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Front cover: Adult male Sykes's monkey *Cercopithecus mitis* × vervet monkey *Chlorocebus pygerythrus* hybrid at Diani, south coast of Kenya. Photograph by Yvonne de Jong and Thomas Butynski. See page 43.

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Callicebus caquetensis: A New and Critically Endangered Titi Monkey from Southern Caquetá, Colombia

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Abstract: We describe a new species of titi monkey *Callicebus* (Primates: Platyrrhini) from the Department of Caquetá, Colombia, that belongs to the *Callicebus cupreus* group. Diagnostic characteristics: it is similar in fur color to *C. ornatus* and *C. discolor*, but has no white band on the forehead as in *C. ornatus* and *C. discolor*, and the hands and feet are not white as they are in *C. ornatus*. The karyotype of this species is $2n=46$, and very similar to that published for *C. cupreus*. Comparing it to neighboring species, it is more similar cytologically to *C. discolor* than to *C. ornatus*. It should be classified as Critically Endangered (CR) due to the severe fragmentation of its habitat and very small population.

Key words: Platyrrhini, Pitheciidae, *Callicebus caquetensis*, new species, primate, Colombia.

Resumen: Se describe una nueva especie de *Callicebus* (Primates, Platyrrhini) del departamento de Caquetá, Colombia perteneciente al grupo de *Callicebus cupreus*. Los caracteres diagnósticos para esta especie son una coloración similar a *C. ornatus* y *C. discolor*, pero careciendo de la banda blanca frontal y de pelos blancos en manos y pies. El cariotipo de esta especie tiene un $2n=46$ muy similar al descrito para *C. cupreus*. Con relación a otras especies colombianas estudiadas, es más similar a los ejemplares de *C. discolor* ($2n=46$) que a *C. ornatus* ($2n=42$). Consideramos que esta especie debe ser catalogada como “En Peligro Crítico” (CR) por la extensa fragmentación de su hábitat.

Palabras claves: Platyrrhini, Pitheciidae, *Callicebus caquetensis*, nueva especie, primates, Colombia.

Introduction

In his book reviewing the behavior and ecology of the Neotropical primates, Martin Moynihan (1976) mentioned his observations of titi monkeys from the upper Caquetá (the piedmont of Colombia's Cordillera Oriental), and referred to them as anomalous when compared to the forms *ornatus* Gray, 1866, *discolor* I. Geoffroy and Deville, 1848 and *cupreus* Spix, 1823. In parentheses he described the animals as follows (p.75):

“The Caquetá animals are anomalous and may deserve special mention. Hershkovitz ignored them, simply because he thought that the species was absent from the area. This is surprising, for *C. [Callicebus] moloch* is conspicuous around Valparaíso, one of the important towns of the *intendencia* [a political subdivision of national territories in Colombia that has been superseded since 1991 by the subdivision of the country into *departamentos* that are

politically equal]. The individuals that I managed to see clearly, close up, in the Caquetá lacked the white stripe above the eyes that is typical of both *ornatus* to the north and *discolor* to the south. They could have been intermediates between one or both of the latter forms and *cupreus*, which occurs downstream, or representatives of an unnamed subspecies.”

He went on to describe the forest where he saw them (pp.76–77):

“I found another pair or family group of *moloch* [Hershkovitz (1963) regarded all Amazonian titis to be subspecies of just two species, *moloch* and *torquatus*] in an even more extreme habitat near Valparaíso (really very near indeed, just outside the town limits). This was a medium-sized expanse of incredibly dense, almost solid, and low forest of small, thin, broadleaved trees and large bushes, hardly 7 meters high at its maximum. During the

rainy season, the whole ground underneath was a morass of pools, streams, and deep pits of liquid mud. In the dry season, some of the pools and streams disappeared, but the area remained damp and the footing very treacherous. Naturally, the titis of this thicket averaged much lower than those of less stunted vegetation.” [His point here was that he believed that “*C. moloch* is the nearest thing to a real swamp monkey in the New World”, p.77].

Moynihan (1976) referred to *Callicebus moloch*, but at the time *moloch* included as subspecies the forms *ornatus*, *discolor*, and *cupreus*, and would consequently have included this form from Valparaíso as a distinct (implied) subspecies. At the time that Moynihan published his observations, the Amazonian titi monkeys were considered to belong to just two species: *C. moloch* (Hoffmannsegg, 1807) comprising seven subspecies and *C. torquatus* (Hoffmannsegg, 1807) three, following the revision by Hershkovitz (1963). In his subsequent revision, Hershkovitz (1990) recognized eight species in his *moloch* group, with the forms *discolor* and *ornatus* as subspecies of *C. cupreus*. Groves (2001, 2005) and Van Roosmalen *et al.* (2005) considered *discolor*, *ornatus*, and *cupreus* to be distinct species. Bueno *et al.* (2006) found karyotypic differences in the form of translocations and inversions that clearly distinguished *Callicebus ornatus* from other Colombian titis, and confirmed that it is a distinct species.

For some years it was risky to travel to Valparaíso because of the presence of insurgent groups and the lack of security. In 2008–2009 we were able to travel to the upper Río Caquetá. With a lull in the violence in 2008, Javier García (a native of Caquetá department) went to Valparaíso (13 July to 24 August 2008) to gather observations and obtain live material that would allow for a proper description of the titi monkey there, and the description of its karyotype. Using local transportation, and geo-referencing observations with GPS, García was able to observe 13 groups of this species by searching on foot and listening for early morning calls. He found two animals in captivity, being kept as pets near Valparaíso, Caquetá, and discussions with the owners led to them being donated to the project. They were taken to Florencia where Defler and Bueno met García in order to take immediate blood samples for karyotyping. On 2 September 2008, the youngest animal died of captive trauma, and García took the monkey’s remains and the living holotype to Bogotá by land on 3 September 2008, where the second, living animal was handed over to the care of the Unidad de Rescate y Rehabilitación de Animales Silvestres (URRAS), Department of Veterinary Sciences, Universidad Nacional de Colombia. The remains of the paratype were delivered to Defler for measurements and preparation of material for the mammal collection at the Institute of Natural Sciences at the Universidad Nacional de Colombia.

In 2009 (8–30 April and from 10–30 May, 2009), García returned to the region to study the distribution of the species. The second live specimen died in captivity of a pathology on

27 January 2009 in the URRAS. Both specimens are deposited in the collection of the Instituto de Ciencias Naturales of the Universidad Nacional de Colombia, Bogotá, including skins, skulls, skeletons and soft tissues.

Callicebus caquetensis sp. nov.

Synonyms. *Callicebus moloch* Hoffmannsegg, 1807: 97; Moynihan, 1976: 75–77 (following Hershkovitz 1963).

Holotype. Juvenile female, ICN 19439, skin, skull, tissues in alcohol, complete skeleton; deposited in the Instituto de Ciencias Naturales (ICN) of the Universidad Nacional de Colombia, Bogotá. Died of a pathology at one year of age in captivity 27 January 2008 at URRAS wild animal care facility at the Universidad Nacional de Colombia. It is a one year-old juvenile. *Callicebus* become adults at sexual maturity during the second year (judging by a tame, free-ranging female *Callicebus lugens* that became sexually mature in June–July of her second year at Caparú Biological Station in Vaupés, Colombia) (Defler 2004, 2010).

Paratype. Juvenile female, ICN 19017 1°6'23.10"N, 75°38'32.50"W east of Valparaíso, Caquetá at the farm of Marino Camacho, vereda [subdivisions of municipalities in Colombia, a concentration of houses generally without roads] El Jardín; skull, skeleton; and tissues in alcohol. Deposited in the collection of the Instituto de Ciencias Naturales (ICN) of the Universidad Nacional de Colombia, Bogotá. Died on 2 September 2008 (probably of captive trauma) at about 7 months of age.

Type locality. Vereda El Jardín, east of Valparaíso, municipality of Puerto Milan, Department of Caquetá, Colombia, 1°8'24.61"N, 75°32'34.04"W, 251 m above sea level.

Distribution. Thirteen groups of *Callicebus caquetensis* were observed in 11 locations from 190 to 260 m above sea level, in a broad band south of the Río Orteguaza around Valparaíso, south to the Río Caquetá around La Solita (Fig. 1). The complete geographic distribution cannot be defined on the basis of the information we have at present, but García was unable to find evidence that it extends west to the Cordillera Oriental. Searches east of Florencia to the Río Caguan gave no indication that the species is found north of the Río Orteguaza. The area east of the known distribution towards the mouth of Río Orteguaza where it meets the Río Caquetá has yet to be surveyed.

Diagnostic characters. This species of *Callicebus* is very similar to *C. ornatus* and *C. discolor*, but it does not have a white bar on its forehead (as do *ornatus* and *discolor*), nor does it have white queridia (as does *ornatus*). In place of a white forehead bar (as in *C. ornatus* and *C. discolor*) the hairs are white and grey agouti, the tips of the hair being white. Posterior to this zone (corresponding to a forehead band) the agouti pattern becomes buffy-orange and black, replacing the white tips with buffy-orange.

