do not allow us to draw any definite conclusions, and consequently, the question remains open as to what extent the number of phrases per song can be used as a parameter to distinguish between different groups or even subgroups of pileated gibbons.

Female pileated gibbons show distinctly different individual song patterns in relation to phrase duration and frequency. Although we found no significant differences in the total song duration of gibbons from different areas (Fig. 2c), we were able to detect significantly longer call phrases among Botum Sakor

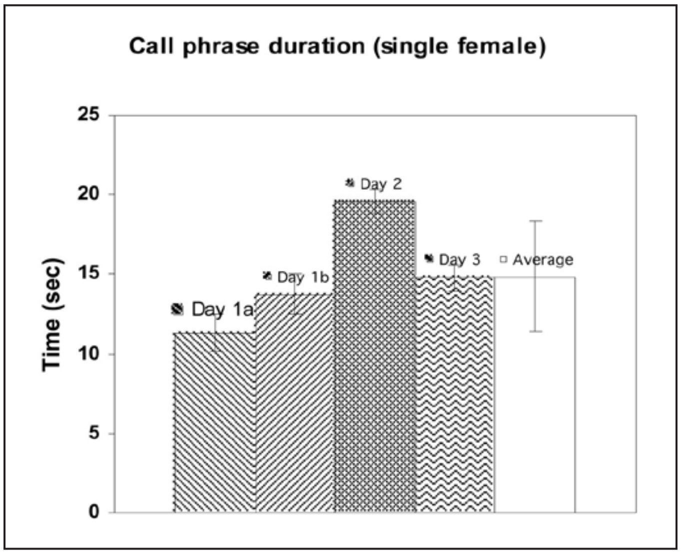

Figure 3. Phrase duration of female great calls in two study sites, Chipat and Botum Sakor. Botum Sakor females' call phrases are significantly longer than the Chipat counter parts (p<0.001, t-test).

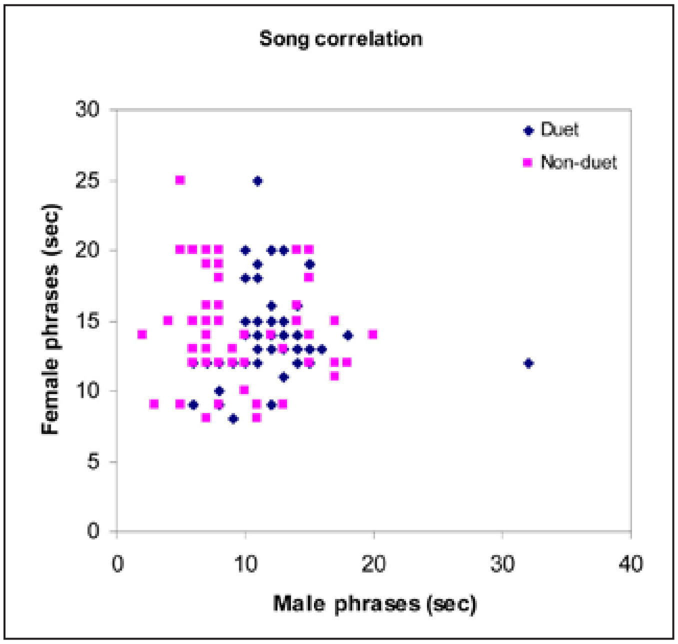

Figure 4. Correlation between male and female call phrases. There is a positive correlation between male phrases that is part of a duet (correlation factor = 0.1568) where as there is negative correlation between female phrases and "un-matched" male phrases (correlation factor = -0.0303).

groups than Chipat groups (p<0.001, t-test) (Fig. 3). It was not possible, however, to confirm any differences between female call phrase duration in the same area, which was partly due to considerable inter-day individual activity (i.e., the individual inter-day fluctuation diluted the effect of variation between two individuals from two different localities; Fig. 2b). It is not clear what induces the inter-day fluctuation in the duration and sequence of female call phrases. There was, however, a significant difference between gibbon songs in terms of the longest and shortest phrase duration (p<0.005, t-test), suggesting that there may be specific local dialects between subpopulations of pileated gibbons and that such dialects are possibly reflected in the duration of respective call phrases.

There are indications that male calling structure is significantly affected by female great call phrases. Male calls that follow female great call phrases ("matched" call phrases) last significantly longer than "solo" male calls (p<0.005, t-test) and their lengths are positively correlated with the female phrase length ($k = 0.1568$). In contrast, the length of male solo calls are negatively correlated with the length of female call phrases ($k = -0.0303$). Furthermore, male calls that form part of a duet song fluctuate less in terms of duration. This lends support to Geissmann's theory (Geissmann 1984, 1999, 2000, 2002) that duet songs are developed through intensive adaptive vocal interaction between males and females, and that such songs constitute a crucial part of gibbon social structure. From a conservation point of view, this suggests that harvesting of either sex may lead to delayed reproductive performance partly due to prolonged pair formation. This, combined with some gibbon species' slow dispersal rate and reluctance to leave their territory even with significant disturbance (Johns 1985, 1986), indicates that any harvest of established pairs of pileated gibbons as pet animals should remain prohibited until further studies are able to quantify to what extent the speed of new pair formation is dependant on song compatibility and adaptability.

Acknowledgments

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Distribution and Conservation Status of the Arunachal Macaque, *Macaca munzala*, in Western Arunachal Pradesh, Northeastern India

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Abstract: The recently described Arunachal macaque, *Macaca munzala*, has to date been reported only from western Arunachal Pradesh, Eastern Himalaya. Our surveys have recorded a total of 35 troops and 569 individuals, probably a conservative estimate, for the macaque population in the Tawang and West Kameng districts of the state. The species appears to be tolerant to anthropogenic habitat change, but is vulnerable to hunting and retaliatory killing in response to crop damage. Data from one part of the area surveyed, however, indicate that the species can attain remarkably high population densities in the absence of hunting. *Macaca munzala* will need to be protected in human-modified landscapes, and the issues of crop damage and retaliatory persecution must be addressed urgently.

Key Words: Arunachal macaque, *Macaca munzala*, Arunachal Pradesh, India, population density, human-wildlife conflict, hunting, conservation

The northeastern part of India (*c*.255,000 km²), comprising seven states, supports the highest diversity (11 species) of primates in the country (Choudhury 2001; Srivastava and Mohnot 2001; Kumar *et al*. 2005; Sinha *et al*. 2005). Of these states, Arunachal Pradesh (26º28′–29º30′ N, 91º30′–97º30′ E; 83,743 km²) is arguably the country's richest region in terms of terrestrial biodiversity. A wide altitudinal range (100 to >6,000 m), an associated diversity of habitats (tropical rainforests, subtropical and temperate forests, alpine meadows), and a unique location at the junction of the Eastern Himalaya and Indo-Burma biogeographical zones contribute to the rich diversity of mammalian fauna in this state (Mishra *et al*. 2004). Large tracts of forest still remain in Arunachal Pradesh, in part due to its low human population density (13 per km²).

Recent surveys in the mid- to high elevations of western Arunachal Pradesh led to the discovery of a rich assemblage of mammals (Mishra *et al*. 2006), including the Arunachal macaque, *Macaca munzala*, first described by Sinha *et al*. (2005). Belonging to the *sinica* species-group of the genus *Macaca*, this relatively short-tailed, dark, and heavy-set primate was found to occur mainly at altitudes between 2,000 and 3,000 m in the westernmost districts of Tawang (2,172 km²; Fig. 1) and West Kameng (7,422 km²). Given the contiguity of habitat, the Arunachal macaque is also likely to occur in the bordering areas of central Arunachal Pradesh, as well as in parts of Tibet and Bhutan, though these areas remain to be surveyed for the species.

We sighted a total of 35 troops and at least 569 individuals of the Arunachal macaque during surveys conducted between April 2004 and August 2005 (Kumar *et al*. in prep). Of these, 32 troops (*c*.540 individuals) were sighted in Tawang and three (*c*.29 individuals) in West Kameng (Fig. 1). Information from local people indicated the possible occurrence of at least 25 more troops in the region. Most of the macaques were sighted within the 2,000–2,250 m altitudinal zone, though we recorded them up to 3,000 m in fir, *Abies densa* (Pinaceae), forests. Local people reported the seasonal occurrence of macaques up to 3,500 m, and we accordingly estimated the total potential macaque habitat (all areas below 3,500 m) within Tawang district to be *c*.800 km² (approximately one-third of the district's total area). In the Zemithang area of this district, which has a relatively high abundance of macaques and where we found most of the existing troops, we recorded 10 troops (234 individuals), and estimated a density of 0.94 troops and 22.01 individuals per km².

More than three-quarters of the Arunachal macaques sighted during our surveys were in human-modified landscapes and forests. More than half of the individuals sighted were in degraded broadleaved forests and degraded open scrub in the vicinity of human habitation. These degraded forests

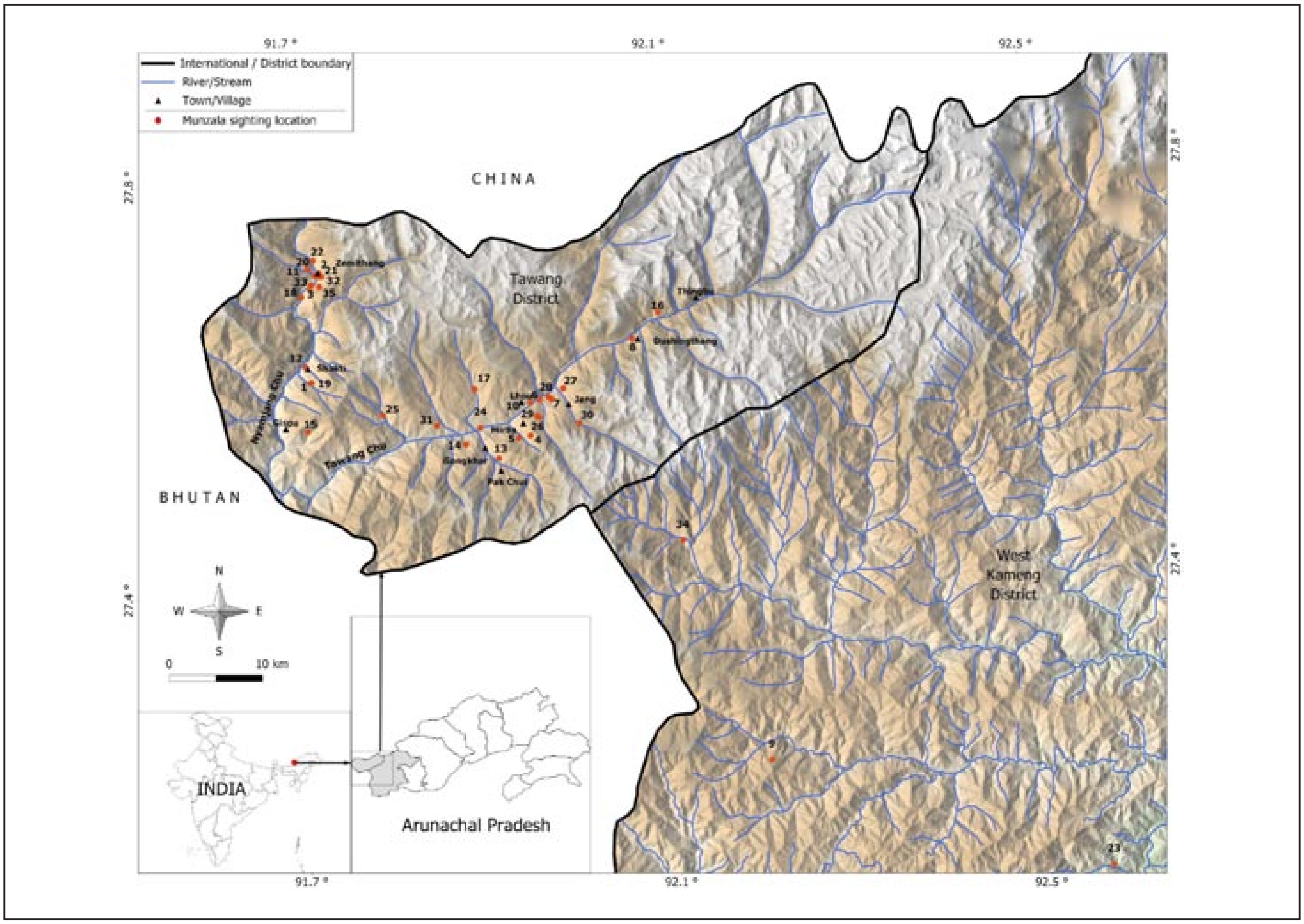

Figure 1. The sighting locations of the Arunachal macaque, *Macaca munzala*, in western Arunachal Pradesh, northeastern India. The cluster of sightings in northwest Tawang district are those from the high-density Zemithang area where the village councils prohibit hunting.

have moderate to high levels of anthropogenic disturbance in the form of felling, livestock grazing, lopping, and leaf litter collection.

We conducted detailed surveys in a number of villages to evaluate the extent of human-macaque conflict in Tawang and West Kameng districts (Kumar *et al*. in prep). In 35 of the 64 villages where we conducted perception surveys, people reported the Arunachal macaque to be the most common cause of crop loss. The extent of crop damage by macaques was found to be greatest at altitudes between 2,000–2,500 m owing to the greater abundance of villages and fields in this zone. We found the intensity of conflict with macaques to be high in five of the six villages where we carried out detailed, door-to-door surveys. The only exception was the high-altitude Thingbu village where conflict with macaques was reported to be very low, and where, due to their religious beliefs, the village council imposes a fine of INR 1000 (*c*.US$20) on anyone hunting macaques. Thingbu is largely pastoral, with very little cultivation. In the other five villages, a high level of conflict was reported by 87% to 100% of the 244 respondents, with the crops most affected being maize and millet (Kumar *et al*. in prep). Crop damage was reported to occur throughout the year but peaked between July to September. In a preliminary analysis, we estimated the financial losses to be between INR3,250 to INR4,600 (*c*.US$70 to 100) per family per year.

In two villages, about 92% of the people acknowledged the occurrence of retaliatory killing of the macaques, while only some respondents reported this in the other three villages where high levels of conflict were also reported. In the four villages where persecution was confirmed, people reported that an average of 35 macaques had been killed over the last five years. Snaring, shooting, and the use of bows and arrows being the most commonly reported means employed to kill them.

In Arunachal Pradesh, we believe that the Tawang district, given its particular ethnic composition and practices, should support the highest density of the Arunachal macaque and provide for its best conservation prospects. In most other areas of the state, hunting, an important tradition for most of Arunachal Pradesh's 26 tribes, seriously threatens most wildlife populations (Datta 2006). Primates are commonly hunted throughout the state, with most of the tribes killing them for their meat and for medicines (Borang and Thapliyal 1993; Singh 2001; Solanki and Chutia 2004). People of the *Monpa* agro-pastoral tribe living in the Tawang district, however, generally do not hunt primates for meat (Solanki and Chutia 2004; Mishra *et al*. 2006). Due to their Buddhist beliefs, hunting, although prevalent, is not as widespread or culturally ingrained in the *Monpa* community as it is in most other tribes of Arunachal Pradesh. In fact, some of the villages in Tawang have voluntarily prohibited the hunting of wildlife in their village forests (Mishra *et al*. 2006). Hunting, however, has deep cultural roots in this state as in much of northeastern India, and its reduction or regulation may not be feasible merely through law-enforcement, but will require a close and culturally sensitive engagement with the local communities.

An important legislative means to facilitate wildlife conservation is the scheduling of species under the Indian Wildlife Protection Act, 1972 (Anonymous 2002). Schedules I and II of this act provide the highest level of legal protection to a species, the basis of the listings being population status in the wild and threats. Currently, our knowledge of the Arunachal macaque's distribution and population sizes are not adequate to permit an informed choice of an appropriate schedule of the act. Furthermore, given that our knowledge of the morphology, genetics, and taxonomic variation among the macaques of northeastern India is still incipient (Kumar *et al*. 2005; Sinha *et al*. 2005; Chakraborty *et al*. in prep), it is perhaps more essential to support the conservation of all species in this macaque evolutionary hotspot, rather than designate individual species into schedules on the basis of incomplete biological and ecological information. In addition, the effectiveness of legislative instruments to effect conservation is completely dependent on the ability to implement them across differing sociocultural contexts. At the present time, it remains a serious challenge to ensure effective on-the-ground conservation of many of the Schedule I species in this part of the country. In culturally complex regions such as northeastern India, it is perhaps more important to design conservation strategies that, in the end, can be implemented, rather than merely slotting species into legal categories.

Our preliminary work thus brings to light both the challenges as well as the opportunities for the conservation of the Arunachal macaque. It appears that conservation efforts for the Arunachal macaque will need to focus on a landscape that has already seen considerable anthropogenic impacts. Among the most important current research needs is a better understanding of the patterns and intensity of crop-raiding, with a view to designing appropriate conflict-mitigation strategies. Although it is unlikely that conflicts can be eliminated, interventions are needed to minimize crop damage as well as offset losses. The potential of a variety of interventions needs to be assessed; these could include the adoption of alternate buffer crops, use of deterrents, better crop protection measures, habitat management in the vicinity of villages, and the introduction of crop compensation or insurance programs.

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Some Observations on the Hatinh langur, *Trachypithecus laotum hatinhensis* (Dao, 1970), in North Central Vietnam

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Abstract: The Hatinh langur, *Trachypithecus laotum hatinhensis* (Dao, 1970), is one of the many Vietnamese primates on the brink of extinction due to hunting and the loss of its natural habitat. This black langur, distinguished by its white moustache and sideburns that extend behind the ears to the nape, inhabits the limestone forests of the Central Annamite Mountains. The Hatinh langur is diurnal and largely arboreal, and group sizes are 15 or more. Here we report on surveys carried out in 1998–1999 in Quang Binh Province to determine the population status of *T. laotum hatinhensis*. In Vietnam, it occurs only in the limestone areas of five districts in the Quang Binh Province and Huong Hoa District of Quang Tri Province. The most important population is in the Phong Nha–Ke Bang National Park of Quang Binh Province; the only Vietnamese protected area where it is known to occur. Some observations on the species ecology and behavior are also included.

Key Words: Vietnam, Hatinh langur, limestone habitats, distribution, sleeping site, hunting, protected area

Introduction

With more than 25 species and subspecies, Vietnam has the highest primate diversity of any country in Asia and the Indochina peninsula. Many are both endemic to Vietnam and endangered. Five of the world's most endangered primates are Vietnamese: the Cat Ba langur (*Trachypithecus poliocephalus*), Delacour's langur (*Trachypithecus delacouri*), the grey-shanked douc langur (*Pygathrix cinerea*), the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*), and eastern black crested gibbon (*Nomascus nasutus*) (Mittermeier *et al*. 2006). The Hatinh langur, *Trachypithecus laotum hatinhensis* (Dao, 1970) is also extremely threatened, being classified as Endangered on the *2006 IUCN Red List of Threatened Species* (IUCN 2006). Once widespread in a number of north-central Vietnamese provinces, deforestation and hunting mean that its distribution is now severely limited, and until recently it was thought to remain in only a few districts of Quang Binh Province. In 2005, however, a new population was found in Huong Hoa District, Quang Tri Province (BirdLife International Vietnam Programme 2005). A report of its occurrence in Gia Lai, well to the south, is disputed (Lippold and Vu Ngoc Thanh 1995; Pham Nhat *et al*. 1996a, 1996b).

Taxonomy and Distribution

The first specimen of this subspecies was collected at the hamlet of Cuc, in Ha Tinh Province (Bourret 1942), and a second was collected by Dao Van Tien, in February 1964, in Minh Hoa District of Quang Binh Province. Dao Van Tien (1970) named it *Presbytis francoisi hatinhensis*. Corbet and Hill (1992) listed it as a subspecies of *Semnopithecus francoisi*, and a number of authors have referred to it as *Trachypithecus francoisi hatinhensis* (e.g., Le Xuan Canh 1992; Dang Huy Huynh *et al*. 1994; Fooden 1996; Pham Nhat *et al.* 1996a, 1996b; Pham Nhat 2002). Although Brandon-Jones *et al.* (2004) listed it as *T. francoisi hatinhensis*, he earlier (1995) considered it to be a species separate from *francoisi*. Groves (2001, 2005) listed it as a full species based on the phylogenetic species concept (see also Workman and Covert 2005). Molecular genetic studies (Roos *et al*. 2001; Roos 2004) aligned *hatinhensis* with *laotum* (Thomas, 1911), placing it as a subspecies, and the name *T. laotum hatinhensis* has since been used by Nadler *et al*. (2003), which is followed here.

Le Hien Hao (1973) noted that the Hatinh langur occurred in the districts of Con Cuong, Tuong Duong of Nghe An Province, and Nhu Xuan District of Thanh Hoa. Over the next

20 years, there was almost no additional information on this subspecies in the wild. In 1992, Le Xuan Canh announced that photos of the Hatinh langur had been taken at a site adjacent to a market in Phong Nha, Bo Trach District of Quang Binh Province. In 1993, the Zoological Museum of Hanoi University collected a specimen, but without specific information on its origin. At the same time, the Forestry University of Vietnam collected a skin in Minh Hoa District of Quang Binh Province. We also collected some specimens at Dai A, Phong Nha, in 1999 (currently preserved at The Zoological Museum of Hanoi National University). Surveys by Pham Nhat *et al*. (1996a, 1996b) indicated that the hamlet of Cuc, Tuyen Hoa District in Quang Binh (the locality where Bourret [1942] collected the species) was the northernmost locality, but that today it is probably extinct there as the remaining limestone forest is severely degraded. There may also be a small population of 20–30 animals in the Khe Net forest, Tuyen Hoa District, but this has yet to be confirmed (Nadler *et al*. 2003).

Lippold and Vu Ngoc Thanh (1995) recorded the Hatinh langur in Con Cha Rang Nature Reserve in Gia Lai Province (14º33′N, 108º35′E). This locality, well to the south of the recognized range, was discussed by Pham Nhat *et al*. (1996a, 1996b) and Nadler *et al*. (2003). Pham Nhat *et al.* (1996a) indicated that its presence there is questionable—it is well to the south of the sites they surveyed—and if the Hatinh langur does survive there it is likely to be a very small relict population. Nadler *et al.* (2003) concluded that the presence of the Hatinh langur in the Tay Nguyen Plateau would be a major extension of its range, and needs further investigation. Vu Ngoc Thanh himself (pers. comm. 2006) believes that it was a mistaken record.

It appears that in the recent past the distribution of this subspecies ranged broadly from Nghe An to Quang Binh (Le Hien Hao 1973). Surveys in the central region of Vietnam carried out since 1998 by a number of scientists of our organization have shown that the Hatinh langur is now restricted to Quang Binh (districts of Minh Hoa, Bo Trach, Tuyen Hoa, Le Thuy, and Quanh Ninh), with the exception of the newly discovered population in Quang Tri Province. From the evidence currently available it would seem that the main stronghold of this population is in the districts of Minh Hoa and Bo Trach, where a vast primary forest exists in limestone ranges, particularly in the Phong Nha–Ke Bang National Park (Nguyen Xuan Dang *et al*. 1998; Nguyen Manh Ha 1999, 2004; Timmins *et al*. 1999).

In total, 16 groups were recorded by our team in Phong Nha in 1998 and 1999. A group was observed at Kim Lu, Tuyen Hoa, and two others, with unknown numbers of individuals, were seen at Cha Tum (Dan Hoa, Minh Hoa) and at Khe Dan (Kim Thuy, Le Thuy) in 2003. In total, 19 groups have been observed in four different districts of Quang Binh Province (Table 1). Additional recent surveys conducted by other researchers in Thanh Hoa, Nghe An, and Ha Tinh provinces failed to find evidence of Hatinh langur, and research conducted by us in 2003 in Quang Tri (Dakrong District), Ha Tinh (Huong Son District), and Nghe An provinces (Pu Huong Nature Reserve and Pu Hoat proposed nature reserve) also provided no evidence of their presence. We conclude that, with the information we have to date, in Vietnam the Hatinh langurs are primarily restricted to Quang Binh Province, with a small population in at least one further site in Quang Tri Province.

Table 1. List of Hatinh langur records and locations in Quang Binh Province, Vietnam.

Group number	Location (Quang Binh province)	Number of individuals
1	Khe Cha Tum (Dan Hoa, Minh Hoa district)	>07
2	Kim Lu (Tuyen Hoa District)	30
3	Khe Dan (Le Thuy District)	
4	Thung Tre (Phong Nha-Ke Bang National Park)	3
5	Thung Tre (Phong Nha-Ke Bang)	7
6	Thung Nhang (Phong Nha-Ke Bang)	12
7	Thung Nhang (Phong Nha-Ke Bang)	15
8	Tro Muong (Phong Nha-Ke Bang)	2
9	Tro Muong (Phong Nha-Ke Bang)	8
10	Tro Muong (Phong Nha-Ke Bang)	5
11	Thung Xuong (Phong Nha-Ke Bang)	6
12	Thung Lau (Phong Nha-Ke Bang)	5
13	Cop Ke (Phong Nha-Ke Bang)	11
14	Dai Cao (Phong Nha-Ke Bang)	7
15	Dai A (Phong Nha-Ke Bang)	10
16	Ba Giang (Phong Nha-Ke Bang)	6
17	Hang En (Phong Nha-Ke Bang)	4
18	Hang En (Phong Nha-Ke Bang)	5
19	Km28 (Phong Nha-Ke Bang)	3

Nadler *et al.* (2003) reported that Hatinh langurs also occur in the west of Khammouan Province of Lao People's Democratic Republic. This is quite reasonable because Phong Nha–Ke Bang shares the same limestone range with Hin Namon of Laos.

Morphological Characteristics

Locally, the Hatinh langur is known as the long-tailed gibbon or black gibbon. They are large monkeys weighing between 6 kg and 9 kg, and differ from the otherwise similar Francois' langur in having the white cheek stripe extend behind the ear onto the nape. Other differences noted by Nadler *et al.* (2003, p. 47) include "the whorls on the head, the shape of the crest, and the white moustache connecting to the white cheek stripes." Head/body lengths, tail lengths, and weights are shown in Table 2. Newborn infants have yellow fur, and begin turning black after two weeks. The infant is almost entirely black at three months.

Habitat

As recognized by a number of authors, these monkeys generally inhabit limestone forests (Osgood 1932; Dao Van Tien 1989; Pham Nhat 2002; Nadler *et al*. 2003) and our research since 1998 has corroborated this finding. The Hatinh langur preferentially inhabits areas with dense forest cover, but they also forage and move about in more open areas.

Table 2. Morphological characteristics of the Hatinh langur, *Trachypithecus laotum hatinhensis*[1].

		Average	n	Source
Head/body length (mm)				
Male	560 –590	575	2	EPRC[2]
	665		1	Brandon-Jones (1995)
Female	540 –570	556	3	EPRC[2]
	500		1	Brandon-Jones (1995)
Tail length (mm)				
Male	820 –870	845	2	EPRC[2]
	810		1	Brandon-Jones (1995)
Female	780 –900	817	3	EPRC[2]
	870		1	Brandon-Jones (1995)
Weight (kg)				
Male	8.2–8.7	8.45	2	EPRC[2]
	8.0		1	Brandon-Jones (1995)
Female	6.4–8.0	7.2	4	EPRC[2]

[1] Source: Nadler *et al*. (2003)

[2] EPRC = Endangered Primate Rescue Center, Cuc Phuong National Park

Dense forests cover approximately 90% of their range in the limestone hills of Phong Nha, Kim Lu, and Dan Hoa of Quang Binh Province. It is when they forage in open environments that it is possible to observe them. It is quite possible, however, that their current preference for these limestone forests is now largely an artefact of the pressures from widespread habitat loss and fragmentation and hunting (Li and Rogers 2005). The term "limestone langurs" was coined, it would seem, during an international symposium on the conservation of Vietnamese primates held at the Cuc Phuong National Park, 18–21 November 2003. Groves (2004) pointed out that this is a useful and ecologically descriptive collective for seven species of langur that are today associated with limestone forests but does not, it would seem, reflect a coevolution of these primates with these particular forests (Li and Rogers 2005).

Breeding and Group Structure

Hatinh langurs have been observed in a number of different social group structures. Group size generally ranges from two to 15 individuals (Nguyen Manh Ha 1999; Pham Nhat 2002), but groups of up to 30 individuals have been observed in Kim Lu, Tuyen Hoa of Quang Binh Province. The group structure normally includes one male and three or four females and their immature offspring (Nguyen Manh Ha 1999), but this may vary in relation to hunting pressure and the quality of the habitat. Hunting severely affects the social structure and number of individuals in the groups. In 1999 and 2000, for instance, during our survey in Phong Nha, local hunters reported that they had gunned down at least three entire groups of Hatinh langurs in Co Khu, Dai Cao, Hung Xuong of Phong Nha, and most of the Hatinh langur groups in Phong Nha and Dan Hoa were diminished due to illegal hunting in the area (Nguyen Manh Ha 1999). Other than the loss that hunted individuals represent to the population, skewed sex ratios and isolation from other groups caused by hunting can have a serious negative impact on population viability. Isolation caused by habitat fragmentation is also a serious concern, presumably affecting group composition due to lack of opportunities for dispersing individuals.

Females give birth to single offspring (Pham Nhat 2002) and breed all year round. Research has shown that births occur at different times of the year; for instance, at Phong Nha they have been recorded in July 1998, February and March 1999, July 2002, August 2003; at Dan Hoa in April 2004; and in Kim Lu in May and June 2004. Pham Nhat (2002) recorded births in August in the Endangered Primate Rescue Center, Cuc Phuong, and in November (probably in Phong Nha). There is a peak in births in the summer and spring, however, when food is abundant, the climate is warmer, and there is less rainfall (Nguyen Manh Ha 1999; Pham Nhat 2002).

Sleeping Sites and Other Behaviors

The sleeping sites are one of the most interesting features of this langur's behavior because of their location. They use the same sleeping sites for many years if there is no disturbance or hunting. Some groups in Tro Muong area, Phong Nha National Park, for example, have not changed their sleeping sites since 1998. They are usually in small caves and crevices in limestone escarpments or even in large limestone caves. The caves provide protection from the rain during the wet season and the cold north wind in the winter, as well as from their natural predators. A hunter in Phong Nha informed us that he shot a yellow-throated marten (*Martes flavigula*) in the Dai Cao area while it was eating a female Hatinh langur that it had presumably killed (this Hatinh langur is preserved in The Zoological Museum of Hanoi National University).

Hatinh langurs seem to prefer cliffs facing west or southwest over those oriented in other directions (Tro Muong, Hang En, Kim Lu, Dan Hoa), a feature that may relate to these cliffs being the warmest location in the late afternoon. The height of sleeping caves on the cliffs is generally about 20 m from the base, but can be up to 50 m. The most remarkable aspect of a typical sleeping cave is the orange or dark-yellow stains below the entrances, the result of urine and the feces that the langurs excrete at night (Fig. 1). The distinctive stain and the strong smell associated with the entrances to these caves and crevices indicate their constant and frequent use by the langurs. Wang *et al.* (2005) noted that the stains on limestone escarpment sleeping sites of *Trachypithecus leucocephalus* became darker after a sleeping site was abandoned.. They noted that if stains were wet then the site was in use, as these dry up after about only one month. Wang *et al*. (2005) found that it was easy to recognize these sleeping sites even after some 10 years of abandonment. Unfortunately, these sleeping sites facilitate the illegal hunting of this species.