Description. See Figures 3a–g and 4a–c. Body and skull measurements of the holotype (juvenile female) and the paratype (juvenile female) are shown in Table 1. *Callicebus*

caquetensis is very similar in color and markings to *C. ornatus* and *C. discolor*, though it lacks the white forehead bar of both of those species and the white hands and feet of *C. ornatus*. Crown from above eyes caudally is a light buffy brown; neck, sides, back and tail are mixed grayish-brown and buffy agouti but often with penciled tail tip on terminal third of tail that is dominantly white and black agouti. The specimen is lightly washed in reddish tones that are absent over the grayish agouti tail; the agouti-colored tail has slight banding proximal to the body. Coloration is sparsely-haired chestnut-red on the ventrum, body, arms, legs and face, extending to dorsal parts of lower arms and lower legs up to the elbows and knees. The reddish also extends to the ventral parts of the neck and onto the cheeks up to the basal parts of the ear, giving the appearance of a red beard. The grayish-brown agouti extends from the back onto the dorsal parts of the arms and legs down to the knees and the elbow, also with some slight reddish washing. Facial skin is darker than the skin on the dorsum, arms and legs, which is pinkish. In place of a white forehead bar (as in *C. ornatus* and *C. discolor*) the hairs are white and grey agouti, the tips of the hair being white. Posterior to this zone (corresponding to a forehead band) the agouti pattern

becomes buffy-orange and black, replacing the white tips with buffy-orange so that it can be said that there is a very faint band of agouti colored hairs composed of white tips and black bands.

Comparisons. *Callicebus caquetensis* is very similar to *C. cupreus* (*sensu* Groves 2005), although it does not have a blackish band on the forehead over the eyes. It is similar to *C. discolor* (*sensu* Groves, 2005), although it has no white band across the forehead as does *C. discolor*. *Callicebus caquetensis* is phenotypically very similar to *Callicebus ornatus* (*sensu* Groves, 2005), but *C. ornatus* has a white band on the forehead and off-white hands and feet. The crown of the head of *C. caquetensis* is a light agouti brown down to the eyes, while *C. ornatus* has first the white band over the eyes and, posteriorly, the crown is darker and contrasting with the lighter grey agouti of the back and sides. *Callicebus caquetensis* is a darker agouti brown than *C. ornatus*, which is closer to grey agouti. An area over the eyes, corresponding to the white band over the eyes of *C. ornatus*, appears lighter due to the appearance of skin showing through the hairs, and due to the white-tipped agouti hairs (which are buffy or brown-tipped posteriorly).

Karyology. (Fig. 2) Chromosome preparations were obtained by M. L. Bueno using standard methods for lymphocyte culture (Moorhead *et al.*, 1960). Blood samples were taken with heparinized syringes (Liquemine, Roche). Peripheral blood was cultured in Minimal Essential Medium (MEM, Sigma) with 20% bovine fetal serum, 10% of Penicillin-streptomycin, Sigma. As mitogens, 0.35 mls P-Phytohemagglutinin (Difco, at 1:16 dilution) were used. A duplicate culture with a crude extract of *Vicia faba* lectin (the procedure of Arango and Moreno, 1977) gave the best preparations. Optimum culture time was 66 hours. QFQ, GTG and CBG banding were carried out as described by Capersson *et al.* (1970), Seabright (1971) and Summer (1972), respectively. Late DNA replication patterns (RBG) were observed after a 5-bromodeoxyuridine (BrdU) terminal pulse (see Camargo and Cervenka, 1980). CBG banding was accomplished using preparations previously analyzed with QFQ banding. Nucleolar organizer regions (NORs) were located by the procedure of Goodpasture and Bloom (1975).

Blood drawn from the holotype in Florencia was taken by airplane to Bogotá for cultivation, but it proved to be contaminated. Blood drawn from the holotype in Bogotá yielded the study material.

This species has a diploid chromosome number of $2n=46$, composed of 7 pairs of metacentric chromosomes and 15 pairs of acrocentric chromosomes. The X chromosomes are submetacentric and preserve the characteristic banding pattern typical for this chromosome found in various primates, including humans (Fig. 2).

The karyomorph is very similar to that reported for *Callicebus cupreus* by Bigoni and Stanyon in O'Brien *et al.* (2006). The *C. cupreus* in the *Atlas of Mammalian Chromosomes* was from the *Callicebus* colony housed at Davis, California, USA, and the animals of that colony are said to have been exported to

Table 1. Body and skull measurements (mm) of holotype and paratype, *Callicebus caquetensis*.

	Holotype ICN 19439 Juvenile female	Paratype ICN 19017 Juvenile female
Tail length	610	
Body length	350	
Hind foot length	70	
Hand length	45 (nail) 42 (no nail)	
Ear length	30	
Basal length	40.9	
Basilar length	37.5	
Condylbasal length	45.25	
Condylcanine length	41	
Greatest length of skull	56.4	50.9
Breadth of braincase	32.85	31.1
Least interorbital breadth	4.65	4.3
Mastoid breadth	33.4	32.2
Postorbital constriction	29.5	27
Mandibular length	34.5	
Bizygomatic breadth	32.6	
Zygomatic breadth	32.6	31.3
Cranial length (braincase)	46.7	
Diastema length	11.8	
Maxillary tooth row	14.9	
Palatal length	19.4	
Palatilar length	15.7	
Nasal length	11.6	
Nasal width	6.1	
Nasal suture length	8	
Postpalatal length	20.4	
Typanic bullae length and width	15.05 × 8.4	
Facial length	18.2	
Mandibular tooth row	18.5	

the United States from Iquitos, Perú (R. Stanyon, pers. comm.; W. A. Mason, pers. comm.). The *C. caquetensis* ($2n=46$) karyotype has homologies with *C. discolor* ($2n=46$) in 21 of the 22 chromosome pairs, differing only by the presence of a very small additional metacentric (8 metacentric pairs) in *C. discolor*. Comparing the karyotype of *C. caquetensis* with *C. ornatus* there are more differences, since *C. ornatus* has only five metacentric chromosomes, among which there is a very large metacentric pair that is not found in *C. caquetensis* nor in *C. discolor*. Additionally, in the analysis of G-bands there are only 17 homologies among the 22 chromosome pairs for *C. ornatus* as compared to *C. caquetensis*. A more complete karyotypic description is in preparation.

Etymology. The name *caquetensis* refers to the Department of Caquetá, where the species was found.

Systematics. This is a species of the *Callicebus moloch* species group as defined by Hershkovitz (1990, p.43) and Groves (2001, pp.172–176). Following Hershkovitz (1990) this group includes *C. cinerascens*, *C. hoffmannsi hoffmannsi*, *C. h. baptista*, *C. moloch*, *C. brunneus*, *C. cupreus cupreus*, *C. c. discolor*, *C. c. ornatus*, *C. caligatus*, *C. dubius*, and *C. personatus* (with four subspecies). Groves' (2001) definition of the *C. moloch* group was similar but he did not accept the validity of the forms *discolor*, *caligatus*, or *dubius* (synonyms of *C. cupreus*), and included *C. coimbrai* described in 1999. Groves (2005) subsequently listed *C. discolor*, *C. caligatus* and *C. dubius* as valid species, following Van Roosmalen et al. (2002). Kobayashi (1995) confined *C. cupreus* (*sensu* Hershkovitz, 1990) to a separate *Callicebus cupreus* species group. Following Kobayashi (1995), it is evident that in appearance and in geographic terms, *Callicebus caquetensis* is part of a *Callicebus cupreus* superspecies (*sensu* Mayr 1931; Mayr and Ashlock 1991); “a monophyletic group of closely related and largely or entirely allopatric species” (Mayr and Ashlock 1991, p.53). *Callicebus caquetensis* is clearly related to

C. ornatus and *C. discolor*, but cytologically it is closer to the latter (see below).

Common name. This monkey is called “macaco” throughout its known distribution, although some use the name “tongo” in the La Solita creek. “Huicoco” is also used, as it is for *Callicebus torquatus* which García found at the headwaters of La Solita creek. We recommend “Caquetá titi monkey” in English.

Conservation status. This species is scarce and its habitat is fragmented. It occurs at very low densities in agricultural land, in fragmented remnants of the former forest. Dispersal is impossible or at best highly dangerous for the animals, since they must cross grassy savanna or barbed wire to reach neighboring forest fragments. The groups seen had an average of 4.1 individuals per group ($n=13$) (Table 2). The authors strongly recommend the species be classified as Critically Endangered (CR) based on the IUCN criteria (B1a,b, B2a,b) (IUCN, 2001); that is, the geographic range in both the extent of occurrence (estimated to be less than 100 km²) and the area of occupancy (estimated to be less than 10 km²) are severely fragmented and continuing to decline due to agricultural activities. It is possible that the population size is fewer than 250 mature individuals, which would include criterion C as well, but more data on the occurrence of this species needs to be collected and a concerted effort made to calculate population size. Immediate efforts are needed to publicize the presence and the state of this primate species as well as create some small reserves in the region. Further surveys are needed to better delimit its geographic range and to clarify the presence of groups of *Callicebus* in northern parts of Caquetá and southern Meta that have been reported to show some of the characteristics of *Callicebus caquetensis*.

Table 2. Size, composition and locations of groups of *Callicebus caquetensis* observed in 2008–2009.