The time of leaving or arriving at sleeping sites is different for each langur group, but quite consistent for each group if there is no evidence of danger or unusual disturbance at the site. Although they usually return to their sleeping sites from 18:15 to 19:00, the time varies seasonally, and depends, for example, on the direction the caves face and their elevation,

Figure 1. A limestone escarpment, sleeping site of a group of Hatinh langur, *T. laotum hatinhensis*, at Phong Nha-Ke Bang National Park, Quang Binh Province. Photograph by Nguyen Manh Ha.

aspects that determine when the sun reaches or leaves the escarpment (Nguyen Manh Ha 1999).

Langurs often return to the vicinity of the sleeping site quite early, around 16:00, and rest and play in the area until entering the caves at dusk. Observation conditions are excellent at this time, and it is then that it is possible to perceive social interactions and to identify the leader of the group. The dominant animal is often aggressive toward juvenile males, and is also the one to initiate movement toward the sleeping site. When he makes a "huut ... huut" sound, repeating it two or three times, the langur group begins to move into their sleeping caves and crevices. When moving down the cliff, the group always travels in single file along a crevice in the rock face or along a tree root. The "huut ... huut" vocalization is also used as an alarm call when a langur sees something unusual or recognizes danger.

Members of the social groups do not share a single sleeping cave, rather the adults separate off; sometimes two animals share a small cave, and on only one occasion did we observe three sleeping together (Hang En of Phong Nha–Ke Bang National Park). This behavior was also confirmed by a local hunter. Individual sleeping sites may be a hole or crevice in the rock or a small cave on the limestone cliffs or on the roof of a big limestone cave (as, for instance, at Hang En and Dai A).

Langurs leave their sleeping caves early; at dawn. It seems that the departure time depends on daylight, because in the summer they leave earlier than in the winter, and the cold weather in the winter may be another factor (Hatinh groups in Tro Muong, for instance). The dominant male is always the one to lead the way when they leave their sleeping caves, and when they return in the evening. This behavior can be observed regularly at the same place with the same groups if the langurs do not perceive any danger.

As with all catarrhines, the Hatinh langur is diurnal and feeds during the day. However, it is difficult to make close-up observations of the langurs when they are traveling because they are always in the forest canopy of the limestone slopes, the terrain is difficult, and they are very vigilant as to the presence of humans. It is quite difficult, as such, to approach them to observe their behaviors, especially their feeding. As with other Vietnamese monkeys such as doucs (*Pygathrix*) and Tonkin snub-nose monkeys (*Rhinopithecus avunculus*), there is as little or no available information on feeding and ranging of Hatinh langurs in the wild.

Population Numbers

We have insufficient data for any accurate estimation of the size of the remaining populations of the Hatinh langur. Twenty groups with 152 individuals were recorded during our surveys. Sixteen of these groups were in Phong Nha. Based on our survey, the most important population is distributed along the Phong Nha–Ke Bang limestone range in Phong Nha–Ke Bang National Park. This national park is currently the only protected area for this langur. The Phong Nha Nature Reserve is 41,132 ha; 24,861 ha of which are limestone forest (Pham Nhat *et al*. 1996a). Other smaller populations can be found in some limestone areas in Minh Hoa, Tuyen Hoa, Le Thuy, and Quang Ninh districts, all of which are isolated.

Threats to the Survival of Hatinh Langurs

The Hatinh langur is one of the most threatened primates in Vietnam due to its continuously declining population. It is listed as Endangered in the Red Data Book of Vietnam and likewise Endangered on the 2006 IUCN Red List (IUCN 2006). As is the case for all primates in Vietnam, the Hatinh langur faces two main threats.

In the districts of Minh Hoa, Bo Trach, and Tuyen Hoa in Quang Binh Province, the Hatinh langur is targeted by hunters for wildlife trade (Fig. 2). The langur and its parts are being traded and used for traditional medicine known as balm in English or "Cao Khi" in Vietnamese. There is no information, however, concerning the international trade or trade in live individuals. Hunting remains the most serious threat to this langur. Despite being illegal throughout its range, this activity continues because hunters consider it an easy prey due to

Figure 2. Male and female (with infant) Hatinh langurs, *T. laotum hatinhensis*, were confiscated near the Phong Nha Nature Reserve from a market in the Phong Nha commune, Quang Binh Province in 1997. Photograph by Nguyen Manh Ha.

its habit of returning to easily identifiable sleeping sites each night.

Habitat loss is the second main threat. This langur is heavily dependent on limestone forests, which are in continuous decline. They continue to be cut, and are becoming increasingly fragmented. Forest clearance and new roads in the limestone landscape make permanent barriers, and further isolate the remaining langur populations. This isolation makes dispersal difficult or impossible, and undoubtedly increases the mortality of dispersing males, and may well lead to inbreeding among the remaining langur groups.

Conclusions

The Hatinh langur is endemic to the limestone landscapes of the Central Annamite Mountains. It is highly social, generally living in groups of 2–15 individuals, it is diurnal and largely arboreal; and the preferred habitat is the limestone forests of this region. In Vietnam, the langur occurs only in the limestone areas of five districts in Quang Binh province, along with the Huong Hoa district of Quang Tri Province. The wild population is declining due to hunting and the loss and fragmentation of their natural habitat. Suitable habitats are now restricted to limestone mountain forest in the two provinces, the most important population being located in Phong Nha–Ke Bang National Park; the only protected area where it is known to occur. There may also be a small population of 20–30 animals in the Khe Net forest, Tuyen Hoa District, but this has yet to be confirmed (Nadler *et al*. 2003).

Recommendations

The Hatinh langur is one of the most threatened primates in Vietnam and appropriate measures and programs for its protection are urgently needed. We recommend the following:

- Strong measures need be taken to eliminate the illegal hunting of this langur and other wildlife in this region, and strict punishments need be applied to those participating in illegal hunting or trading not only for this langur and its parts but for all illegal wildlife trade activities.
- The Phong Nha–Ke Bang National Park has the most important remaining population of the Hatinh langur and is, besides, the only protected area where it occurs. The park should be increased in size to include limestone areas to its northwest (see also Pham Nhat *et al*. 1996a).
- Conservation education campaigns increasing the profile and stressing the value of Hatinh langurs and wildlife in general are urgently needed for the local communities and villages within their known range.
- Surveys are needed to map the remaining limestone forests of the region and to better understand the size and distribution of the remaining Hatinh langur populations in the wild.
- A detailed, long-term study on the demography, ecology, and behavior of the Hatinh langur should be set up. This should also address the extent and dynamics of the threats they face, which will be crucial for implementing a long-term conservation strategy.

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Conservation Programs for the Endangered Javan Gibbon (*Hylobates moloch*)

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Abstract: The Javan gibbon (*Hylobates moloch*), found in Western Java, is one of the rarest and most endangered of the hylobatids. Two workshops, which brought together Indonesian primate biologists, international scientists, zoos, local and international nongovernmental organizations, and government organizations, have been carried out for the conservation of this species. In 1994, a Population and Habitat Viability Analysis (PHVA) workshop was held focusing on the distribution, status, and threats of wild populations of Javan gibbon, and in 1997, a second was held to discuss strategies for rescue and rehabilitation. The results have been used to develop guidelines to save the Javan gibbon in the wild, and to trace further directions for research on, and the monitoring of, the remaining populations. To date, major accomplishments are as follows; headway has been made on protecting their stronghold habitats through the creation of the Gunung Ciremai National Park and the development of a conservation corridor, incorporating Gunung Salak into Gunung Halimun National Park and enlarging the Gunung Gede Pangrango National Park, which increased the size of the two parks to 135,000 ha in total and more than doubled the amount of protected habitat for the Javan gibbon; programs have been set up for monitoring the pet market as well as populations in the wild; a rescue and rehabilitation center has been established, as has an education program and a conservation awareness campaign using the Javan gibbon as a mascot species.

Key Words: Javan gibbon, *Hylobates moloch*, Java, conservation

Introduction

The island of Java marks the most southeasterly limits of the ranges of a number of primates of mainland Asia. Some in Sumatra and Kalimantan are already extinct, including the pigtail macaque, orangutan, and tarsiers. These local extinctions are believed to be quite ancient, but others are very recent, dating back only a few decades, such as the loss of the Javan tiger, *Panthera tigris javanicus* (see Seidentsticker 1987). Of the five primates living in Java today, the Javan gibbon, *Hylobates moloch* (Audebert, 1797) (Fig. 1) and the grizzled leaf monkey or surili, *Presbytis comata* (Desmarest, 1822), are now categorized on the *IUCN Red List of Threatened Species* as Critically Endangered and Endangered, respectively (IUCN 2006). The Javan leaf monkey, *Trachypthecus auratus* (É. Geoffroy, 1812) and Javan slow loris, *Nycticebus coucang javanicus* É. Geoffroy, 1812 are ranked as Vulnerable, and the only primate still relatively abundant on the island is the long-tailed macaque, *Macaca fascicularis* (Raffles, 1821) (Supriatna and Hendras 2000; Supriatna *et al*. 2001).

There are about 14 species of gibbon; all restricted to Asia (Marshall and Sugardjito 1986; Groves, 2005). Six are found in Indonesia, in Sumatra, Java, and Kalimantan, but only the Javan gibbon has been listed as Critically Endangered, facing as it does the highest risk of extinction due to habitat loss and hunting for pets (Supriatna *et al*. 2001). The Javan gibbon is now found only in forest remnants of western (*H. moloch moloch*) and central Java (*H. moloch pongoalsoni* Sody, 1949). Two workshops have been carried out to examine the conservation status and discuss conservation measures for the species. A Population and Habitat Viability Analysis (PHVA) workshop was held in 1994, run by the IUCN/SSC Conservation Breeding Specialist Group (CBSG) (Supriatna *et al.* 1994), and a second workshop, organized by Conservation International Indonesia in collaboration with the University of Indonesia and the Nagao Environment Fund Japan in 1997, examined particularly the rescue and rehabilitation programs for the species (Supriatna and Manullang 1999). The workshops, especially the second, resulted in intensified efforts on

Figure 1. An adult male Javan gibbon, *Hylobates moloch*, at the Javan Gibbon Center, Bogor, Indonesia.

the part of experts, governments and conservation organizations to save the Javan gibbon.

During the last two decades, much attention has been given to obtaining population estimates of the gibbons surviving in the small patchy forests in west and central Java (Asquith 1995; Asquith *et al*. 1995; Nijmen and van Balen 1998, Supriatna *et al*. 1998; Djanubudiman *et al.* 2004; Nijman 2004). A number of students and scientists have carried out surveys in specific sites such as the Gunung Slamet Protected Forest (Supriatna *et al.* 1992), Ujung Kulon National Park (Gurmaya 1992; Wibisono 1995), Gunung Halimun National Park (Sugardjito *et al.* 1997, Sugardjito and Sinaga 1999), Gunung Gede Pangrango National Park (Purwanto 1996; Rahardjo 2003), Gunung Simpang Protected Area (Subekti 2003), and Gunung Tilu Protected Area (Al Rasyid 2003).

There have been numerous initiatives and campaigns to save the Javan gibbon. Notable was the media campaign and education program at the Badogol Conservation Education Center in the Gunung Gede Pangrango National Park, set up and supported by the Gunung Gede National Park Management, Conservation International, the Alami Foundation, and the University of Indonesia. Every year more than 5,000 people visit the site. The aim is to report and detail the plight of the Javan gibbon and promote an understanding of the link between conserving wildlife and the benefits to the people in securing their natural forests.

Threats to the Javan Gibbon

An island of about 130,000 km² (slightly larger than New York State), Java has been overcrowded for the last 200 years. Before independence in 1945, the Dutch government tried to relocate some of its human population to other islands in order to reduce the pressures on the environment. The rate of population increase accelerated in the 19th century, and by the 20th, and in the 40 years from 1961 to 2000, the population of Java almost doubled, from 63 million to more than 115 million (Whitten *et al*. 1996; Biro Pusat Statistik 2006). This burgeoning human population and the island's long history of farming, back to at least 1,000 years ago, has significantly reduced Java's forest cover. Whitten *et al.* (1996) estimated that more than 1.5 million ha had already been lost to farmland and teak plantations by 1000 A.D. Prior to World War II, Java's forests had been reduced to 23% of their original extent (Seidensticker 1987). By 1973, this had dropped to 11%, and by 1990, to an estimated 7%—only 0.96 million ha of forest remnants (FAO 1990). Most of the natural forests remaining today are in national parks or other, variously effective, forms of protected areas, including those for watershed conservation. Large areas of "forest" cover on the island are tree plantations (teak, pine, and others), mixed community forests, or forest research areas (silviculture).

Java continues to lose its forests—significantly so following the Indonesian government's decentralization of forest management to the regencies. In 2001, the central government adopted new laws on responsibilities for natural resource management and the allocation of the pertinent budgets. Forest management, except for conservation areas, has been given over to local governments, some of which focus on short-term economic gain from activities such as logging, rather than the sustainable, long-term management of natural resources. One aspect that results in the persistence of these threats is that local people, including decision-makers, do not have adequate information concerning the importance of conservation, and the long-term benefits that local people can derive from these forests, such as watershed services. The major cause of natural forest loss today is not, however, industrial-scale logging, but encroachment and depredation by smallholders—tree cutting for subsistence plots, collection of firewood, forest fires, and charcoal production.

The balance of five years of decentralization in the responsibilities for forest management is one of further forest loss in Java. Satellite images spanning 10 years, from 1985 to 1997, show a reduction in forest cover not only in the watershed protection forests but also in the protected areas (Holmes 2000). The forest of the Gunung Simpang Protected Area lost almost 15% (from 15,000 ha) during this time, Ujung Kulon National Park lost 4% of its 76,100 ha, and Gunung Halimun National Park lost 2.5% of 42,000 ha (director, Conservation Area of the Ministry of Forestry pers. comm. 2001).

The pet trade is another major problem for the Javan gibbon. It is believed that an entire second population (nearly 300 individuals) is illegally held in captivity in Indonesia; most frequently as pets (Supriatna *et al*. 1994). The north coast of the island of Java is a major route for the trafficking of Indonesian nonhuman primates, including lesser apes from Java (Malone *et al*. 2004). As such, Javan gibbon hunters throughout the island are likely to be involved in the supply and sourcing of the illegal trade in primates and other wildlife. One of the biggest challenges in enforcing the regulations is the willingness of the authorities to become engaged in and carry through the required judicial procedures. Illegal logging, felling for firewood and local construction industries, encroachment of protected areas, and illegal trading in wildlife are widespread and yet unpunished.

Distribution and Key Populations

The first population survey of the Javan gibbon was carried out in 1978 by Kappeler (1984). He identified 25 populations in forest patches in West and Central Java. Asquith *et al*. (1995) resurveyed the populations located by Kappeler and identified further populations in western Java close to Gunung Simpang. The report on the 1994 Javan Gibbon and Javan Langur (PHVA) Workshop indicated no more than 400 Javan gibbons in protected areas (30 of them), with a further 386 to 1,957 living in 23 forest patches elsewhere (Supriatna *et al*. 1994). Asquith *et al*. (1995) estimated less than 3,000 individuals in central and western Java. A subsequent survey from 1994 through 1997 uncovered a number of new sites and populations in Ujung Kulon and Gunung Halimun national parks, now two of the species' major strongholds (Supriatna *et al*. 1998). Supriatna *et al.* (2001) estimated a population of 400–2,000. Further populations were brought to light by Nijman and his colleagues; one in small area of forest in West Java, and others in three large and significant forests in Central Java, on the southern slopes of Gunung Segara (Pembarisan Mountains), Gunung Cupu-Simembuat, and Gunung Jaran (Nijman and Sözor 1995; Nijman and van Balen 1998; Nijman 2004). Nijman (2004) indicated the total number of wild gibbons in Java to be between 4,000 and 4,500. Following a year-long survey, Djanubudiman *et al*. (2004) estimated a population of between 2,600 and 5,304.

Many of the forest patches maintaining gibbons are minute and have less than 10 individuals — a number well below the demographic and genetic thresholds for their mid-to long-term persistence (Lande 1988). They are evidently at high risk of extinction unless subjected to intensive conservation efforts. Although conservation programs might best be focused primarily on core populations such as those in the national parks of Gunung Halimun, Gunung Gede Pangrango, and Ujung Kulon (Supriatna *et al*. 1994), consideration must be given to smaller populations functioning as critical stepping-stone populations allowing for the maintenance of genetic diversity, genetic exchange, dispersal and colonization — processes vital for the long-term survival of this species.

The majority of the surviving Javan gibbons are now confined to small populations in isolated forest patches. With burgeoning human populations and the uncertain future of the already scarce and fragmented forests, there is a need to establish a wildlife sanctuary to allow for the rescue and translocation of the scattered and isolated gibbons groups before their forests are destroyed. Although the translocation of wild animals is still fraught with difficulties, this strategy may be the only conservation option in this case, particularly when so much of the forest on Java is scheduled for imminent destruction. The translocation of rescued groups proved to be a highly successful component of the overall strategy for the conservation of the golden lion tamarin (*Leontopithecus rosalia*) in the Atlantic forest of Brazil. In the early 1990s, 42 lion tamarins in six groups, each isolated in tiny forest remnants, were captured and introduced to a secure forest. They thrived, and in May 2006, numbered more than 250 in about 25 groups, comprising about 18% of the entire population (1,400) in the wild (Kierulff *et al*. 2002; M. C. M. Kierulff pers. comm, 24 May 2006). Prolonged monitoring and in-depth studies of their demography, ecology, and behavior need to accompany a program of this sort. Analyses are in progress to determine the extent and nature of genetic variability in the remnant populations and the degree of divergence among them. Such information will contribute to a decision as to whether such a strategy is necessary and justifiable and, if the answers are positive, will allow for the determination of which populations should be given highest conservation priority (Avise 1994).

Although estimates of remaining gibbon numbers may vary, there can be no doubts as to the significant threats that all current populations are facing: principally from continuing habitat degradation and fragmentation. Today almost all the remaining Javan gibbon habitats are submontane and

Table 1. Javan gibbon habitat areas and populations of importance for effective conservation measures.

Protected area / area	Habitat (km²)	Forest size (km²)	Forest type	Estimated population	Source
Ujung Kulon NP G. - Payung G. – Honje	 30 85	761	Lowland	300–560	Kappeler (1984) Gurmaya (1992), Wibisono (1995), Asquith *et al.* (1995), Rinaldi (2000), Nijman (2004), Djanubudiman *et al.* 2004
Gunung. Halimun NP Gunung Salak	235 76	400	Lowland, submontane, montane	900–1221	Nijman (1995); Supriatna *et al*. (1998), Sugardjito and Sinaga (1999), Djanubudiman *et al*. (2004)
Gunung. Gede Pangrango NP	50	140	Lowland, submontane, montane	447	Djanubudiman *et al*. (2004), Suryanti (2006)
Gunung Papandayan PF	130		Submontane and montane	527	Djanubudiman *et al.* (2004)
Telaga Warna PA		50	Submontane	476	Djanubudiman *et al*. (2004)
Gunung Simpang PA	110	150	Submontane		Asquith *et al.* (1995), Djanubudiman *et al.* (2004)
Gunung Tilu PA	30	80	Submontane	196	Djanubudiman *et al.* (2004)
Gunung Kendeng PF, Dieng Plateu	90		Submontane	492	Djanubudiman *et al.* (2004)
Gunung Slamet PF	38.6		Lowland, submontane, montane	96	Seitre and Seitre (1990); Supriatna *et al.*(1992), Nijman (1995); Djanubudiman *et al.* (2004)

NP = national park, PF = protection forest. PA = protected area.

montane forests (Gunung means mountain). The major exception is Ujung Kulon National Park, but there are also small portions of lowland forest in Gunung Halimun and Gunung Gede national parks. Only the three national parks in West Java, Gunung Gede Pangrango, Gunung Halimun, and Ujung Kulon, have the potential to maintain populations of more than 100 individuals, but some protected areas (Gunung Simpang, Gunung Tilu dan Telaga Warna) and protected forests for watersheds (Gunung Kendeng, Gunung Papandayan) also have significant numbers of gibbons (Table 1).

The most recent survey (supported by the U.S. Fish and Wildlife Service) documented the disappearance of a number of forests over the last decade, notably Bojong picung and Pasir susuru, besides the imminent loss of gibbon habitat in Leuweung Sancang, Gunung Jayanti, Gunung Tangkuban Perahu, and Telaga Warna, where only part of the remaining forests are in legally protected areas (Djanubudiman *et al.* 2004). Knowing the actual numbers of gibbons is important, but paramount now is, where possible, the protection of these forests, avoiding their destruction and controlling hunting and where gibbons and their forests are doomed, some means to have them translocated or taken into captive breeding programs for later reintroduction.

Conservation Measures for the Javan Gibbon

Population and Habitat Viability Analysis workshop

In May 1994, more than 50 people participated in a PHVA workshop for the Javan gibbon (Supriatna *et al*. 1994). The workshop established guidelines for a captive management program, not just as a hedge against extinction, but also to rationalize and facilitate the placing of confiscated animals. Also highly recommended was a public awareness campaign that focused on the threats to the Javan gibbon and its habitat. Follow-up workshops developed the criteria for site selection, guidelines for quarantine procedures and veterinary policy, and recommendations regarding enclosure design, nutrition, population sources, rehabilitation, and education and research programs, besides a plan to establish a Javan gibbon rescue and rehabilitation center.

Figure 2. A comparison of forest cover on the island of Java in 1985 (above) and 1997 (below). Sources: RePPProt (1985); Indonesia, Ministry of Forestry and World Bank (2000).

On the last day of the conference, a working group was established to lay out the guidelines for establishing a captive management program. Immediate recommendations included a survey of pets, the establishment of a Javan gibbon studbook, the preparation of a gibbon husbandry manual, and training in gibbon health and husbandry techniques for Indonesian Zoo Association (PKBSI) staff. Not all of these recommendations have been acted on, but nevertheless remain a priority. A survey of pets and gibbons held in Indonesian zoos was carried out in 1996 (Supriatna *et al.* 1998). Information was gathered from the Offices for Conservation and Natural Resources (BKSDA) of West Java, Central Java, and Jakarta, and subsequently verified, checking with the zoos and pet owners. The numbers of pets registered in West Java, Central Java, and Jakarta were 54, 41, and 36, respectively. Most pets were found to be in very poor health, and some were traded or had died of parasitosis or infectious diseases (Supriatna *et al*. 1998). The studbook is run from Perth Zoo, Australia, while other recommendations, such as training in gibbon health and developing a manual for gibbon husbandry, were carried out after the rescue and rehabilitation workshop in 1999.

Rescue and Rehabilitation Program

Following the 1994 PHVA workshop, Conservation International, the University of Indonesia, and the Nagao Environment Fund (NEF) of Japan hosted an international workshop on Javan Gibbon Rescue and Rehabilitation in August 1997 (Supriatna and Manullang 1999). Eight papers were presented on such topics as the population status in the wild (Gunung Halimun National Park) and population genetics; *ex situ* conservation and cryo-preservation (Abinawanto and Supriatna 1999); government policy on rehabilitation, management, nutrition, and cage design; and protocols for caging. A significant element of the workshop was the presentation of techniques, methods, and lessons learned by experts on the rehabilitation gibbons in Thailand. Other aspects considered were the existing government policy on rehabilitation, the IUCN protocols, and the experiences of zoos in gibbon caging and husbandry. Supriatna *et al*. (1998) also informed that the reported numbers of gibbons kept as pets were not entirely accurate because many were misidentified.

The phylogenetic tree for hylobatids clearly shows the Javan gibbon to be a monophyletic group separate from other gibbons (see, for example, Takacs *et al*. 2005). DNA sequence data suggest strongly, however, the existence of two lineages, a western lineage and an eastern lineage extending into Central Java (Supriatna *et al*. 1999; Andayani et al. 2001). Morphological differences between these two gibbons are subtle, and the release of confiscated animals to the wild must, therefore, occur with extreme caution. It is also essential that zoos identify their gibbons for their correct husbandry within a breeding program, not only so as to maintain the identity of the subspecies but also because out-breeding may have deleterious effects on reproductive performance. The conclusion of this workshop resulted in a recommendation to the Government of Indonesia to establish a Rescue and Rehabilitation Center (Supriatna and Manullang 1999).

Recommended also was a breeding program to preserve the genetic diversity of the species in captivity. It was argued that a captive breeding programs had a vital role to play in the survival of the Javan gibbon. There are a small number held in zoos outside Indonesia, but the first step would be to improve our understanding of the reproductive behavior and physiology of the species. Two graduate students from University of Indonesia and Bogor Agriculture University are currently carrying out research with respect to this (Sjahfirdi *et al* 2006a, 2006b) and have already made significant inroads to understanding the menstrual cycle and the behavioral and physiological determination of the periovulatory phase. Studies such as these will, we hope, contribute to an understanding as to why the Javan gibbon shows such low reproductive rates in captivity

Javan Gibbon Center

During the XVIII Congress of the International Primatological Society (IPS), held in Adelaide, Australia, in 2001, the international nongovernmental organization (NGO) Conservation International (CI) and the Silvery Gibbon Project (SGP, Australia) agreed to collaborate to establish a Javan Gibbon Center (JGC) for the maintenance and rehabilitation of rescued and confiscated gibbons. The JGC receives donated or confiscated gibbons (usually pets) with the short-term goal of assessing their medical and behavioral status, and restoring them to full health. Because there are so few Javan gibbons remaining, the genetic material of these illegally held (and likely unreleasable) animals is too important to be lost. The JGC is working, therefore, to: (1) retrieve pet Javan gibbons; (2) manage an *ex situ* population; (3) conduct noninvasive research, including genome resource banking; and (4) provide for public awareness and education programs focusing on the Javan gibbon and its imperiled status in the wild. This work is carried out in collaboration with the Indonesian Ministry of Forestry (Department of Forest Conservation and National Parks, the Provincial Natural Resources Agency, and the Forestry Research and Development Center), the Javan Gibbon Foundation, and the University of Indonesia.

The JGC formally opened in mid-2003 on land donated by a local ecotourism hotel. It is currently (June 2006) home to six rescued gibbons. A number of facilities have been constructed, including a guard station; an office; a medical and quarantine facility; and individual, bonding, and socialization enclosures. The infrastructure and staffing of the JGC are, however, still far from complete. More gibbon enclosures are needed to accommodate animals that are currently turned away because of space and staff constraints.

In parallel with the work in the JGC, there is an urgent need for education outreach to local communities living in and around the Javan gibbon's remaining forests. Some efforts have been made but they are as yet incipient. Outreach is critical so that when animals are successfully rehabilitated and can be released, there will be ample support and understanding, and protection provided by the local communities involved.

Securing More Habitat Via Corridor Development

As mentioned above, the molecular genetics study by Andayani *et al* (2001) suggested the presence of two lineages of Javan gibbons. A western lineage is represented by the large population of Gunung Halimun, while the eastern lineage includes isolates around Cianjur-Sukabumi complex (possibly covers Gunung Masigit, Gunung Tilu, Gunung Ciremai, and Gunung Sawal) and Gunung Slamet in central Java. These may relate to the named subspecies of western (*H. moloch moloch*) and central Java (*H. moloch pongoalsoni*) (see Brandon-Jones *et al.* 2004; Groves 2005). This finding has consequences for conservation policy: (1) gibbons in the Gunung Halimun complex should be managed as a separate and distinct conservation unit — they should not be considered as stock to reinforce the threatened isolates of the eastern lineage; (2) the Cianjur-Sukabumi complex presents a second distinct unit — gibbons from there can be moved among the different localities within this complex; (3) although the gibbons in Gunung Slamet are not evolutionarily distinct from populations in the west, they merit special attention because they might represent a case of peripheral isolation.

The forests and the gibbon population of Gunung Halimun are almost linked to the Gunung Salak Protected Forest and the Gunung Gede-Pangrango National Park. With approximately 1,800 to 2,000 individuals — almost half of the entire wild population — these three mountain ranges are the major stronghold for Javan gibbon populations today. These protected areas comprise an integrated conservation management system that protects the last remaining tropical forest remnants on Java, and also guarantees water supplies for 35 million people in Jakarta, Indonesia's capital, and neighboring cities, besides numerous industries along the rivers that run north-south in western Java. In 2003, the government agreed to create a corridor of these protected areas by incorporating Gunung Salak into Gunung Halimun National Park and enlarging the Gunung Gede Pangrango National Park. This decision, which increased the size of the two parks to 135,000 ha in total, more than doubled the amount of protected habitat for the Javan gibbon. The management of the Gunung Gede Pangrango National Park has created a buffer of vegetation to secure the new boundaries of this recent park expansion by developing a small community agroforestry and reforestation program (Conservation International Indonesia 2005).

Educating People to Save the Javan Gibbon

For more than five years (2000–2006), Conservation International Indonesia has led the GEDEPAHALA Consortium (Gede-Pangrango-Halimun-Salak), comprised of

17 NGOs, eight government institutions and research centers, four universities, and two private companies. The objective of the consortium is to raise the awareness of all stakeholders (including government, business enterprises, and local communities) concerning the advantages of maintaining, protecting, and expanding the two parks for human welfare, notably in the maintenance of a reliable long-term water supply, the generation of carbon sequestration benefits, and the protection of wildlife.

About an hour's drive from Jakarta, this montane region is of major importance for tourism. There are hundreds of hotels, restaurants, and recreation areas, and for obvious reasons the tourism industry there must be a major target for awareness campaigns concerning the value of the forests, their wildlife, and the plight of Java's endemic ape. In 2001, the Alami Foundation, Conservation International Indonesia, and the park authority created the Badogol Conservation Education Center to secure local support for the parks through an understanding of the behavior of wildlife and by generating direct and indirect benefits to the local communities. A Mobile Conservation Education Unit is used to take the conservation education program beyond the park's gates, visiting communities surrounding the Gunung Gede-Pangrango National Park to encourage local residents to incorporate conservation concepts in their daily activities. The Mobile Conservation Education Unit uses the characters of Moli the Javan gibbon, and Telsi the Javan hawk-eagle, to deliver a conservation message, besides showing wildlife films, stimulating discussions, and playing interactive games, and making a small library accessible to local groups (Conservation International Indonesia 2005).

Other Conservation Measure Needs and Recommendations

There has been a dramatic loss of natural habitats throughout Indonesia, and the massive destruction of its forests and the loss of the Javan tiger signal a clear extinction crisis in Java, as in so many other regions of the country. The last and richest habitats across Java are now under the greatest pressure. Unprotected lowland forests are likely to be completely cleared unless aggressive measures are taken by government officers and NGOs. The range of the Javan gibbon has been dramatically reduced by habitat loss and human encroachment. Of 37 forests previously inhabited by this species and registered by Kappeler (1984), many were found to severely degraded and no longer suitable or able to sustain viable populations just 10 years later (Asquith *et al.* 1995). Djanubudiman *et al.* (2004) further emphasized that illegal poaching is another serious threat to the species. Specific recommendations for the conservation of the Javan gibbon include the need to encourage government officers to take action in curbing illegal trade in gibbons, to double their efforts to patrol the existing parks, to create programs to monitor populations both in and outside protected areas, and to discourage the trade by confiscating pets and placing them in a rehabilitation program.

Indonesian forestry reform is moving rapidly, with a growing interest among stakeholders to seize this opportunity to promote greater sustainability in the forestry sectors, as well as to increase local community involvement in the management of their forest resources. There is a growing concern regarding the provision of effective long-term management for Indonesia's extraordinary system of conservation areas — in Java comprising almost 90% of the island's remnants forests. There is, consequently, an urgent need to implement a demonstrative program to earn public support for the potential direct and indirect benefits of the parks. The charm of the endangered Javan gibbon can be used to develop ecotourism programs, and generate income for all stakeholders in and around the protected areas where it occurs.