	Adult male	Adult female	Subadult	Juvenile	Infant	Total	Place	Coordinates
1	1	1	1	1	0	4	Finca Nilson Barragán	1°08'38.3"N 75°36'00.4"W
2	1	1	0	2	1	5	Finca Nilson Barragán	1°08'40.8"N 75°36'43.0"W
3	1	1	0	1	0	3	Finca Alirio Santanilla	1°08'09.4"N 75°35'51.4"W
4	1	1	0	1	1	4	Finca William Cuartas	1°8'17.9"N 75°34'28.5"W
5	1	1	1	0	1	4	Quebrada El Resbalón	1°06'30.4"N 75°32'42.8"W
6	1	1	2	0	1	5	Finca Moisés Cruz	1°06'54.4"N 75°37'27.3"W
7	1	1	0	1	1	4	Finca Fidelino Peña	1°07'11.0"N 75°38'01.1"W
8	1	1	2	1	1	6	Vereda La Florida	1°10'7.92"N 75°35'43.86"W
9	1	1	1	0	1	4	Quebrada La Solita	0°54'57.42"N 75°39'15.76"W
10	1	1	1	0	0	3	Quebrada La Solita	0°55'05.2"N 75°39'00.6"W
11	1	1	0	0	1	3	Finca Yaneth Soto	0°54'12.6"N 75°35'31.22"W
12	1	1	0	0	1	3	Finca Doña Amparo	0°55'15.4"N 75°33'34.9"W
13	1	1	1	2	1	6	Finca Edilberto Suárez	0°54'47.8"N 75°33'36.3"W
Total						54		
Average group size						4.1		
							Holotype: In captivity	1°8'24.61"N 75°32'34.04"W
							Paratype: In captivity	1°6'23.10"N 75°38'32.5"W

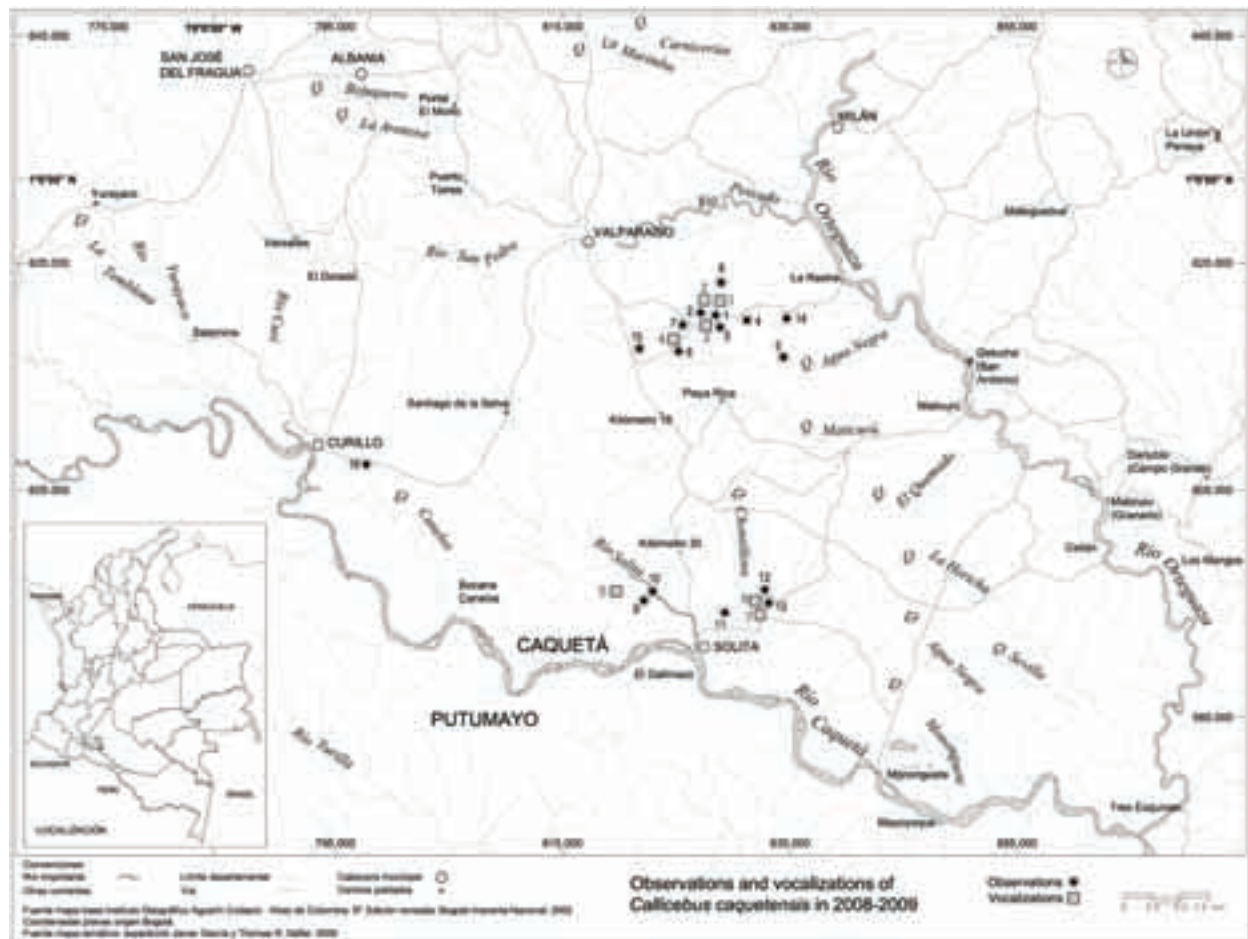


Figure 1. Observations and locations of groups of *Callicebus caquetensis* in the upper basin of the Río Caquetá, Colombia.

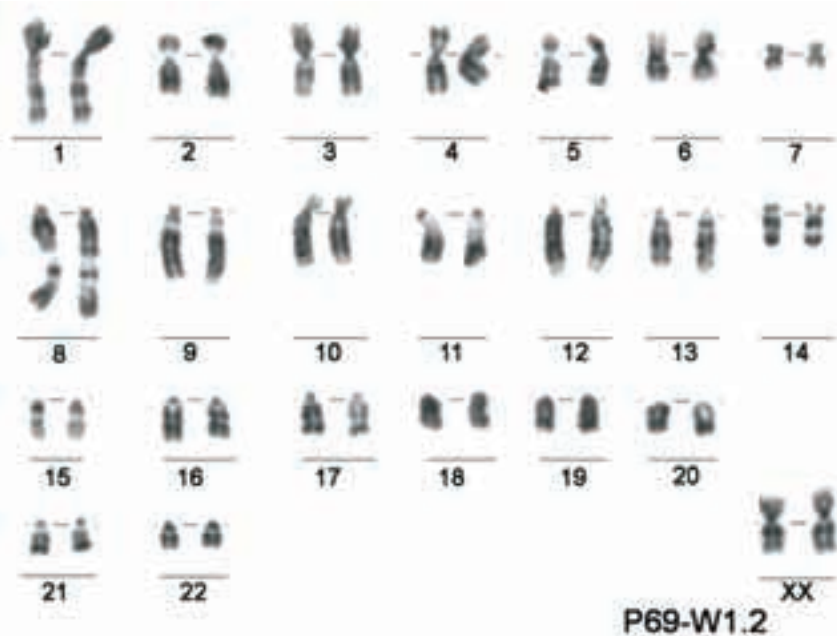


Figure 2. Karyotype of holotype: *Callicebus caquetensis*.



Figure 3a. Adult *Callicebus caquetensis* temporarily captured.



Figure 3b. Adult *Callicebus caquetensis* temporarily captured.



Figure 3c. Adult *Callicebus caquetensis* temporarily captured.



Figure 3d. Adult *Callicebus caquetensis* in low tree.



Figure 3e. Holotype of *Callicebus caquetensis*. Young female.



Figure 3f. Holotype of *Callicebus caquetensis*. Young female.



Figure 3g. Holotype of *Callicebus caquetensis*. Young female.



Figure 4a. Lateral view of holotype skull: *Callicebus caquetensis*.



Figure 4b. Superior view of holotype skull: *Callicebus caquetensis*.



Figure 4c. Inferior view of holotype skull: *Callicebus caquetensis*.



Figure 4d. Lateral view of holotype inferior mandible: *Callicebus caquetensis*.