Legislation providing for regional autonomy, which went into effect in January 2001, is fundamentally reshaping the relationship between Jakarta and local authorities for all sectors, including forestry policy, legislation, and administration. Local governments are anxious to increase their revenues from natural resources, including efforts to levy taxes on private and state-controlled operations. District and provincial officers are now allowed to pass local regulations. These may have negative or positive implications for forest conservation and indigenous livelihoods. One positive implication is the increased facility and capacity for NGOs to lobby for local regulations that recognize indigenous rights to natural resources and promote the sustainable use of forests and their resources. A potential negative implication is that district administrators can now issue large numbers of permits for local companies to exploit their forests. This movement has to be anticipated by conservationists and government conservation officers, promote greater local participation in resource allocation decisions, and demand a greater accountability on the part of regional governments.

The principal recommendation regarding the application of scientifically grounded conservation management of the Javan gibbon is the need for research on their population genetics. There is genetic evidence that the Javan gibbon split, around 100,000 years ago, into two distinct lineages, western and central (Supriatna *et al.* 1999; Andayani *et al.* 2001). This finding must be considered when planning the relocation of groups from doomed habitats — a vital tactic for conservation of the genetic variability of the species. Genetic research on on this species has to date been based on a limited number of samples, and any plan for translocation should first be based on a more complete understanding of the demography and population genetics of the species in the various parts of its range. If we can still conserve the forests remaining today, and eliminate hunting pressure, there is still hope for the survival of the Javan gibbon.

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Ecology and Conservation of the Golden Langur, *Trachypithecus geei*, in Assam, India

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Abstract: The aim of this study was to understand plasticity and resilience in the behavioral ecology of one of India's most endangered primates, the golden langur (*Trachypithecus geei*) inhabiting forest reserves in Assam. Our survey revealed that golden langur populations in Assam are isolated; restricted to just pockets of suitable habitat. Their forests face severe human pressure mainly due to illegal logging, hunting, and widespread invasion for both commercial interests and by displaced refugees. An extensive survey using a stratified random walk transect method estimated a total population of 943 individuals living in 96 groups. About 40% of the langurs recorded were immature and the average group size was 9.8. Adult sex ratio was 1.5 to 5.0 adult female for each adult male. Four groups inhabiting forests with varying degree of disturbance were monitored using focal animal sampling for 1,728 hours during 12 months. Records on activity budgets, food and feeding behavior, and reproductive and ecological profiles indicated significant differences between them, attributed to differences in habitat quality. Small groups, isolation, proportionately few infants and juveniles, and habitats of increasingly poor quality are all parameters suggesting further decline in the golden langur population of the region. Conservation initiatives focusing on research, education, and community participation are show considerable success.

Key Words: Primates, northeast India, conservation, golden langur, demography, habitat quality, population ecology, community participation

Introduction

The golden langur, *Trachypithecus geei*, discovered in 1954, is known to occur in India between the River Sankosh in the west and the River Manas in the east, and from the Assam-Bhutan border foothills in the south to the inner Himalayan range in the north. Gee (1956) and Khajuria (1956, 1962), provided the first information on its morphology and distribution. Although described in the genus *Trachypithecus*, the golden langur has also been ascribed to the genus *Presbytis* (e.g., Mukherjee and Saha 1974; Roonwal and Mohnot 1977; Mukherjee 1978; Napier and Napier 1985) as well as *Semnopithecus* (e.g., Brandon-Jones 1984; Corbet and Hill 1992). It is a member of the capped langur, *T. pileatus*, group, and Corbet and Hill (1992) and Groves (1993) have suggested it might even be best considered a subspecies of *T. pileatus*, although this has not been substantiated. Brandon-Jones *et al*. (2004) and Groves (2005) listed it as a full species distinct from *T. pileatus.*[1]

There have been a number of surveys to establish the range and population status of golden langurs in India and Bhutan (Gee 1961; Wayre 1968; Mukherjee and Saha 1974; Mukherjee 1978; Subba 1989; Choudhury 1992; Wangchuk 1995). Although providing considerable data concerning their geographic distribution and many aspects of their behavior, none were systematic in their approach, and are limited as such in the sort of information required for their conservation. *Trachypithecus geei* has the highest legal protection under the Indian Wildlife Protection Act (1972) [now called the Wildlife (Protection) Amendment Act 2002], being listed in Sched-

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[1] Although *T. geei* was first intentionally described by Khajuria (1956), Corbet and Hill (1992) recorded that it was inadvertently described earlier by Gee (1956), although Brandon-Jones *et al*. (2004) argued that the nature of Gee's description made it unavailable, and that Ali and Santapau, then editors of the *Journal of the Bombay Natural History Society*, who mentioned the name in the issue with Gee's article, were the true, if equally inadvertent, authors of the species group name. Groves (2005) ascribes authorship to Khajuria (1956).

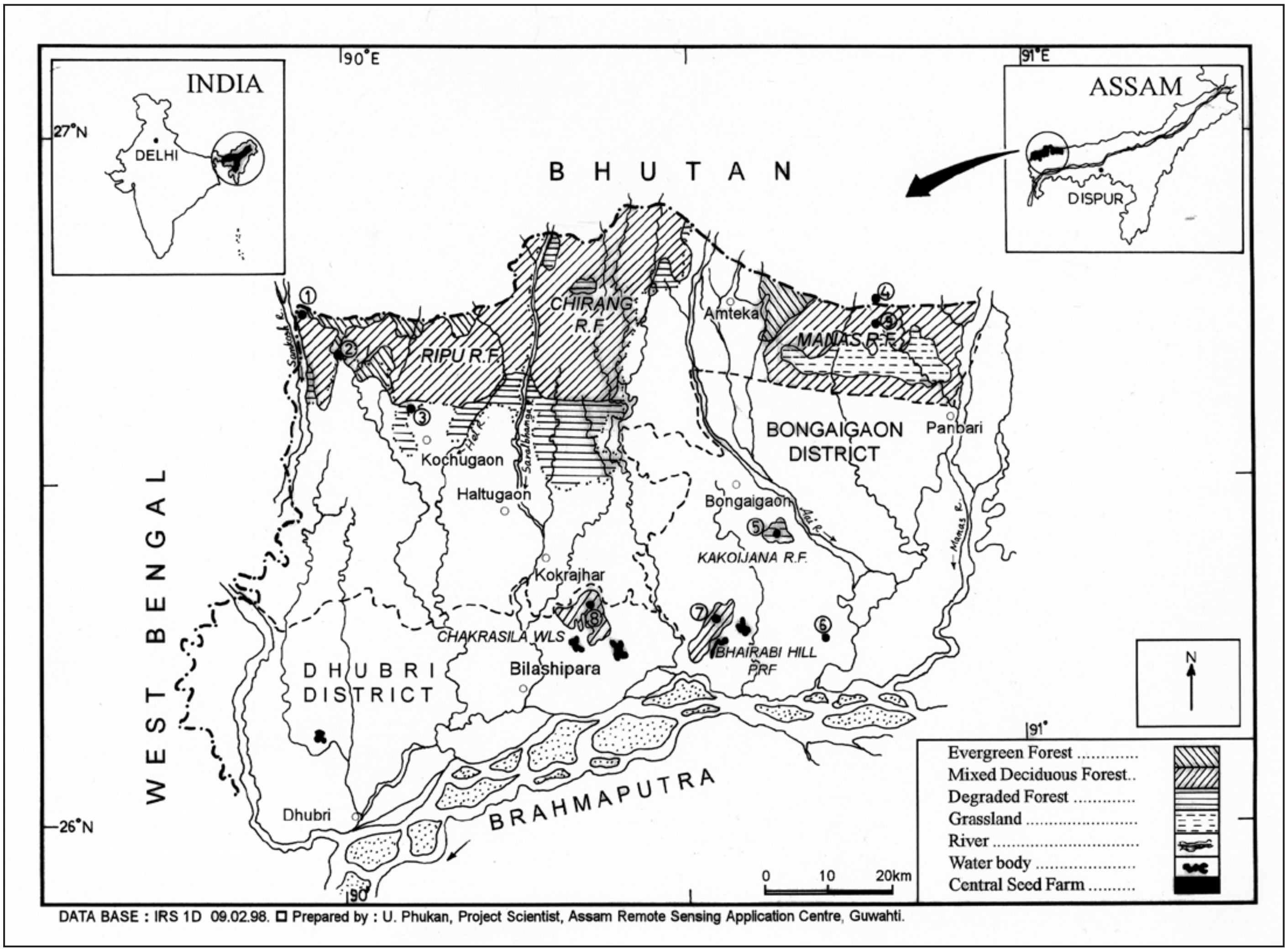
ule I, which prohibits killing, trapping, capturing, and keeping them as pets (Srivastava 1999). Under the auspices of the Indo-U.S. Primate Project, Srivastava *et al.* (2001b) surveyed the entire known range of the species in western Assam. Their findings indicated declining populations. As a next phase of that study we collected data to examine the nature of the population changes and change in habitat quality. We also monitored focal populations inhabiting different habitats with varying degrees of disturbance to understand the long-term consequences on behavioral ecology and survival, which are essential for conservation management. Results on population and habitat change are presented here.

Methods

The conservation program for the golden langur had three components: research, education, and community participation. The survey and research were conducted in three stages: an extensive survey, an intensive survey, and the collection of long-term ecological and behavioral data from two populations, one of which we considered undisturbed (Koilamoila: Manas Reserve Forest) and the other under pressure from human activities (Lalbithi: Chirrang Reserve Forest). As part of our community participation program we established a nongovernmental organization and self-help group, promoting community education and reforestation to ensure the survival of golden langurs and their habitat.

Extensive survey

The extensive survey was conducted to obtain a general picture of the status and distribution of the species and the rate of change in their populations. A survey carried out by the Indo-U.S. Primate Project in 1997 (Srivastava *et al.* 2001b) was used as a baseline, and we revisited the same transects during September–October 2001, using essentially the same methodology for vegetation assessment and age-sex classification. Additional surveys were conducted between November 2002 and March 2003, and in February 2004, in the areas that we were unable to survey in 2001. A team of four to seven people walked in the Manas National Park and the Ripu, Chirrang, and Manas reserve forests, covering more than 100,000 ha of forests. A stratified-random transect method was used (NRC 1981; Srivastava *et al.* 2001b). All observers were trained and performed a reliability test before undertaking



DATA BASE : IRS 1D 09.02.98. □ Prepared by : U. Phukan, Project Scientist, Assam Remote Sensing Application Centre, Guwahti.

Figure 1. Distribution of golden langurs, and vegetation profile of their habitat in western Assam, India.

the survey. When primates were encountered, the observers recorded as much demographic data as possible, along with data on habitat.

Intensive survey

Two sites were selected following the initial survey, one at Manas Reserve Forest and the other in the Chirrang Reserve Forest, for intensive surveys in order to obtain complete counts for age-sex composition data on as many groups as possible. Two permanent, 4–5 km transects were prepared — one each in the different habitats of the Chirrang and Manas reserve forests — were monitored by four observers each month to record seasonal changes in demography. These transects were repeated six times each month (n = 144; total transects = 12 months × 6 each month × 2 habitats) to locate focal groups (n = 19) and record the demographic details.

Study sites

The Koilamaila study site in the Manas Reserve Forest (349.6 km²), and Lalbithi study site of Chirrang Reserve Forest (592.54 km²) are in the Aie Velley and Kachogaon forest divisions, respectively, near the town of Bongaigaon, Assam. These areas were first notified as reserve forests on 27 August 1881. The area was declared a World Heritage Site by UNESCO in 1985, and notified officially by the central government of India in 1999 (Fig. 1). The area has high degree of biodiversity because it is located between the Indian, Ethiopian, and Indochinese biogeographic regions. The habitat is tropical and subtropical evergreen to semievergreen forest, and tropical moist deciduous *Shorea robusta*–type forest. The dominant tree species are *Mesua ferrea*, *Castonopis indica*, *Terminalia belerica*, *Sapium bacatu*, *Artocarpus chaplasa*, *Dillenia indica* and *Sterculia vilosa* (Champion and Seth 1968; Kanjilal 1997; Srivastava 1999). Height relative to ground classifies the forest biotope as ground cover, lower canopy (5–10 m), middle canopy (10–15 m), and top canopy (15–20 m and above). The annual temperature range is 15–35ºC and the minimum and maximum annual rainfall are 1,200 mm and 4,000 mm, respectively, with an average relative humidity of 83%.

Habitat evaluation

At each location where primates were encountered and at 500-m intervals, habitat parameters were measured in 10-m-radius circular plots. A total of 514 plots were recorded. Due to the varying numbers of animals encountered, our sample size varied for each reserve forest; Ripu Reserve Forest (n = 292), Chirrang Reserve Forest (n = 88), Manas Reserve Forest (n = 74) and Manas National Park (n = 60). The canopy cover was recorded as the percentage of total canopy volume using the following scale: No canopy cover, 1–20%, 21–50%, 51–75%, and more than 75%. Canopy height; ground cover; dominant tree, shrub, herb species; and phenological states were recorded at 500-m intervals on each transect walked. The degree of encroachment by humans cultivating land within the forest, and estimates of forest quality were recorded, as was any evidence of grazing or logging. Comparative assessments of habitat change were made by direct observation and as reported by the Forest Survey of India (India, Forest Survey of India 2003) using satellite images.

Twelve Modified Wittaker plots (Stohlgren *et al*. 1995) were established and monitored every month on predetermined dates (2–3 days). A total of 1,090 trees from 112 species (at least six trees of more than 20 cm girth at breast height from each species) were numbered and measured for their height, diameter at breast height, crown width, and crown density. We also established a variable line transect of 2 km and monitored it for three days every month to record the vegetation and the langur groups we saw there. Each marked tree was enumerated for different plant parts: leaf buds, young leaves, mature leaves, flower buds, flowers, unripe fruit, ripe fruit, and seeds (also see Kent and Coker 1994). The abundance of a given plant part was recorded as the proportion of total canopy volume using a 0 to 3 scale, referring to the value 1–25%, 26–50%, 50–75%, and more than 75%, respectively.

Results

Distribution

Fifty-four transects of approximately 4 to 12 km (total 410 km) were surveyed in the Ripu, Chirrang, and Manas reserve forests. An additional 28 km of transects were surveyed in Manas National Park. All animals located were in the three reserve forests named and in the western part of Manas National Park (Fig. 1). Golden langurs were not encountered in Manas National Park east of the River Manas. Our survey confirmed that golden langurs are not found outside their known ranges between the three rivers (Sankosh, Manas, and Brahmaputra) as was reported earlier by Gee (1956).

Group size and composition

A total of 943 individuals in 96 groups were recorded during the census. Of these, 567 were adults, indicating that about 40% of the animals located were immature. Group size and composition, and the populations in the three reserved forests and Manas National Park are presented in Table 1. The smallest group contained four individuals and the largest 19, with an average group size of 9.8. Of 943 individuals, 157 (16%) were adult males, 332 (35%) were adult females, 78 (9%) were unsexed adults, 376 (40%) were immature (202 juveniles and 174 infants), and the remaining individuals were not assigned any age and sex category. The adult sex ratio was 2.1 females per male (range, 1.5–5.0). The majority of groups had one adult male. We also encountered an all-male group with males of all age classes in Manas National Park. The composition of 11 groups in the Chirrang Reserved Forest and eight groups in the Manas Reserved Forest monitored on a monthly basis is shown in Table 2. The birth rate varied significantly with 0.43/female (Manas Reserve Forest) and 0.27/female (Chirrang Reserve Forest).

Population density

Golden langur group and individual densities were estimated from transect data for each reserve separately and compared with the information provided by Srivastava *et al*. (2001b) (Table 3). The greatest number of groups and individuals/km² were found in Chirrang Reserve Forest, and the lowest numbers were in Manas National Park. A negative relationship between group density and habitat quality as a simple measure of percentage of canopy cover (Tables 4 and 5) is evident, except in the Ripu Reserve Forest. This is also true when individual density is compared, again except for the Ripu Reserve Forest. This suggests that as the quality of habitat deteriorates, the number of groups and individuals increases. These findings are also true when data obtained from satellite images are used (Table 5, Data Source: IRS-1C & 1D LISS III; India, Forest Survey of India 2003).

Habitat quality

The political unrest in the area between the late 1980s and late 1990s has lead to the present day deforestation crisis and all the reserve forests suffered from the so-called *tragedy of the commons*. Although commercial logging was banned by an interim order of the Supreme Court of India in the late 1990s, illegal encroachment and woodcutting using hand tools have severely affected these forests reserves (Srivastava *et al*. 2001b). Areas that were classified as dense forest during the 1997 survey were recorded with no canopy cover or severe loss of canopy cover in the present study (for example, certain patches of Ripu Reserve Forest). Data obtained on canopy cover indicated that more than 60% of the area of Ripu Reserve Forest had less than 20% of canopy cover, Chirrang Reserve Forest had 40%, Manas Reserve Forest had 26%, and Manas National Park had 40%. Accordingly, using habitat parameters, logging, and grazing pressure Manas National Park and Manas Reserve Forest, Chirrang Reserve Forest, and Ripu Reserve Forest were classified as undisturbed (or least disturbed, with the highest degree of protection) to the most disturbed, in that order.

An analysis of 12 permanently marked Modified Whittaker plots with 1,090 trees of 112 species showed a plot diversity of 2.5 for undisturbed habitat and 1.9 for the disturbed habitat. The average diameter at breast height for all trees over 10 m was 0.86 m in the undisturbed habitat and 0.78 m in the disturbed habitat. Home range also varied, with 4.3 km² for undisturbed habitat to 1.2 km² for disturbed habitat.

We estimated the available suitable langur habitat for each of the four sites (three reserved forests and a national park) on the basis of habitat parameters (canopy cover, ground cover, average DBH and number of lianas) collected from sample plots independently. Table 5 provides information on the total area of the reserves, total forest cover, canopy cover, and availability of suitable golden langur habitat (for details on total forest cover and canopy cover, definitions, and district boundaries (see India, Forest Survey of India 2003).

Table 1. Group composition, size, and average group size at different locations.

Location	Area (km²)	Adults			Juveniles	Infants	Total groups	Total	Average group size	Adult sex ratio
		Male	Female	?						Male : Female
Ripu RF	605	62	142	39	64	69	41	376	9.2	1 : 2.3
Chirrang RF	593	69	106	26	91	65	35	357	10.2	1 : 1.5
Manas RF	350	19	49	10	32	29	14	139	9.9	1 : 2.6
Manas NP	500	7	35	3	15	11	6	71	11.8	1 : 5.0

RF = Reserved Forest, NP = National Park.

Table 2. Age/sex composition of groups monitored every month between November 2001 and December 2002, and September 2003 and February 2004 inhabiting disturbed and undisturbed forests.

Study population	Total groups	Total individuals	Average group size	Adults			Juveniles	Infants
				Male	Female	?		
Chirrang RF (disturbed)	11	119	10.8	19	51	10	26	13
Manas RF (undisturbed)	8	81	10.1	8	25	8	25	15

RF = Reserved Forest.

Table 3. Sample plots, group and individual densities at different locations during 1997[1] and 2001.

Location	Area (km²)	Sample plots[1]	Density/km² 1997[1]		Sample plots	Density/km² 2001	
			Group	Indiv.		Group	Indiv.
Ripu RF	605	328	6.2	46.5	292	2.8	25.8
Chirrang RF	593	112	7.2	64.3	88	7.9	81.1
Manas RF	350	130	1.8	20.2	74	3.8	37.6
Manas NP	500	120	1.0	8.2	60	2.0	23.7

[1] Data from Srivastava *et al.* (2001b); RF = Reserved Forest, NP = National Park.

Discussion

Golden langurs are land locked between three rivers (Manas, Sankosh, and Brahmaputra) and the Himalayan mountain ranges in the north. There they occupy moist evergreen, dipterocarp, riparian, and moist deciduous forests (Srivastava 1996, 1999). They are able to survive in degraded habitats dominated by secondary growth, and also outside of their natural range in Assam and Tripura (Srivastava 1996; Srivastava *et al*. 2001c; Gupta and Srivastava in press). However, 93% of the entire golden langur population, technically an island population, is confined to these forest reserves that have varying degree of disturbance. We estimate that not more than 1,500 individuals are now left in India. A larger population may exist in Bhutan, estimated at more than 4,340 individuals, but these figures are based on an extrapolation from 58.5 km² of a study area to a hypothetical 2,000 km² area of pristine broadleaf forest in the Black Mountain National Park (Wangchuk 1995). The total known suitable habitat of the golden langur in India is less than 500 km² (Table 5; Srivastava 2006). However, it has become increasingly clear, based on field studies on the different primate species, that they are not uniformly distributed in any given habitat and, rather, occupy pockets of suitable habitats within their range in what seems to us a quite uniform habitat. It is imperative, therefore, to obtain information on suitable habitats for any conservation initiative. Although the Ripu, Chirrang, and Manas reserve forests are important golden langur habitats, human pressures have increased instability and resulted not only in an overall decrease in the amount of suitable habitat, but also in discontinuities in the distribution of the remaining habitat (for example, Ripu Reserve Forest with several small clearings and a larger gap between Manas Reserve Forest and Chirrang Reserve Forest, see also Fig. 1). These findings further suggest that past and widespread golden langur populations are now reduced in size and split into a metapopulation. Habitats that are fragmented suffer increased edge effects, and populations become more vulnerable to adverse environmental conditions such as increased light and temperature or decreased humidity. Although Manas National Park receives the highest protection under the Wildlife (Protection) Amendment Act 2002, it contains only about 20 km² of suitable golden langur habitat for two reasons: the River Manas running through the park is a barrier, restricting them to the western one-third of the national park, and most of the western part of the park is a grassland and therefore, managed (controlled burning almost every year) for other endemic and endangered species (e.g., pygmy-hog, hispid hare, gaur, water buffalo, tiger, and elephant). Complete protection of the Ripu, Chirrang, and Manas reserve forests is urgent. We believe it is important to upgrade the status and protection of the golden langur habitat, so that the metapopulation can be linked through forest corridors to prevent genetic fragmentation of the various populations.

Brooks et *al.* (2002) in their critical analysis of world Biodiversity Hotspots have shown that the habitat loss has resulted in an extremely large number of threatened species, with the probability of their extinction high in the absence of immediate conservation action. Primates are no exception. In a recent study at Borajan Reserve Forest of Assam, India, Srivastava *et al.* (2001c) demonstrated that forest degradation on a very small scale eroded 60% of a primate population (five species) within a span of four years between 1995 and 1998. Similar conditions are fast developing for these reserve forests with a combination of social disturbance, inadequate forest department resources, and political and population pressure resulting in their rapid degradation. For example, only 70 km² of suitable golden langur habitat remains in the 610 km² of the Ripu Reserve Forest. However, we believe there is still time to act and provide adequate protection, mainly by upgrading the legal status of the reserve forests and planning effective conservation strategies with active community participation and education.

Although the number of groups and individuals sighted did not vary significantly when the number of sightings was adjusted for the number of transects surveys (effort), it shows a declining trend from a total population of 1,064 (130 groups) estimated in the 1997 survey (Srivastava *et al*. 2001b) to 943 (96 groups) in the 2001 survey. The average number of groups sighted per sample plot was similar (0.19 group/sample) for both surveys, but the average number of individuals sighted per sample plot increased slightly from 1.54 individuals/sample in 1997 to 1.83 individuals/sample during 2001. The 2001 survey team obtained information from local residents (mainly from the Bodo community) and as such were possibly facilitating the location of langur groups.

Table 4. Percent of sample *plots with* indicated levels of canopy cover.

Habitat quality	Ripu RF	Chirrang RF	Manas RF	Manas NP
Number of plots[1]	292	88	74	60
No canopy cover	44.5	25.0	16.2	36.6
Canopy cover 1– 20%	19.8	20.5	10.8	16.7
Canopy cover 21– 50%	20.1	34.1	33.8	23.3
Canopy cover 51– 75%	10.3	13.6	29.7	36.6
Canopy cover >75%	4.5	6.8	9.5	13.3

[1] Samples were always taken at 500-m intervals. They were also taken at the point of contact with golden langurs; accordingly the number of sample plots differ from reserve to reserve. RF = Reserve Forest, NP = National Park.

Table 5. Total area, forest condition and habitat quality index (HQI) at different locations.

Protected area	Total km²	Forested in 2003[1]	Very dense forest[2]	Moderately dense forest[3]	Suitable langur habitat[4]
Ripu RF	605				70
Chirrang RF	593	9165	205	709[5]	250
Manas RF	350	300	33	267	150
Manas NP[6]	500	218	35	183	20

[1] India, Forest Survey of India 2003 (Source: IRS-1C & 1D LISS III), [2] Canopy cover over 70%. [3] Canopy cover between 40–70%. [4] Estimated from area surveyed and groups sighted. [5] Ripu and Chirrang reserve forests combined. [6] Langurs not found east of River Manas. RF = Reserved Forest, NP = National Park.

Figure 2. Golden langur, *Trachypithecus geei.*

Using the 1997 survey, Srivastava *et al*. (2001b) suggested a "sink effect" for the golden langur populations inhabiting these reserves. The populations are restricted to a small area due to the loss of suitable habitat. The authors also demonstrated that populations in undisturbed habitats live in smaller groups with lower population densities, and populations in disturbed habitats live in larger groups with higher densities because food is more clumped and unevenly distributed within the habitat. A similar trend was found in this study, providing further support for the idea that the disturbed habitats will ultimately erode, as in the case of Ripu Reserve Forest. There the individual and group densities were higher during 1997 surveys. The langurs have declined drastically, from 6.2 groups and 46.5 individuals to 2.8 groups and 25.8 individuals per km² in 2001 (Table 3). Srivastava *et al*. (2001b) also suggested that higher densities generate a higher probability of disease and pathogen spread, as in the case of zoo and captive animals. Nevertheless, it is unclear why the group and individual densities have increased for Chirrang and Manas reserve forests, even though the habitats have degraded during this period (for details see Tables 4 and 5). The only explanation we can offer at this time is that the populations have either moved from Ripu Reserve Forest to these reserves (to the *sink*) or have developed higher growth and fertility rates, responding to isolation and the restricted area available. Understanding how habitat quality affects population processes remains a challenge.

The low population size and group size of the golden langurs are comparable to some of the other critically endangered langurs of the world, such as the golden-headed langur (*Trachypithecus poliocephalus*), Delacour's langur (*T. delacouri*), and the Tonkin snub-nosed langur (*Rhinopithecus avunculus*) (for review, see Srivastava *et al*. 2001b). The ratio of adults to immatures varies between locations, with half of the population being immature at Koilamoila (Manas Reserve Forest) and only 32% immature in Lalbhiti (Chirrang Reserve Forest). This probably reflects different levels of habitat quality and protection. These findings indicate the need to upgrade the Red List categorization of the golden langur to Critically Endangered (IUCN 2006). Although under India's Wildlife (Protection) Amendment Act of 2002 golden langurs are listed in Schedule I, which prohibits their persecution, hunting, and capture for any reason, sporadic hunting incidences have been reported in the area for meat or for sports.

However, the long-term effects in terms of the nutritional costs on survival and reproduction are not known. The ability of golden langurs to survive on few fast-growing exotic plantation species (Srivastava *et al*. 2001a) and the relative facility with which they can establish themselves in new areas (Gupta and Srivastava, in press) could be used as a management tool to increase the resource base for forest restoration and plantations. The information on staple food plants provided us with the opportunity to prepare a comprehensive reforestation and restoration program. Long-term data on the metapopulation of golden langurs in relation to habitat destruction are needed to estimate demographic rates and shapes of recruitment functions. An assessment of fecal glucocorticoid levels as a measure of environmental stress, interindividual variability of the timing of puberty and corresponding hormonal and behavioral changes will provide vital clues to predict future population trends. Analysis of the nutritional content, secondary components, and toxicity of the plant materials eaten by these langurs will also help underline the effects of habitat change on reproductive success.

Community Participation

Intensive long-term research on the dynamics of ecosystem is necessary to enhance holistic management plans. Research provides the basic data to help prevent and lobby against the uncontrolled destruction and exploitation of natural ecosystems. Nevertheless, we have also learned that baseline research is not enough to conserve any threatened species or its habitat, because human pressures are mounting on all these ecosystems. Participation at all levels is needed to translate the basic research and theoretical solutions into a reality. Our efforts in this regard have shown very encouraging results.

Figure 3. Golden langur, *Trachypithecus geei.*

Establishment of New Horizons

The field researchers and assistants trained to collect systematic ecological and behavioral data during the project were encouraged to form a nongovernmental organization (NGO) to further the goal of community participation in the conservation of golden langurs and their habitats. The move initiated by project researchers Mr. Edison Naezary and Maheswar Moshahary with the help of Mr. Rajen Islari, and Mr. M. Brahma and local community resulted in the formation of *New Horizons*, an NGO dedicated to conserving golden langurs. This group not only initiated a nursery for the propagation of golden langur food plants but also started a massive reforestation program in the Chirrang and Manas Reserve Forest. They also began a self-help group for women to take part in a weaving project. The group was further joined by other five NGOs to be members of the Manas Biosphere Conservation Forum, which is now coordinated by Community Conservation Inc. (Community Conservation 2006).

Education

In order to motivate local communities to participate in our conservation initiatives it was imperative to provide research findings in Bodo, the local language. Educational material in the form of booklets, posters, and leaflet in the regional language were published and distributed free for an awareness campaign. A leaflet, “An Appeal: Save Manas Biosphere Reserve” on helping the Manas Biosphere reserve and what people can do to protect it was produced. This was issued on the occasion of the 47th Wildlife Week of India. Another leaflet, “Save Golden Langurs,” was also published. A booklet and a poster highlighting the uniqueness of golden langurs and their status and distribution was printed in Bodo, the language of most of the residents within the reserve forests.

Reforestation program

The reforestation program built on an earlier initiative to establish nurseries at Koylamoila and Lalbiti. A participatory scheme was adopted for a reforestation program to improve conservation education and planting those species that are the staple diet of langurs and also ofvalue to the local communities.

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Ranging Behaviour of Hanuman Langurs (*Semnopithecus entellus*) in Three Different Habitats

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Abstract: We studied the ranging patterns of three troops of Hanuman langur (*Semnopithecus entellus*) in Kumbhalgarh Wildlife Sanctuary, 200 km south of Jodhpur, in the western Aravalli Hills of Rajasthan, India. The home ranges were 106, 45, and 70 ha. This study suggests that the availability of preferred foods, including farm crops and provisioned food, determine the day range of langurs. Comparison of the day ranges of these troops suggests that langurs will raid crops whenever the opportunity is available. They also readily accept foods supplied by humans. Their exploitation of these foods reduces day lengths and range size compared with troops living in forested areas.