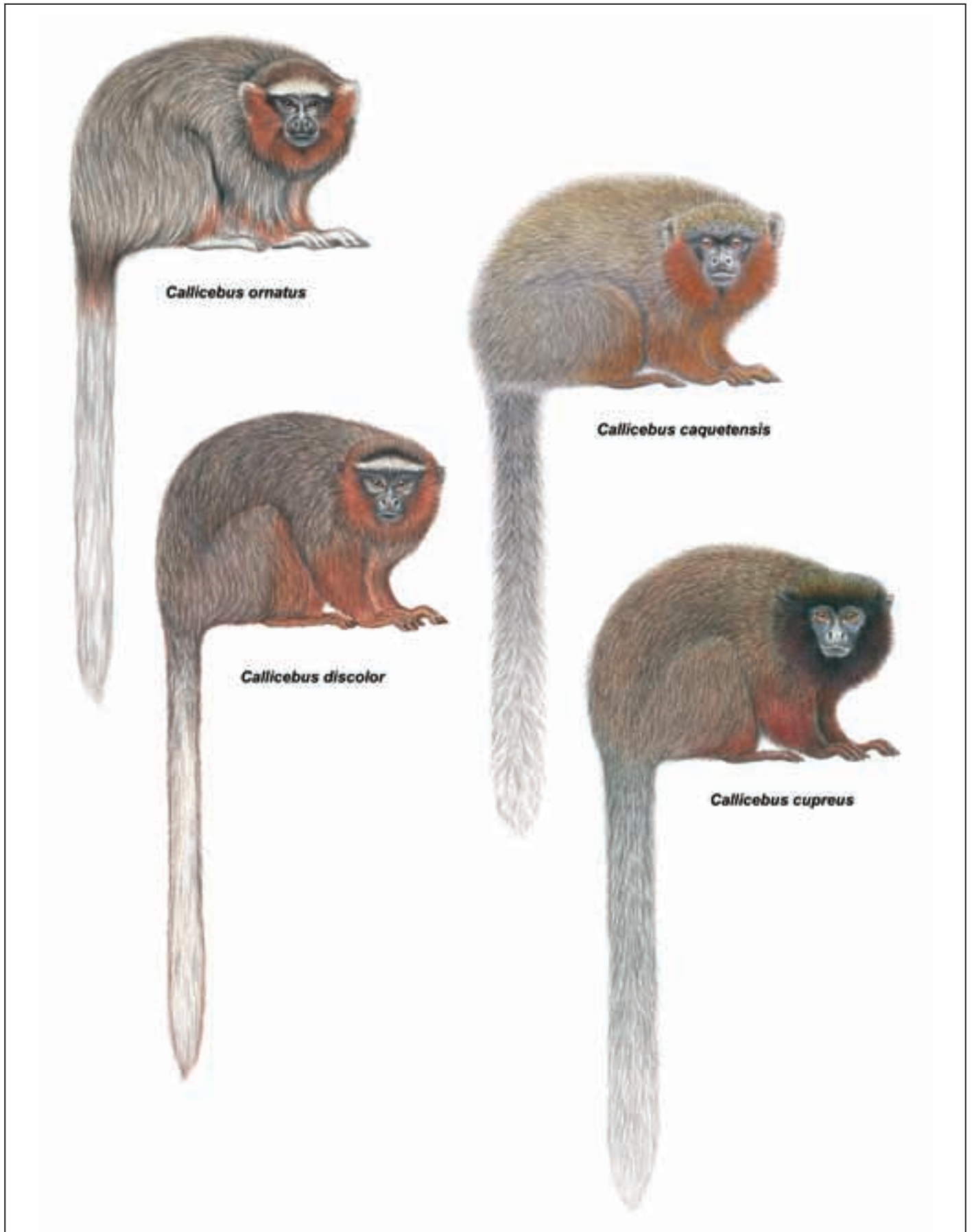


Figure 5. Four titi monkeys of southern Colombia, Amazonian Ecuador, and northern Peru. *Callicebus ornatus*, *Callicebus discolor*, *Callicebus cupreus*, and the new species described here, *Callicebus caquetensis*. Illustrations © Stephen D. Nash/Conservation International.

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The Urban Monkeys Program: A Survey of *Alouatta clamitans* in the South of Porto Alegre and Its Influence on Land Use Policy Between 1997 and 2007

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Abstract: Endemic to the Atlantic Forest, the southern brown howler monkey, *Alouatta clamitans*, can still be found in forest fragments in the metropolitan area of Porto Alegre, the capital of the state of Rio Grande do Sul, in the south of Brazil. The Urban Monkeys Program (UMP) has been monitoring their numbers since 1994. Here we report on the results of the initial surveys carried out from 1994 to 1996 and discuss the variables that are determining the loss or survival of the howler monkey groups. We also examine how our results have influenced the politics of land use over the last ten years (1997–2007). Porto Alegre has an area of 47,630 ha. About 30% is a rural/urban matrix and the remainder is entirely urban. There are 44 hills in the municipality and all have been affected by human occupation and activities. We overlaid a grid on a map 1/50,000, with quadrates of 1 km² divided into four quadrates of 500 m² each. We surveyed all the quadrates that contained forest. The presence of howler monkeys was recorded by direct observation, the presence of feces, and by their vocalizations. Complementary information was obtained by talking to the local people. We used a field protocol to record the absence or presence of howlers, habitat quality and the extent and type of human disturbance or use. We surveyed 5,125 ha and found howler monkeys in 2,921 ha (57%). The physiognomy, altitude and connectivity with forest in other quadrates were the three predictors of the presence of howler monkeys. Reasons for this include the fact that human use for such as agriculture, cattle breeding, housing estates, and roads is more concentrated in the lowlands than in the more hilly areas. Our findings suggest that the brown howler monkeys of Porto Alegre live as a meta-population. We participated in forums to discuss land use and management decisions. UMP influenced the creation of 895 ha of municipal protected areas over the 10 years. UMP initiated a civil enquiry concerning problems of the electrocution of howler monkeys using power lines. Two years after, as a result, the Rio Grande do Sul State Electricity Company insulated the cables in the areas where they presented a hazard. In 2002, a bill of amendment was passed (municipal law no 482/99), which provided for tax exemption for landowners who conserve natural areas or use their land for agriculture. Our recommendations for the future include: 1) maintenance of the current rural matrix in the south of Porto Alegre; 2) the creation of the “Morro São Pedro Natural Park”; 3) the establishment of a federal strategy for primate conservation in urban areas in Brazil; and 4) the inclusion of a criterion concerning human population density in the areas of occurrence for the threatened categories of the IUCN Red List.

Key words: Brown howler monkey, *Alouatta clamitans*, survey, conservation, advocacy, land use

Introduction

The southern brown howler monkey, *Alouatta clamitans* Cabrera, 1940, is endemic to the Atlantic Forest. Formerly considered a subspecies, it was recently separated from *Alouatta guariba* (Humboldt, 1812) on the basis of cranio-metrical parameters and pelage (Gregorin 2006). The species occurs in eastern Brazil, from the Serra do Espinhaço, Minas Gerais, south to the basin of the Rio Camaquã, Rio Grande do Sul (Printes *et al.* 2001; Gregorin 2006), occurring also in Misiones, northeastern Argentina (di Bitteti *et al.* 1994).

There are three primates in the state of Rio Grande do Sul: *Alouatta clamitans* Cabrera, 1940; the black howler monkey, *Alouatta caraya* (Humboldt, 1812); and the black-horned capuchin *Cebus nigratus* (Goldfuss, 1806). The brown howler monkey occurs in forest fragments in the municipality (including some suburban areas) of Porto Alegre, the state capital (Fundação Zoobotânica do RS 1976). The *Programa Macacos Urbanos* (Urban Monkeys Program – UMP) based at the Federal University of Rio Grande do Sul has been monitoring their numbers since 1994 (Buss 1996). Populations were found in the south of the municipality, where, however, the rural zone is undergoing rapid urbanization (Romanowski *et al.* 1998).

One of the IUCN Red List criteria for the classification of threatened species is “Severely fragmented” (Criterion B)” (IUCN 2001). This IUCN defines as follows: “The phrase ‘severely fragmented’ refers to the situation in which increased extinction risk to the taxon results from the fact that most of its individuals are found in small and relatively isolated subpopulations (in certain circumstances this may be inferred from habitat information). These small subpopulations may go extinct, with a reduced probability of recolonization.” Severe fragmentation precisely describes the situation of the brown howler monkeys in the municipality of Porto Alegre. Group sizes are generally larger than is considered typical for the species, reproductive rates are high, and there is considerable variation in group composition. Fragmentation makes dispersal difficult and dangerous, and promotes inbreeding depression (Jardim 2005).

The city of Porto Alegre and its metropolitan area has 3,718,778 inhabitants, 3.2% (53,447 people) living in slums (Maricato and Tanaka 2006). Urbanization began in the north, near the docks, and gradually moved south, with the city gradually taking over the oldest green areas, including islands, hills and river basins. Some of these areas, most especially the hilly regions, have howler monkey populations or isolated groups. The UMP’s aim in monitoring the howler monkey populations has been to look for extirpation patterns in order to carry out measures to protect them (Printes *et al.* 2000). An understanding of their occurrence and status in the municipality has allowed us to establish a conservation strategy for the species. The loss of rural areas to the spread of large and small cities is occurring worldwide (Folke *et al.* 1997), but effective mitigation is possible at a local scale.

Here we report on the results of the initial surveys carried out from 1994 to 1996 and discuss the variables that are determining the loss or survival of the howler monkey populations and groups. We also show how our results have influenced the politics of land use over the last ten years (1997–2007), and the extent to which a scientific approach is effective in influencing planning and land use policy in expanding cities.

Methods

Porto Alegre

Excluding its metropolitan region, Porto Alegre (30°01'S, 51°13'; 0 to 317 m above sea level) has an area of 47,630 ha (Fig. 1). In 2007, the urban population in the town was 1,420,667 inhabitants (IBGE, 2007). The city was founded in 1772, on the banks of the Rio Guaíba. Today about 30% of Porto Alegre is a rural/urban matrix and the remainder is entirely urban. The climate is subtropical humid (Cfa). The mean temperature in the hottest month is a little over 22°C and there is no marked dry season. Mean annual rainfall is 1,324 mm.

The forests of the region have their origin in two migration routes followed by angiosperms 5,000 years ago: one from the Paraná and Uruguay basins and the other from the coastal rain forests (Porto, 1998). Rambo (1954) estimated that 87% the plant species of Porto Alegre flora originated from the western plateau of Rio Grande do Sul, the open vegetation of Chaco, central and southern Andes, and the rain forest.

Brack *et al.* (1998) have catalogued 268 species, 171 trees, in 64 families in the flora of Porto Alegre. Myrtaceae, with 27 species, was found to be the most important family for the trees, and Asteraceae, with 17, was the principal family for shrubs. According to Brack *et al.* (1998), one-third of the species of the Rio Grande do Sul flora occurs in Porto Alegre. After ten years of collection and studies, they were able to define eleven distinct floral communities in Porto Alegre.

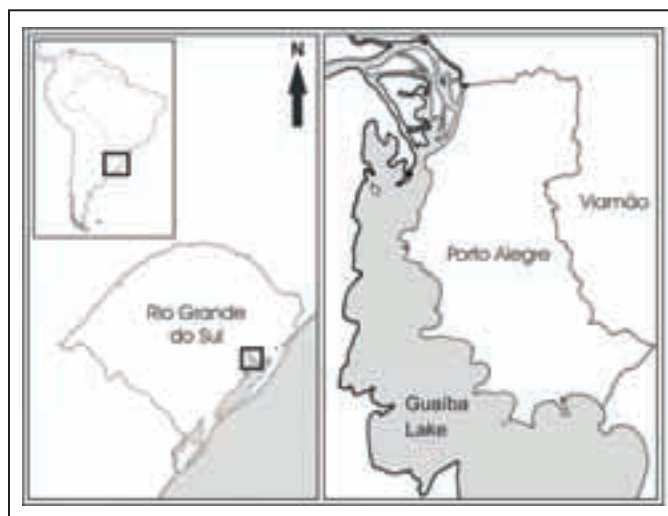


Figure 1. Porto Alegre, Rio Grande do Sul, Brazil.