Key Words: Ranging behavior, *Semnopithecus entellus*, Kumbhalgarh Wildlife Sanctuary

Introduction

The home range is the area normally traversed by an individual or group of animals during activities associated with foraging, resting, mating, and shelter seeking (Burt 1943). The ways in which primates use their home ranges vary enormously. Groups of the same species may differ in their ranging temporarily or permanently, during different times of the day, different seasons, and years, besides showing spatial differences across habitats. A number of factors such as the quality and abundance of food items, their distribution in time and space, the size and composition of the foraging group, body weight, and population density may influence the ranging behavior of primates (Dunbar 1988). Human influences such as provisioning (Wada 1983), and habitat disturbance, such as logging (Johns 1983), also strongly affect home range size and ranging behavior. In Hanuman langurs, home ranges often overlap, even quite extensively. In bisexual troops home ranges can vary from 7 to 1,300 ha, and can be even larger for all-male bands — 430 to 2,200 ha (Jay 1965; Sugiyama *et al*. 1965; Vogel 1971; Mohnot 1974; Roonwal and Mohnot 1977; Rajpurohit 1987; Srivastava 1989; Rajpurohit and Sommer 1993; Bennett and Davies 1994; Chalise 1995; Schuelke 1998; Chhangani 2000).

We recorded the ranging behavior of three troops of Hanuman langur at the Kumbhalgarh Wildlife Sanctuary (KWS) in northwestern India. Although living in areas that appear generally similar, the langurs confront subtle differences in a number of ecological aspects that affect the resources available to them.

Methods

Study site

The Kumbhalgarh Wildlife Sanctuary (KWS) of 585 km² is between 20º05′ and 23º3′ N, and 73º15′ and 73º45′ E, 200 km south of Jodhpur in the western Aravalli Hills of Rajasthan, India (Fig. 1). Altitude ranges from 288 m to 1,215 m a.s.l. KWS has distinct winter, summer and monsoon seasons. Summer temperatures generally fluctuate between 30ºC and 35ºC, but can get as high as 46ºC during May and June. The mean temperature in winter is 5ºC, and it can be as cool as 2ºC in December–January. The average annual rainfall during the 4-year study period was 725 mm: maximum 950 mm and minimum 403 mm (Chhangani 2000). The forest is broadly dry deciduous or woodland type, dominated by gorya dhawa (*Anogeissus latifolia*), salar (*Boswellia serrata*), gol (*Lannea coromandelica*), kherni (*Wrightia tinctoria*), dhawa (*Anogeissus pendula*), kumbat (*Acacia senegal*), khair (*Acacia catechu*), ber (*Ziziphus mauritiana*), and dhonk (*Butea monosperma*). The undergrowth consists mainly of jharber (*Ziziphus nummerlaria*), ardnsa (*Adhatoda vasica*), gangan (*Grewia tenex*), franger (*Grewia flavescens*), kanter (*Capparis

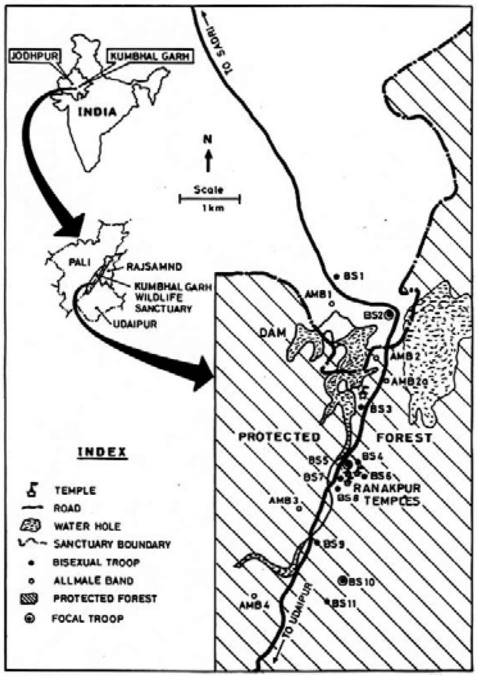

Figure 1. Location of Hanuman langur troops and bands in Kumbhalgarh Wildlife Sanctuary.

Table 1. Home ranges of the three focal Hanuman langur troops BS-2, BS-5 and BS-10. during the period January 1996–December 1999.

Troop	Size	Approximate home range size (ha)
Savika BS-2	38–43	106
Ranakpur temple BS-5	31–37	45
Forest BS-10	32–34	70

separaia), and lantana (*Lantana camara*). Some climbers and grasses are also found.

Other notable animals of the KWS include leopard (*Panthera pardus*), hyaena (*Hyaena hyaena*), Indian wolf (*Canis lupus*), jackal (*Canis aureus*), sloth bear (*Melursus ursinus*), four-horned antelope (*Tetracerus quadricornis*), chinkara (*Gazella g. bennetti*), porcupine (*Hystrix indica indica*), samber (*Cervus unicolor*), blue bull (*Boselaphus tragocamelus*), toddy cat (*Paradoxorus hermaphordiatus*), jungle cat (*Felis chaus*), fox (*Vulpes bengalensis*), crocodile (*Crocodilus palustris*), and rock python (*Python molurus*).

Study groups and ranging

The three focal troops of this study were the Savika troop (BS-2), the Ranakpur temple troop (BS-5) and the Forest troop (BS-10) (Table 1). The home ranges of these troops were plotted on the basis of the marked quadrates they used (each quadrate was 100 m × 100 m). Quadrate numbers and the position of the animals were recorded at the point between every two focal samples. The study period was January to December 1996. Day range size was calculated by the number of quadrates used from dawn to dusk and was recorded for a minimum of eight consecutive days (range, 8–10 days) in a month.

Results

Home range and day range

During the study period (January–December 1996), the Savika troop (BS-2) used 106 quadrates; a home range of approximately 106 ha. Similarly, the Ranakpur temple troop (BS-5) and the Forest troop (BS-10) used 45 and 70 quadrates, respectively; home ranges of 45 ha and 70 ha (Table 1).

Savika troop (BS-2): The number of quadrates used per day by the Savika troop (BS-2) ranged from 10 to 30, and the annual mean day range size was 21.1 ha. The smallest number of quadrates were used in April (mean of eight days: 17.8) and maximum number of quadrates in June (mean of eight days: 26.3) (Table 2; Fig. 2).

Ranakpur temple troop (BS-5): During the study period the number of quadrates used per day by the Ranakpur temple troop (BS-5) varied from 6 to 22, and the annual mean day range size was 12.27 ha. The smallest numbers of quadrates were used in January (mean of 8 days: 8.3) and the maximum number of quadrates in July (mean of 8 days: 16.1) (Table 3; Fig. 3).

Forest troop (BS-10): The total number of quadrates used by the Forest troop (BS-10) ranged from 9 to 28, and the annual mean day range size was 19.74 ha. The smallest number of quadrates were used in March (mean of 8 days: 15.8), and the maximum number in July (mean of 8 days: 23.0) (Table 4; Fig. 4).

The langur troops traveled most during the months of June and July. This is probably related to food shortage—April, May, June, and July are the driest months in KWS—and animals are forced to move over a wider area to procure food and water.

Factors influencing ranging pattern

The availability of food in the home range, its distribution, and type and abundance in time and space influence day range size. In this study we recorded the percent time spent in eating different types of food and compared them with day range size and number of quadrates used by the three focal troops in different months. For this we took the largest and smallest day range traveled in each month by the three different troops. We also calculated the percent time dedicated to their natural diet and to crops by the Savika troop (BS-2), and the percent time dedicated to natural food and provisioned food by the Ranakpur temple troop (BS-5). We also calculated the percent time dedicated to different plant parts, such as leaves, flowers, and fruits by the forest troop (BS-10) on each of those days.

The Savika troop (BS-2) covered 26.08 quadrates (range, 22–30) every month in their largest day range. On these days 78% (range, 61.9%–92.6%) of their feeding was dedicated to their natural diet, and 21.9% (range, 7.4%–38.1%) to crops. They covered 15.8 (range, 10–21) quadrates every month on the smallest day range when 56% (range, 45.1%–68.9%) of their feeding was dedicated to their natural diet, and 44% (range, 26.3%–54.9%) to crops. This clearly suggests that Savika troop BS-2 had a larger day range when eating more of their naturally occurring food than when they were raiding crops. The details of the largest and smallest day ranges and relative proportions of feeding time spent on naturally occurring foods and crops are given in Tables 5 and 6.

The Ranakpur temple troop (BS-5) traveled a mean of 16.9 (range, 11–25) quadrates, when their diet was composed of 65% naturally occurring foods and 35% provisioned food. The smallest average day range was 7.9 (range, 6–12) quadrates, and the diet averaged 57% naturally-occurring foods and 43% provisioned food, indicating that they tended to travel less on days when they spent more time eating provisioned foods (see Tables 7 and 8).

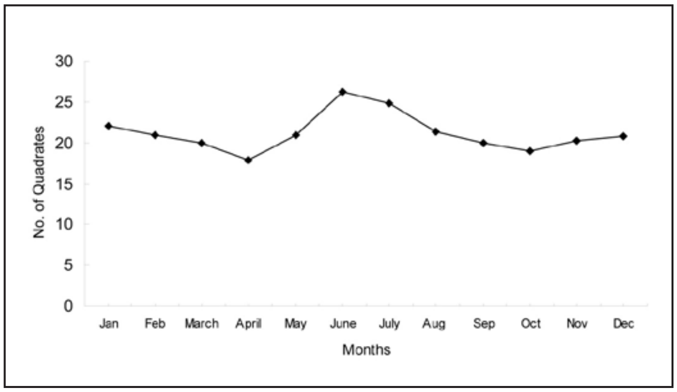

Figure 2. Mean monthly use of quadrates by troop BS-2 in 1996.

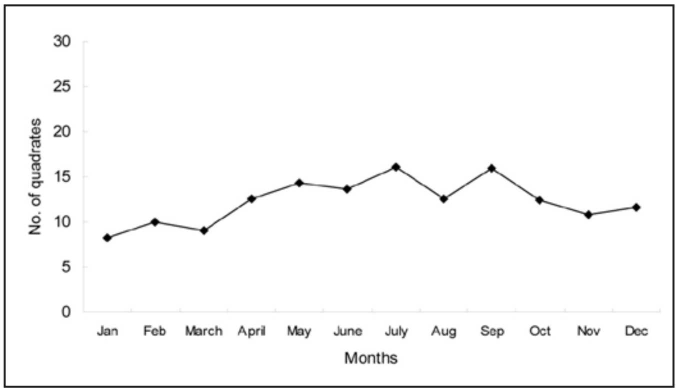

Figure 3. Mean monthly use of quadrates by troop BS-5 in 1996.

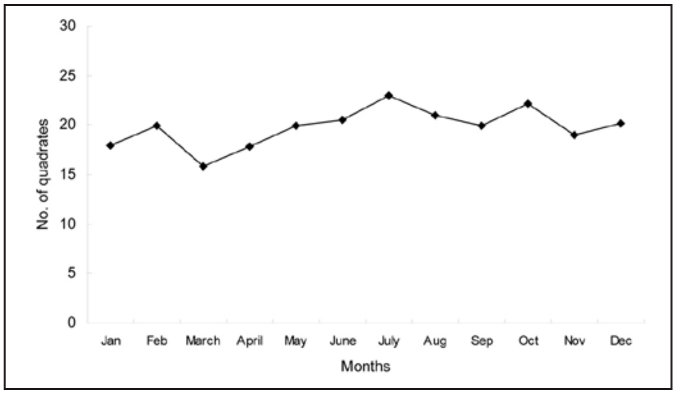

Figure 4. Mean monthly use of quadrates by troop BS-10 in 1996.

The day range size of the forest troop (BS-10) tended to be larger (mean, 24.4 quadrates used) when the troop ate more flowers (28%) and fruits (42%) and fewer leaves (26%). The BS-10 troop traveled over smaller day ranges (mean, 14.5

Table 2. Number of quadrates used by the Savika Hanuman langur troop (BS-2) during 1996.

Observation days	1	2	3	4	5	6	7	8	Mean
Months	**Quadrates used**								
January	18	19	20	21	24	28	25	21	22.0
February	19	21	20	19	20	29	19	20	20.9
March	17	18	15	21	24	23	20	21	19.9
April	18	22	14	12	21	18	22	15	17.8
May	14	20	19	26	22	19	26	21	20.9
June	20	25	27	23	28	30	27	30	26.3
July	28	22	25	21	27	22	28	26	24.9
August	19	22	18	27	16	19	28	21	21.3
September	10	21	15	27	19	23	20	24	19.9
October	20	21	19	13	16	20	22	21	19.0
November	16	19	18	28	20	24	18	19	20.3
December	23	19	22	18	24	16	22	22	20.8

Table 3. Number of quadrates used by the Ranakpur temple Hanuman langur troop (BS-5) during 1996.

Observation days	1	2	3	4	5	6	7	8	Mean
Months	**Quadrates used**								
January	8	7	11	10	9	6	8	7	8.3
February	13	10	11	8	10	9	12	7	10.0
March	11	8	7	10	9	12	8	8	9.1
April	10	12	9	16	11	15	12	16	12.6
May	18	14	17	18	13	16	11	7	14.3
June	8	15	12	18	14	19	13	10	13.6
July	21	18	15	19	12	16	15	13	16.1
August	9	12	17	14	10	15	11	13	12.6
September	25	9	19	11	22	19	13	9	15.9
October	6	14	10	9	17	11	15	17	12.4
November	16	9	14	7	11	9	11	9	10.8
December	18	8	12	10	13	12	9	11	11.6

Table 4. Number of quadrates used by the Forest Hanuman langur troop (BS-10) during 1996.

Observation days	1	2	3	4	5	6	7	8	Mean
Months	**Quadrates used**								
January	15	20	14	22	18	16	21	17	17.9
February	17	18	21	15	24	20	23	21	19.9
March	25	9	19	22	18	9	13	11	15.8
April	18	20	18	12	19	21	14	20	17.8
May	21	10	27	15	23	19	24	20	19.9
June	16	22	24	18	23	20	19	22	20.5
July	28	22	20	25	22	21	26	20	23.0
August	14	21	25	19	26	18	20	25	21.0
September	17	21	20	19	22	18	23	19	19.9
October	18	21	19	20	28	23	26	22	22.1
November	20	19	21	13	16	20	22	21	19.0
December	16	18	23	19	23	18	20	24	20.1

Table 6. Savika troop (BS-2): The smallest day range size in each month and percent time dedicated to their natural and cultivated food on those days (Chhangani, 2000).

Months	Quadrates used	Natural food (%)	Cultivated food (%)
January	18	51.2	48.8
February	19	65.3	34.7
March	15	50.6	49.4
April	12	45.4	54.6
May	14	53.5	46.5
June	20	68.9	31.1
July	21	73.7	26.3
August	16	60.5	39.5
September	10	48.9	51.1
October	13	45.1	54.9
November	16	50.7	49.3
December	16	58.2	41.8
Mean	**15.08**	**56**	**44**

Table 7. Ranakpur temple troop (BS-5): Largest day range in each month by and percent time dedicated to their natural and provisioned food on those days (Chhangani, 2000).

Months	Quadrates used	Food consumption (%)	
		Natural	Provisioned
January	11	53.4	46.6
February	13	58.1	41.9
March	12	64.5	35.5
April	16	70.5	29.5
May	18	73.8	26.2
June	19	71.3	28.7
July	21	74.6	25.4
August	17	62.8	37.2
September	25	69.7	30.3
October	17	57.2	42.8
November	16	61.3	38.7
December	18	59.4	40.6
Mean	**16.9**	**65**	**35**

Table 8. Ranakpur temple troop (BS-5): Smallest day range in each month and percent time dedicated to their natural and provisioned food on those days (Chhangani, 2000).

Months	Quadrates used	Food consumption (%)	
		Natural	Provisioned
January	6	41.8	58.2
February	7	37.6	62.4
March	7	56.7	43.3
April	9	62.2	37.8
May	7	64.9	35.1
June	8	58.2	41.8
July	12	73.3	26.7
August	9	66.6	33.4
September	9	68.5	31.5
October	6	52.4	47.6
November	7	55.1	44.9
December	8	46.8	53.2
Mean	**7.9**	**57**	**43**

quadrates used) when they ate relatively more leaves (62%) and fewer flowers (16%) and fruits (20%) (see Tables 9 and 10).

Sleeping sites

All groups tended to use large trees for their sleeping sites in limited portions of their home ranges (about 100–150 m²). Sites were one large tree, or two to six small trees, or a combination. The Savika troop (BS–2) used four sleeping sites during the year: all were along the road. Of these, one was a single *Ficus benghalensis* tree, and the other three sites were three to five *Azadirachta indica*, *Ficus racemosa*, and *Eucalyptus camaldulensus* trees (Table 11). The Ranakpur temple troop (BS-5) used three sleeping sites: two were a single large tree, one was *Ficus benghalensis* and the other was a *Tamarindus indica*, whereas the third site was two trees — *Tamarindus indica* and *Azadirachta indica* (Table 11). The Forest troop (BS-10) used five sleeping sites, all of them of two to six trees, including *Lannea coromandelica*, *Boswellia serrata*, *Azadirachta indica*, *Albizia procera*, and *Anogeissus latifolia*. The

Table 9. Forest troop BS-10: Largest day range in each month and percent of feeding time dedicated to leaves, flowers, and fruits on those days (Chhangani, 2000).

Months	Quadrates used	Percent consumption of plant parts			
		Leaves	Flowers	Fruits	Others
January	22	28.4	56.3	7.2	8.1
February	24	25.4	68.7	1.4	4.5
March	25	31.9	60.3	6.3	1.5
April	21	28.4	51.6	18.2	1.8
May	27	18.4	21.9	56.2	3.5
June	24	12.9	15.8	68.2	3.1
July	28	13.6	15.2	70.5	0.7
August	26	29.4	8.2	61.4	1
September	23	39.5	5.3	49.7	5.5
October	28	24.6	7.3	59.2	8.9
November	20	32.5	8.4	55.4	3.7
December	24	35.4	9.6	51.3	3.7
Mean	**24.3**	**26**	**28**	**42**	**4**

Table 10. Forest troop BS-10: Smallest day range in each month and percent of feeding time dedicated to leaves, flowers and fruits on those days (Chhangani, 2000).

Months	Quadrates used	Percent consumption of plant parts			
		Leaves	Flowers	Fruits	Others
January	14	58.2	28.4	12.5	0.9
February	15	54.5	31.4	8.9	5.2
March	9	73.4	20.7	4.3	1.6
April	12	69.5	18.5	9.6	2.4
May	10	71.6	14.8	12.6	1
June	16	65.3	6.4	21.8	6.5
July	20	58.4	9.4	29.2	3
August	14	67.3	8.9	19.7	4.1
September	17	57.9	12.5	29.1	0.5
October	18	49.2	19.2	31.4	0.2
November	13	64.4	13.4	21.3	0.9
December	16	51.9	11.2	35.2	1.7
Mean	**14.5**	**62**	**16**	**20**	**2**

heights of the sleeping trees of the three groups ranged from 6 to 20 m (Table 11).

Shifting sleeping sites

Temporary shifts in sleeping sites were observed on a number of occasions in bisexual (including the three focal groups) as well as all-male bands. Sleeping site "b" of the Savika troop (BS-2; see Table 11) was next to a farm: the troop moved there to raid the maturing crops. When chased by the farm owners and their dogs they would revert to sleeping sites "a" and "c." The temple guards would chase the Ranakpur temple troop (BS-5) from sleeping site "a," because they would spoil their offices. Sleeping sites used by the Forest troop (BS-10), on the other hand, were evidently related to the presence of predators. The toddy cat (*Paradoxorus hermaphordiatus*), for example, would cause females carrying infants to move to the canopy or thin branches of neighboring high trees). Larger predators would result in the troop moving to a different sleeping site the next day, choosing especially the thin branches of such high trees as *Lannea cormandelica* or *Anogeissus latifolia*. Some trees, such as *Ficus benghalensis*, have branches that are big and low and easier for panthers (*Panthera pardus*) and other cats to climb. Other reasons for shifting sleeping sites included attacks by honeybees (*Apis dorseta*) and Black-rumped Flameback (*Dinopium benghalense*). Although roaming bands of male langurs would sometimes sleep with the bisexual troops, at other times they could be the cause for them to move away. Two large troops (B-8 with 113 and B-9 with 74 individuals), for example, would often flee when confronted by an all male band (AMB4) of only 21 individuals.

Discussion

A number of factors are responsible for variation in the langur home range size, including availability and abundance of food, the availability of agricultural crops and provisioned food, group size and composition, population density, predator pressure, and agricultural activity and human interference, besides other environmental factors (see, for example, Jay 1965; Clutton-Brock 1977; Isbell 1983; Kimura 1999; Masaaki and Imaki 1999). Hanuman langur troops are hardy and adaptable, and the availability of food and its distribution is the major factor (Raemakers 1980; Marsh 1981; Isbell 1983; Bennett 1986; Newton 1992), as we found at KWS.

In this study, the home range used by the Ranakpur temple troop (BS-5) was 45 ha, which is similar to those of the garden troops of Jodhpur (60–96 ha) studied by Mohnot (1974) as well as at Kailana, Jodhpur (40 ha) (Agoramoorthy 1987), and Mt. Abu (38 ha) as found by Hrdy (1977). The home range of the Savika troop (BS-2) was larger at 106 ha and approximates to those found for the open habitats of Jodhpur (74–132 ha) by Mohnot (1974), Borries (1989) (100 ha) and Srivastava (1989) (150 ha). At Shimla, Sahoo (1993) estimated a mean home range for langurs in forest habitat to be 136 ha. The Forest troop (BS-10) was 70 ha, which is closer to that found for the langurs at Sariska National Park, Rajasthan (60 ha), studied by Vogel (1971).

The day range sizes of the three groups varied markedly and were influenced by resource availability (crops and provisioned food) besides habitat quality. The density and diversity of trees, shrubs and herbs varied considerably. More than 50% of dissimilarity was of vegetation found between troop BS-2 and troop BS-10. Tree felling, farming, human interference,

Table 11. Sleeping sites, sleeping trees and their heights for the three focal troops in KWS study area.

Focal troops	Sleeping site	No. of trees in the sleeping sites	Plant species serving as sleeping trees	Height of sleeping trees (m)
Savika troop (BS-2)	a	1	*Ficus benghalensis*	15
	b	1 2	*Ficus racemosa* *Eucalyptus camaldulensis*	12 18, 15
	c	2 2	*Azadirachta indica* *Eucalyptus camaldulensis*	8, 6 20, 18
	d	1 1 1	*Ficus benghalensis* *Azadirachta indica* *Eucalyptus camaldulensis*	15 10 18 +
Ranakpur Temple troop (BS-5)	a	1	*Ficus benghalensis*	17
	b	1	*Tamarindus indica*	14 +
	c	1 2	*Tamarindus indica* *Azadirachta indica*	16+ 12, 10
Forest troop (BS-10)	a	4	*Lannea cormandelica*	10–14
	b	2 2	*Boswellia serrata* *Anogeissus latifolia*	14, 16 12, 15
	c	1 1 1	*Lannea carmandelica* *Azadirachta indica* *Albizia procera*	12 10 12
	d	2 2 1	*Lannea carmandelica* *Boswellia serrata* *Albizia procera*	10, 14 12, 15 10
	e	2 2 1	*Anogeissus latifolia* *Lannea cormandelica* *Boswellia serrata*	10, 12 12, 15 13

Photo 1. Tourists offering food to langurs.

Photo 3. Fruit (*Bombax ceiba*) feeding by langurs.

Photo 2. Flower (*Albizia procera*) feeding by langurs.

Photo 4. Cultivated feeding by langurs.

grazing pressure, and predation were factors varied among the troops and were also considered when studying their feeding and ranging behavior (Chhangani, 2000). The differences in home range size between focal troops were quite evident, while, interestingly, the day range size in general was quite similar. The Ranakpur temple troop (BS-5) with a home range of 45 ha traveled through a mean of 12.27 ha with a mean of 16.9 quadrates on larger day ranges and mean 7.9 quadrates on smallest day ranges per day. Whereas troops BS-2 and BS-10 with larger home ranges sizes of 106 ha and 70 ha, maintained similar day ranges sizes, averaging 21.10 ha and 19.74 ha. Both troops showed almost similar means for their largest (means 26.08 [BS-2] and 24.4 [BS-10]) and their smallest day ranges (means, 15.8 [BS-2] and 14.5 [BS-10]).

Home range size differs widely in different distributional zones of *Semnopithecus entellus*, and we may tentatively generalize that they are more extensive in open habitats than in forest (Mohnot 1974; Roonwal and Mohnot 1977). Sugiyama *et al*. (1965) observed that sparse food availability forced langurs to travel more widely.

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Book Review

Chimpanzees of the Budongo Forest, Uganda

Review of *The Chimpanzees of the Budongo Forest: Ecology, Behaviour, and Conservation* by Vernon Reynolds. Oxford University Press, Oxford. 297pp. ISBN: 0-19-851546-4. Paperback: US$ 69.50. 2005.

Here is the latest addition to a very specialized genre: books about chimpanzee field-sites that are titled "*The Chimpanzees of...*" It is at least the fifth such book, following those by Ghiglieri (1984), Goodall (1986), Nishida (1990), and Boesch and Boesch-Achermann (2000). If the title is derivative, the subtitle is more revealing of the contents, and here (to quote Meatloaf), "Two out of three ain't bad!"

Chimpology is full of interesting practitioners, but even among such a colorful bunch, Vernon Reynolds stands out. He was one of a trio of pioneers (Jane Goodall and Adriaan Kortlandt being the others) who founded field studies of chimpanzees in the 1960s. He (and wife Frankie) did the fieldwork, wrote his book (Reynolds 1965), and moved on to other things. Then, after an interlude of almost 30 years, at a stage of career when most primatologists have already retired to the armchair, he decided to return to Budongo, impelled by an incident that exemplified the accelerating threat to the existence of our nearest living relations in Africa. The paramount status given to conservation in this book is what makes it stand out among its counterparts.

Four of the book's 12 chapters are devoted to human-ape interaction in or around the Budongo Forest, a medium-altitude, semideciduous block of 435 km^2. This most northerly of the major forested areas in western Uganda is a forest reserve (but not a national park). Its history of timber extraction in various forms goes back to colonial times, and even today one of the chief problems with conservation is illegal pit-sawyering for mahoganies.

The most pointed threats to the chimpanzees are snaring and trapping. One-third of the individuals beyond infancy in the Sonso study community are crippled from snare injuries. If this proportion is generalized to the Budongo population as a whole, almost 200 unfortunate apes are suffering at any one time, and this figure omits those who die in pain from such injuries. The chapter on snaring makes for excruciating reading at times, but also talks pragmatically of the pros and cons of measures taken to tackle the problem. It is the best treatment in print on this vexed topic.

Another telling chapter is a case study of a relict community, Kasokwa, of only 13 chimpanzees, hanging on in a nearby 73-ha riparian forest. Their situation is perilous, and Reynolds gives all sides of the story, from the viewpoints of the apes, local people, and researchers. The problem is not just deforestation and agricultural incursion, but also the choice of sugar cane as the preferred crop, which is an irresistible temptation to crop-raiding. Here, as elsewhere, Reynolds is frank in his assessments, and in his recounting of the successes and failures of attempts at conservation intervention.

Finally, the book is the best yet on emphasizing in detail the various types of human-ape interaction that have implications for the latter's morbidity and mortality. Exemplary cases of rapid veterinary response, either in the case of disease outbreak or for necropsy, are described in full. Parasites are given their due. The Budongo Forest Project is a standard-setter in how to implement a modern field study.

The behavioral aspects of the book are more uneven, with an emphasis on unusual events. There is, for example, an entire chapter on infanticide but only two paragraphs on play. An intra-community killing gets a useful whole chapter. Most of the usual topics, from sex to grooming to dominance struggles, are covered in enough detail to allow comparison with other populations elsewhere. Notably, like other Ugandan populations, the Budongo chimpanzees show little tool-use.

Ecology is given shorter shrift. For example, there is no list of sympatric fauna beyond primates, and although predators are referred to, none are named. Other primates are consigned to an appendix, where a major competitor, *Papio anubis*, gets only two paragraphs. Feeding ecology gets more space, but inexplicably three rankings of dietary preference are never inter-correlated, leaving the reader to wonder which to follow. Apparently, the most fed-upon species of plant is *Broussonettia papyrifera*, an exotic introduced in the 1950s (which recalls the dependence of the Gombe chimpanzees on another introduced species, the oil palm).

The findings of the book are well documented, and Reynolds is generous and meticulous in giving credit for results to his extensive team of Ugandans and expatriates. However, this inclusiveness also poses a problem: 37% (98 of 360) of references listed are to unpublished theses, dissertations, reports, abstracts, etc. Having not gone through the rigors of scientific peer-review, it is not clear how much stock can be put in their data or conclusions, however timely and ingenious are the topics tackled.

Overall, the book is an effective blend of science and conservation. More than any of its predecessors in the genre, it takes seriously and unflinchingly the challenges of long-term protection of apes in African forests. The book's purchase price is not cheap, but it deserves as wide an audience as possible among primate conservationists. We can all be glad that Vernon Reynolds chose to return to Budongo.

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Regional Newsletters

The IUCN/SSC Primate Specialist Group also produces regional newsletters/journals which publish short articles and notes on general and specific aspects of primate ecology, taxonomy, distributions, behavior and conservation, tropical forest ecology and conservation, forest destruction, and protected areas. Also please send information on projects, research groups, events, recent publications, courses, funding sources, activities of primatological societies and NGOs, and other newsworthy items of interest to primate conservationists, directly to the editors at the addresses below.

Madagascar - *Lemur News*

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Neotropical Region - *Neotropical Primates,* Mesoamerica

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Asian Region - *Asian Primates*

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African Region - *African Primates*

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Instructions to Contributors

Articles submitted to Primate Conservation

Manuscript Format
All manuscripts should be typewritten, double spaced with generous margins, and accompanied by the text on diskette in Word format or by e-mail in RTF or as a Word document. Please indicate on a separate cover page the author to which correspondence should be sent, including fax number and e-mail, the month and year the manuscript was completed, up to six key words, and a short running title. Abstracts are not published. Footnotes are to be avoided (except for tables and figures). Subdivision titles, for example, Methods, Conclusions, etc. are not necessary. Please give all measurements in metric units. Please accent all foreign words carefully. The literature cited should be in the following style:

Example – journal article:
Struhsaker, T. T. 1972. Rain-forest conservation in Africa. *Primates* 13: 103–109.

Example – chapter in book:
Goodall, A. G. and C. P. Groves. 1977. The conservation of eastern gorillas. In: *Primate Conservation*, H. S. H. Prince Rainier of Monaco and G. H. Bourne (eds.), pp.599–637. Academic Press, New York.

Example – book:
Soulé, M. E. 1987. *Viable Populations for Conservation*. Cambridge University Press, Cambridge, UK.

Example – dissertation:
Homewood, K. M. 1976. Ecology and Behaviour of the Tana Mangabey (*Cercocebus galeritus galeritus*). PhD thesis, University College, London.

Maps
Maps should always be made as concise as possible and should include an inset showing the location of the area discussed in relation to its home country or continent.

Photographs
Black-and-white prints are ideal. Original color slides from which we can make prints are also acceptable. However, please send only sharply-focused, high quality slides and photographs. Please label each slide or photograph with the photographer credit and number the identifying caption. Captions should be listed on a separate sheet, or after "Literature Cited." We are always interested in receiving high quality photographs for our covers, especially those of little known and rarely photographed primates, even if they do not accompany an article.

All Figures
Please indicate on all figures the title and author of the manuscript to which they belong and package them carefully to avoid damage in the post. Figures will only be returned at the special request of the author. Electronic high resolution files (300 dpi) of maps, photographs and figures can be sent in any one of the following types of files: EPS, TIF, or JPG. Please, however supply a hard copy of all drawn maps or figures, preferably in the size in which they should be published.

Please send your contribution to:

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