The hilly areas, especially in the south, are covered by forest. The trees reach about 15 m in height. Grasslands cover the higher elevations due to the shallow soils. Sandy soil forest (*restinga*) (upper Palaeolithic dunes) characterizes the lower, flat areas of the Guaíba basin. The climate is wet in the winter, and the floral communities are distinct from those of forests at higher elevations (Brack *et al.* 1998; Fialho 2000). These ecosystems are threatened by cattle ranching, agriculture, and urbanization. The brown howler monkeys live in both the hills and restingas.

Although a federal law (11.428/06) protects the Atlantic Rain Forest remaining in Brazil, we have witnessed its rapid destruction and occupation over the last 15 years in Porto Alegre. The plains near the rivers and, likewise, the hilly regions are gradually being taken over by housing estates. There are 44 hills in the municipality and all have been affected by human occupation and activities: deforestation, fires, water pollution, motocross trails, alien invasive species, and cattle breeding (Velez *et al.* 1998). The housing estates in the forest fragments increase the mortality of the howler monkeys through death and mutilation caused by power lines (Printes 1999; Lokschin *et al.* 2007), road kill, dogs, and increased parasitosis (Valladares-Padua *et al.* 1995; Pickett *et al.* 2001; Cabral *et al.* 2007).

Surveys

The first surveys focussed on the southern part of Porto Alegre, which has the most forest in the municipality (see Fig. 2, stage 1). We overlaid a grid on a map 1/50,000, with quadrates of 1 km² divided into four quadrates of 500 m² each. This grid was then transposed onto a map scale 1/5,000 for use in the field. We surveyed all the quadrates that contained forest. Each survey involved at least three people, who spent up to 2 hours in search of howler monkey groups. For our localization we used a compass and a field map. The presence of howler monkeys was recorded by direct observation, the presence of feces, and by their vocalizations. Complementary information was obtained by talking to the local people. We used a field protocol to record the absence or presence of howlers, habitat quality and the extent and type of human disturbance or use. Parameters recorded were: a) percentage of the area with forest, assessed using maps, aerial photographs and field observations; b) distribution of the forest in the quadrate (continuous or fragmented), assessed using the maps and aerial photographs; c) connectivity of the forest with other quadrates, using a scale of 0 to 4 (0=isolated quadrate and 4=connection with all four surrounding quadrates); d) hydrography (presence of rivers, streams, and lakes); e) altitude; f) topography (flat, slope, or hill top); g) habitation (presence of houses and how many); and h) access to the quadrate, the presence of a narrow or wide trail, a road or highway, and estimating the amount of road traffic.

Analysis

Multiple logistic regression was performed using SPSS software. The parameters *a* to *h* were tested as predictors for

absence/presence as a dependent variable in the analysis. We used a maximum likelihood for estimation criterion. Statistical significance was set at 0.05 (Zar 2009).

Advocacy

We have participated in forums since the beginning of the Urban Monkeys Program in 1994 to discuss the land use and management decisions. The forums included those focussing on the resolution of conflicts concerning forest conservation versus industrial or urban development, especially the expansion of residential areas. For example, we have taken part in the so-called Participatory Budget, an official instance for discussion of priorities for public spending (from 1991–2003). Other examples include our participation in the Municipal Planning Forum, a working group composed of local municipal experts and citizens allowing for discussion of plans and local laws concerning land use and occupation, and the municipalities Environmental Council. In extreme cases, we have also been involved in judicial processes to guarantee the preservation of certain forests and their monkeys, combined with organized protests and media campaigns (Figs. 3 and 4). In some cases we were able to draw on legal mandates to talk directly with landowners, and propose alternatives that would

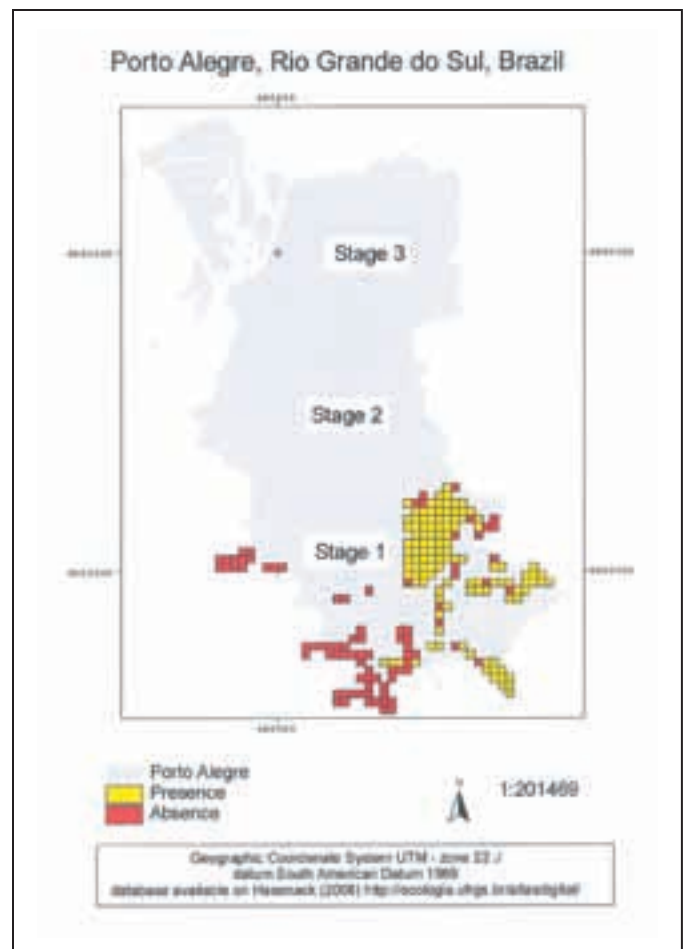


Figure 2. The three stages of survey and the distribution map of *Alouatta clamitans* in south of Porto Alegre, Rio Grande do Sul, Brazil.

be favorable for both the landowners and for the conservation of the forests and their resident howler monkeys.

To assess our influence concerning land use policy over the last ten years, we used: 1) the area (ha) that was converted into private or public reserves in Porto Alegre from 1997 to 2007; 2) the results of the judicial actions in terms of improvement to the well-being and safety of the howler populations; 3) the laws and decrees that were created by the municipality to protect wildlife, resulting at least in part from activities and contributions of the UMP.

Results and Discussion

Lessons from the past: the survey results

We surveyed 205 quadrates (5,125 ha) and found howler monkeys in 57% of them (2,921 ha) (Fig. 2). We saw howler monkeys in 28 quadrates, and in the remainder we identified their presence from finding their feces. The logistic regression analysis showed that topography (coefficient = -1.37; SE = 0.49; $p = 0.005$), altitude (coefficient = 1.25; SE = 0.29; $p < 0.001$) and, to a lesser extent, connectivity with forest in

other quadrates (coefficient = 0.57; SE = 0.27; $p < 0.05$) were the three predictors of the presence of howler monkeys. Reasons for this probably include the fact that human use for such as farming, cattle breeding, houses and roads is more concentrated in the low-lying (flat) areas than in the more hilly areas, and also that tree species diversity is higher and the vegetation structure is more complex on slopes of the hills than in the lowlands (Fialho, 2000).

Brown howler monkeys were found in only one quadrate that was completely isolated. All others had forests that were connected to those in at least one neighboring quadrate. Howler monkeys were found to occur in 83% of the category 4 quadrates (continuity with all four neighboring quadrates). As such there is a high probability of howlers being found in quadrates which have forest that extends into three or four other quadrates. Forest connectivity is, therefore, an important parameter for the maintenance of howler monkeys in Porto Alegre, corroborating the hypothesis that isolation is decisive in determining local extinctions. Although the forest cover percentage in each quadrate was not an important predictor, it should be noted that howlers were not found in 86% of the quadrates with less than 10% (2.5 ha) of forest.

The results clearly indicate that the presence of howler monkeys is influenced by features of the landscape. The lack of association between the howler's presence and the number of houses in the quadrate is possibly due to the fact there were few houses in the majority of them. The howlers are quite able to live in areas of, say, 25 ha when there are just one or two houses. Land use in the area is more agricultural than urban, and is compatible as such with the survival of the howlers to the extent that forest patches are left standing and with some connectivity between them (Estrada 2007). One can predict that a negative correlation would appear with an increase in the density of houses. There is no significant association between the presence of howlers and the type of access to the quadrate. Traffic speed is possibly more important than actual form of access (a highway or a road). The volume of traffic and speed can make dispersal more hazardous (road kill), effectively increasing the isolation of the forest patches (Jardim, 2005). As with the numbers of houses, traffic volume and speed of course increases with increased urbanization (more and improved roads and highway).

Together these quantitative variables are important to evaluate the biogeographic context of the distribution of the howler monkeys in Porto Alegre (Fig. 5). The population of the Morro São Pedro (*morro* = hill) is the largest and probably the most important. It is connected to the Lami and Boa Vista populations through the forests along the Rio Lami, which also form a corridor between the flat lowlands and the Morro da Extrema, east of the Morro São Pedro. The impacts of urbanization are very evident, with the absence of howler monkeys surrounding the Morro São Pedro. For example, we accompanied the gradual displacement of howler groups up the north face of the hill following the beginning of the construction of the Favela do Castelo (*favela* = slum) in 1999. Prior to this, urbanization has isolated the howler monkey



Figure 3. “The right to live together”, an environmental education event in the Morro São Pedro, 1999.



Figure 4. The Urban Monkey Program's sticker.

population along the isthmus of Ponta Grossa and, according to those we interviewed, the monkeys disappeared about 40 years ago. The absence of forest corridors prevents recolonization. Today we are witnessing the gradual demise of a group in a lowland area of *restinga* forest in the Lami district that has been isolated since 1997. The animals suffer heavy parasite loads, because the water in the forest fragment is polluted by sewage and domestic waste from the nearby houses (Cabral *et al.* 2007). Dogs are another problem, chasing the monkeys and killing them when they go to the ground.

Our findings suggest that the brown howler monkeys of Porto Alegre now live as a metapopulation. We have no understanding of the occurrence or rates of dispersal, but it is clear that the permanence of the various subpopulations depends on the availability and suitability of corridors between fragments and a sufficient genetic flux (Chepko-Sade and Halpin 1987). The decrease in the number of occupied forest fragments and increasing isolation makes dispersal ever more difficult (Primack and Rodrigues 2001). Jardim (2005) studied 10 howler groups of this metapopulation and found that group size was larger than is typical for this species elsewhere, with high reproductive rates and correspondingly variable group composition, all indicating increased population densities, low dispersal and intense group dynamics. However, the long-term survival of these populations is uncertain due to the increasing pressures of urban occupation and the consequent fragmentation of their habitat. Further studies on population

densities and population dynamics, sex ratio, and effectiveness of corridors are needed to propose measures for the preservation of this metapopulation.

Lessons for the future

Lacking sufficient public initiatives to administer and control urban growth, the hills of Porto Alegre are fast being destroyed by the loss of the natural vegetation and the consequent erosion (Brazil 2004). The legislation is ineffective, and there is an estimated demand for more than 100,000 domiciles in Porto Alegre and its metropolitan region (Maricato and Tanaka 2006). Furthermore, land speculation in some regions of Porto Alegre, such as the islands and the older district, has for many years resulted in social exclusion, violence and environmental degradation. Urban planning and the accompanying legislation has no impact on the unregulated urban growth on the periphery, nor even sometimes for development and construction in the formal economy. The last census in Brazil (in 2000) revealed that 55 million people (32% of the population) live in just 11 big cities in Brazil (that includes Porto Alegre) and 82% of the people have inadequate housing (IBGE 2007). Our results are showing that the existence of the howler monkey metapopulation in Porto Alegre is merely a result of chance and Porto Alegre's own particular history. The hilly countryside has allowed for the permanence of forest on the slopes to date, but it would seem not forever, unless urban planning specifically and forcefully incorporates

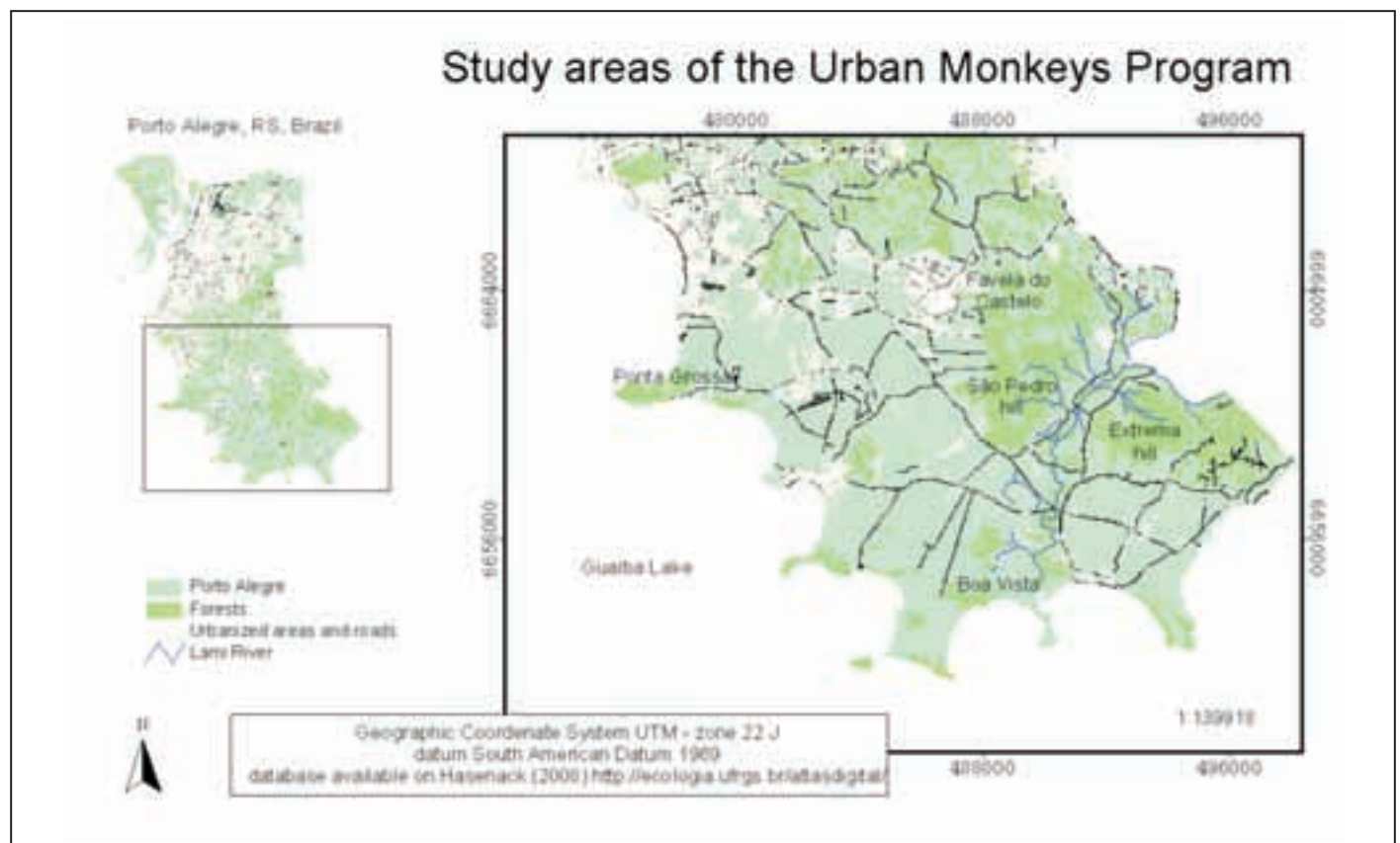


Figure 5. Study areas of the UMP.

the value of the remaining forests, for leisure, their services in terms of erosion prevention and water regulation, and the wildlife they contain.

Near urban centers, the occupation of natural areas occurs through the gradual expansion of slums, as is happening along the northern slopes of the Morro São Pedro and in the Lami *restinga*. In the rural areas, on the other hand, the occupation is agricultural, for example to the south of the Morro São Pedro and the Morro da Extrema, and in the Lami wetlands. While both rural and urbanized areas if properly planned can allow for the preservation of some forest fragments (and even corridors), the urbanized areas present further hazards for the howler monkeys such as dogs, water pollution, food scarcity, and increased chances of electrocution from power lines (Printes 1999; Lokschin *et al.* 2007).

Role of the UMP

How has the UMP fared in influencing land use patterns and urban planning in favor of the conservation of forests and the howler monkeys? We can evaluate its success using three parameters.



Figure 6. The southern brown howler monkey, *Alouatta clamitans*. Female and offspring at Lami, Porto Alegre, Rio Grande do Sul, Brazil. Photograph by Adriano Becker.

1. The area of private or public reserves created in Porto Alegre between 1997 and 2007

In all, UMP was influential in the creation of 895 ha of protected areas over the 10 years (Table 1). This would appear to be a small area, but in the urban context the number is very meaningful, and these valuable hectares are protecting some of the most important forest patches for howler monkeys. Other areas are in the process of receiving protected status. Other institutions and people of course were involved and contributed markedly to the creation of these protected areas, but the UMP's vital contribution has been the maps of the distribution and numbers of howler monkeys, in essence serving as flagship species for the forests. The map was crucial, for example, in the case of the expansion of the Lami Biological Reserve, and has provided solid arguments for the definition of the boundaries of the future Morro São Pedro Natural Park.

2. Legislative measures for the conservation of the howler monkey

The first judicial action was in 1996, when the local government decided to create a landfill for urban waste at the Morro da Extrema. The UMP had identified the area as an important corridor for the howlers. We formally denounced the proposal to the federal justice as illegal on the basis of the Forest Code (*Código Florestal*, No. 4771, 15 September 1965), arguing that the area had numerous streams (the Forest Code, has special provisions for the protection of forest along water courses) and was also important for the conservation of the howler monkey. Although the complaint was formally registered and the UMP had the full support of the local communities, the municipal government and the judiciary reached a compromise agreement, and the rubbish tip was established in 1997 (Reichert and Anjos 1997). Between 1998 and 2003, the municipal employees reported seeing the howler's crossing over the tip. Our failure was in part due to the inexistence at the time of the Environmental Crimes Law, decreed only in 1998 (*Lei de Crimes Ambientais*, No. 9605, 12 February 1998). This law incorporates the precautionary principle and dispenses proof in an environmental risk assessment.

The most important action of the UMP in the judiciary was the civil enquiry number 21/2003, concerning the electrocution of howler monkeys and other animals that climb onto the power lines. Documentation on the mutilation and

Table 1. Land (ha) converted to protected areas in Porto Alegre from 1997 to 2007.

Name	Area (ha)	Status	Domain	Influence of the UMP
Lami Biological Reserve	79 + 102	Created	Public (Municipal)	Process of expansion (102 ha) and development of the management plan (1999–2002)
Morro do Osso Natural Park	27 (with provision for another 87 ha)	Created	Public (Municipal)	Support for and participation in its creation (1996–2002)
Morro São Pedro Natural Park	Approx. 500	Creation in abeyance (political issues)	Public (Municipal)	Support for and participation in its creation (1999–2002)
Econsciência Private Reserve (RPPN)	Approx. 100	In the process of being created	Private	Support for and participation in its creation (2000–2007)
Total	895			

Table 2. Municipal legislation in Porto Alegre influenced by the UMP (1997–2007).

Municipal Laws and Decrees	Objective
Municipal Law 434/99	Municipal planning for urban and sustainable development
Municipal Law 482/2002 Decree 14265/2003	Exemption of taxes for agricultural land and natural areas
Municipal Law 8971/2002 Decree 14196/2003	Obligation to insulate electric cables

death of howler monkeys was very important in this case. UMP has been collecting information on incidents of this sort since 1999, using photographs, veterinary reports and interviews with inhabitants near the power lines (Printes 1999). After two years in the judiciary, the final decision was in favor of the howlers. The Rio Grande do Sul state electricity company (CEEE - *Companhia Estadual de Energia Elétrica - Rio Grande do Sul*) consequently insulated the cables in the areas where they presented a hazard (Lokschin *et al.* 2007). The UMP was appointed by the judiciary to make an inventory of priority areas. The decision was based on the Environmental Crimes' Law and was the first of its kind in Brazil. Since 2005, about US\$50,000 has been invested in the insulation of cables where wildlife is at risk. The number of cases of electrocution has decreased substantially as a result, and the UMP continues to monitor any further incidents for the CEEE to take the appropriate measures.

3. Municipal laws and decrees for the protection of wildlife

The UMP has been influential in the creation of municipal legislation concerning three major issues (Printes *et al.* 2000) (Table 2). The municipal planning for urban and sustainable development eliminated the legal concept of “rural area” within the metropolitan region in 1999 (Municipal Law 434/99) (Porto Alegre 2004). This act had very direct and major consequences in terms of soaring taxation, relaxed conservation laws applicable to the land concerned and, as a corollary, increased risks of unregulated urbanization and habitat destruction. We started a movement together with the farmers to create legal ways to stimulate the agricultural activities and the conservation of the natural areas. In 2002, an amendment bill for the municipal law number 482/99 guaranteed tributary exemption to landowners who conserved natural areas or demonstrated the use of their land for agriculture. Until 2006, 14 owners received benefits due to their protection natural vegetation on their land, and another 400 due to farming activities (Teles 2006).

Considerations

The co-existence of non-human primates and people in a rural matrix landscape has been well documented in a number of countries (Chiarello and Galetti 1994; Estrada and Coates-Estrada 1996; Estrada *et al.* 2006; Crockett 1998; Siex and Struhsaker 1999). In the absence of hunting, the howlers are perfectly able to live in fragments, in disturbed areas and very

close to human communities (Crockett 1998). We believe that if habitat loss is halted and corridors are maintained (and created), groups of howlers survive.

We propose the following:

- Preservation of the current rural features (green areas and corridors) in the southern part of the metropolitan area of Porto Alegre;
- The creation of the “Morro São Pedro Natural Park” important for the *Alouatta clamitans* metapopulation;
- The establishment of a federal strategy for primate conservation in urban areas in Brazil to counteract and moderate urban growth;
- Include human population density in the areas of primate occurrence as a new criterion for the IUCN Red List, as suggested by Harcourt and Parks (2003).

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An *Aotus* Karyotype from Extreme Eastern Colombia

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Abstract: The paper ‘*Aotus* diversity and the species problem’ (Defler and Bueno 2007, *Primate Conserv.* 22: 55–77) reviewed the distribution of the *Aotus* karyotypes in Panama and Colombia. It included a discussion of a night monkey from Maipures, Vichada, Colombia, that we captured live and karyotyped for a project at the Universidad de Los Andes, Bogotá, Colombia, in 1983. In 1984, in an unpublished manuscript, we hypothesized that this specimen was a natural hybrid of *Aotus brumbacki*. Our identification was based on the karyotype G-band patterns, capture location, fur color, and a skin and skull preserved at the Instituto de Desarrollo de Los Recursos Naturales y Renovables (INDERENA), Bogotá, now at the Instituto de Alejandro von Humboldt. Defler and Bueno (2007) had interpreted the karyotype by assuming that all 50 chromosomes were paired. However, the authors had used data from an indistinct photograph of a karyotype without G-bands. This prompted us to review our original data using contemporary digital techniques to re-examine the G-band pattern origins of the chromosomes and further define the karyotype. We used precise chromosome G-band measurements and digital arm-ratio analyses to provide convincing evidence that the specimen is in fact a hybrid of *Aotus brumbacki*.

Key Words: Colombian primate, *Aotus brumbacki*, hybrid, G-banding karyotype, digital chromosome measurements

Introduction

In the early 1980s, we discussed Colombian *Aotus* diversity with the mammalogist Philip Hershkovitz of the Chicago Field Museum of Natural History, specifically concerning his 1983 revision of the genus (Hershkovitz 1983). Since one of us (TRD) was working close to the Río Orinoco, in Tuparro National Park, Colombia, Hershkovitz encouraged us to trap some night monkeys there, in order to confirm or refute the supposition that *Aotus trivirgatus* existed west of the Orinoco. *Aotus trivirgatus* was still unknown karyologically, and we hoped to provide geo-referenced Colombian specimens for this purpose. The precise provenance of most karyotyped specimens was unknown, creating problems for interpretation of karyotype origins and distributions. At that time the only geo-referenced collection site for a night monkey in Colombia was the holotype for *Aotus hershkovitzi* Ramirez-Cerquera, 1983, from Boyacá, on the eastern flanks of the Cordillera Oriental (see Defler *et al.* 2001). That collection site helped prove that the taxon was in fact a synonym of *Aotus lemurinus*. *Aotus lemurinus* had previously been associated with

karyotypes from Panama. The Panamanian karyotypes were subsequently interpreted to represent a distinct species, *Aotus zonalis* Goldman, 1914 (Hershkovitz 1983; Groves 2001; Defler 2004).

Following Hershkovitz’ request, we trapped a female night monkey at Maipures, Vichada, on the west (Colombian) bank of the Río Orinoco in 1983. Under the subtitle “*Aotus brumbacki* and the Maipures specimen”, Defler and Bueno (2007) discussed the identity of this specimen based on a poorly reproduced copy of a photomicrograph of its chromosomes, resulting from the work of M. V. Monsalve, R. Oliveira and T. R. Defler at the Universidad de Los Andes in 1984. In analyzing the image, Defler and Bueno (2007) indicated four pairs of metacentric, nine pairs of submetacentric (two of which were poorly resolved, but believed to be submetacentric), and eleven pairs of acrocentric chromosomes, along with one pair of sex chromosomes. They identified the specimen as *Aotus brumbacki* Hershkovitz, 1983 (p.217), based on the *A. trivirgatus trivirgatus* karyotype of Yunis *et al.* (1977), which Hershkovitz (1983) had synonymized with *A. brumbacki*. Defler and Bueno (2007) pointed

out, however, that “none of three previously published descriptions of chromosomal morphology for *A. brumbacki* (Brumback 1974; Yunis *et al.* 1977; Torres *et al.* 1998) agreed completely in the characteristics of the $2n = 50$ chromosome types, and showed considerable variation in the identification of numbers of metacentric, submetacentric and acrocentric chromosomes.” (p.58). They concluded that *A. brumbacki* should be subjected to further studies of its chromosome morphology. *Aotus brumbacki* is characterized by five pairs of “median-submedian” metacentric, seven pairs of subterminal and twelve pairs of terminal autosomal chromosomes. The sex-chromosome pair consists of a median X-chromosome and a small terminal Y-chromosome (Brumback 1974). The Defler and Bueno (2007) interpretation of the Maipures specimen lacked cytogenetic analyses of chromosome arm lengths.

The genus *Aotus* shows considerable variation in the number of chromosomes. De Boer (1974) described diploid numbers of 49 and 51 in *A. trivirgatus* ssp., while Yunis *et al.* (1977) found diploid numbers of 50 and 54 in *Aotus trivirgatus*. For *A. trivirgatus griseimembra*, Yunis *et al.* (1977) found karyotypes with diploid numbers of 50, 52 and 54. Brumback *et al.* (1971) and De Boer (1971, 1972, 1974) described karyotypes with diploid numbers of 52, 53 and 54 (resulting from Robertsonian polymorphisms) also in *A. trivirgatus griseimembra*.

A study of 35 Colombian *Aotus* by Torres *et al.* (1998) showed karyotypes with diploid numbers from 46 to 58. The distribution of the *Aotus* in this study covered the area from 8°40'0"N to 4°12'55"S and 75°40'52"W to 69°56'26"W. Our Maipures *Aotus* from the west bank of the Río Orinoco has a karyotype with a diploid number of $2n = 50$, as do a number of specimens reported by Torres *et al.* (1998) from the Department of Meta nearby.

Here we expand the karyotype analyses of the Maipures specimen by: 1) classifying the chromosomes based on visual observation of G-band patterns; 2) digitally calculating chromosome arm ratios and total chromosome lengths; and 3) digitally calculating the distribution of banding patterns to match chromosomes. We explain the analyses of the G-band pattern of the karyotypes that support our earlier identification of the *Aotus* specimen.

Methods

In 1983, we trapped two living night monkeys from a group in a tree hollow on the west bank of the Río Orinoco, at Maipures, Department of Vichada (5°12'51.69"N, 67°50'03.44"W). We determined the karyotype of a female (IAvH4105) in the Laboratory of Human Genetics of the Universidad de Los Andes, Bogotá, Colombia. We delivered the two specimens (IAvH3888 and IAvH4105) to the Instituto de Desarrollo de Los Recursos Naturales y Renovables (INDERENA), and both are now part of the permanent collection at the Alexander von Humboldt Institute, Claustro de San Agustín, Villa de Leiva, Boyacá, Colombia.

We cultured 5 ml of the peripheral blood of the *Aotus* specimen IAvH4105 for 72 hours at 37°C in 5 ml of RPMI 1603 medium (Grand Island Biological) supplemented with 20% fetal calf serum and 0.2 ml of phytohemagglutinin M (Difco), according to a modification of the method by Moorhead *et al.* (1960). We obtained prometaphase chromosomes using the amethopterin cell synchronization technique developed by Yunis (1976). The cells were spread on a slide, and the slide was then air-dried and stained with Giemsa. Our study used the G-banding technique described by Sumner *et al.* (1973). We karyotyped well-spread prometaphase chromosomes obtained by screening fifty mitoses with chromosome complements of $2n = 50$.

We arranged the karyotypes according to the Miller *et al.* (1977) criteria to differentiate species of *Aotus*, arranging the G-band chromosomes with metacentrics first, then submetacentrics and acrocentrics last. We measured the length of short and long arms of our specimen using National Institutes of Health ImageJ (US National Institutes of Health) and Acrobat PDF software. We analysed each of the chromosomes in the karyotype photomicrographs using three different analyses: 1) ImageJ, 2) ImageJ with the option “invert,” and 3) ImageJ with the option “converting band density to peak data.” Using the results of these digital approaches, we re-organized the karyotypes in three groups according to the mean arm ratio values as follows: metacentric arm ratio, 1-1.9; submetacentric plus subtelocentric arm ratios, 2-3.9; acrocentric plus telocentric arm ratio, >4.0.

The reference karyotype of *Aotus brumbacki* was obtained from the photomicrograph in the journal article by Brumback (1974). We measured the arm ratio (length of the long arm divided by the length of the short arm) and total complement length for each chromosome using National Institutes of Health ImageJ (US National Institutes of Health 2009), and Acrobat PDF software. We analysed each chromosome of this karyotype with ImageJ and ImageJ with the option “invert”. The option “converting band density to peak data” in ImageJ was not used in the analyses because this karyotype did not have bands.

We expressed the length of each chromosome of our specimen and of *Aotus brumbacki* (Brumback 1974) as the percentage of the X-containing haploid complement length (%TCL) according to Torres *et al.* (1998). Results of these chromosome measurements obtained from our specimen and the *Aotus brumbacki* karyotype (Brumback 1974) are shown in Table 1.

Our research was approved by the *Comité de Investigaciones* of the Universidad de los Andes, Bogotá, Colombia. It complied with national requirements to leave biological samples with INDERENA, and it adhered to the American Society of Primatologists' principles for the ethical treatment of nonhuman primates.

Results

Our analyses of G-band chromosomes in the karyotypes of the Maipures specimen and the holotype were consistent with the existence of two different haploid complements with different numbers of metacentric and submetacentric chromosomes, but with identical numbers of acrocentrics and haploid complements, each consisting of 25 chromosomes. Each chromosome was classified as metacentric, submetacentric or acrocentric by measuring digital images according to the G-band distribution and arm length ratios. The peak data obtained with ImageJ allowed us to match five metacentric pairs, six submetacentric pairs, and nine acrocentric chromosome pairs as homologous. Some chromosomes were not homologous. We therefore divided the chromosomes into two groups, each one with a haploid complement of 25 chromosomes. Group I (Haploid A in Fig. 1) consisted of six metacentric (including one X-chromosome), seven submetacentric and twelve

acrocentric chromosomes. Group II (Haploid B in Fig. 1) consisted of seven metacentric (including one X-chromosome), six submetacentric and twelve acrocentric chromosomes. We show the G-banding karyotype of the *Aotus* IAvH4105 with 50 chromosomes (Fig. 1). The chromosome measurements of the *Aotus* karyotypes are expressed as percentages of the total chromosome length (TCL) and mean of the arm ratio (Table 1).

These findings are consistent with the existence of two different haploid complements with 25 chromosomes each. We confirmed the preliminary conclusions in our unpublished 1983–1989 *Aotus* project indicating that the specimen was an *Aotus brumbacki* hybrid. Using digital tools we identified chromosomes that did not match as pairs according to their G-band patterns and in their long- and short-arm ratios.

The accepted morphological description of the karyotype for *Aotus brumbacki* is that of Brumback (1974) of a male specimen, originally referred to as *Aotus azarae*

Table 1. Chromosome measurements of the Maipures specimen's two haploid complements (n = 25) and the diploid *Aotus brumbacki* complement (2n = 50).

Haploid Complement A					<i>Aotus brumbacki</i> ** Complement				Haploid Complement B				
	%TCL		Arm Ratio		%TCL		Arm Ratio			%TCL		Arm Ratio	
Chromosome	x	s	x	s	x	s	x	s	Chromosome	x	s	x	s
1 ^M	6.1	0.74	1.5	0.32	6.7	7.95	1.8	0.14	1 ^M	6.3	4.30	1.3	0.22
2 ^M	5.6	0.56	1.2	0.13	5.8	2.69	1.2	0.25	2 ^M	4.9	4.37	1.5	0.14
3 ^M	3.9	1.09	1.7	0.14	4.1	5.00	1.5	0.24	3 ^M	4.4	4.09	1.3	0.08
4 ^M	3.9	2.37	1.6	0.53	3.8	7.76	0.9	0.11	4 ^M	4.1	4.15	1.5	0.32
5 ^M	3.5	3.39	1.3	0.21	4.0	3.84	1.7	0.14	5 ^M	3.3	1.98	1.6	0.24
6 ^S	5.9	2.10	2.7	0.34	5.7	1.47	5.0	1.02	6 ^M	4.7	7.83	1.8	0.07
7 ^S	4.6	1.92	3.2	0.18	5.7	7.81	7.3	0.76	7 ^S	6.1	3.46	2.6	0.22
8 ^S	4.4	0.95	3.6	0.63	5.6	3.58	3.1	0.03	8 ^S	4.7	2.01	3.3	0.16
9 ^S	4.2	1.82	3.5	0.30	4.9	1.33	3.0	0.55	9 ^S	4.2	2.53	3.0	0.37
10 ^S	3.6	2.90	3.8	0.29	4.6	2.06	3.1	0.15	10 ^S	4.1	1.91	3.5	0.70
11 ^S	3.7	2.21	2.3	0.21	4.3	0.62	2.6	0.15	11 ^S	4.0	0.71	2.9	0.58
12 ^S	2.9	1.78	2.9	0.28	3.5	12.22	2.3	1.02	12 ^S	4.0	1.52	2.1	0.03
13 ^A	5.3	2.48	5.6	0.26	4.4	12.43	5.6	2.73	13 ^A	5.3	2.56	5.9	0.40
14 ^A	4.6	1.71	9.3	2.68	4.1	1.19	11.5	7.39	14 ^A	4.4	2.17	8.8	1.05
15 ^A	4.0	3.19	6.3	1.75	3.6	18.19	5.8	3.77	15 ^A	3.8	3.29	4.7	0.16
16 ^A	4.2	2.73	4.8	0.10	3.4	4.73	8.2	3.95	16 ^A	3.7	2.67	4.5	0.45
17 ^A	3.6	2.45	5.2	0.22	3.1	2.60	17.0	10.19	17 ^A	3.6	2.03	5.2	0.10
18 ^A	3.4	2.17	4.3	0.23	3.2	6.61	8.4	5.01	18 ^A	3.3	1.58	4.1	0.18
19 ^A	2.9	2.47	4.1	0.20	2.8	4.98	15.1	8.22	19 ^A	2.9	3.92	4.3	1.12
20 ^A	2.9	2.93	4.9	0.08	2.6	1.25	7.7	0.88	20 ^A	2.7	3.26	4.7	0.66
21 ^A	2.8	4.31	4.6	0.34	2.6	3.44	6.2	0.38	21 ^A	2.8	3.02	5.0	0.09
22 ^A	2.7	5.61	6.0	3.55	2.5	2.77	8.5	2.52	22 ^A	2.9	3.42	4.9	2.21
23 ^A	2.6	3.53	4.8	0.63	2.4	1.06	7.6	1.00	23 ^A	2.6	3.55	4.9	0.45
24 ^A	2.7	1.57	6.7	2.45	2.2	4.01	5.2	1.47	24 ^A	2.7	0.76	4.3	0.92
X ^M	5.3	3.69	1.3	0.30	4.4	0.00	1.7	0.00	X ^M	4.6	4.04	1.2	0.23

*%TCL (%Total Chromosome Length) = relative length; x = mean; s = standard deviation.

^M= Metacentric; ^S=Submetacentric; ^A=Acrocentric

**Measurements obtained from the *Aotus brumbacki* karyotype (Brumback 1974).

Humboldt, 1812, but corrected by Hershkovitz (1983) as representing the new species that he named *Aotus brumbacki*. This karyotype was shown in Figure 1 in Brumback (1974) and was published again by Hershkovitz (1983) (Figure 7: *Aotus brumbacki* [holotype] FMNH 123035 [head in alcohol]). We measured the chromosomes of this karyotype by using ImageJ and Acrobat PDF software and our results indicated that five pairs of chromosomes and the X-chromosome fell into the metacentric category with values less than 2, and seven fell into the submetacentric category. Although the short arms of the acrocentric chromosomes were difficult to measure, their values were higher than 4.0, falling into the category of acrocentric chromosomes. The mean ratio and relative lengths are shown in Table 1. These results confirmed that

our digital measurements are in agreement with the numerical values found in our Maipures *Aotus* specimen.

Our karyotype results of the Maipures specimen were validated by a methodology that included: 1) G-banding pattern examinations by four colleagues at the University of British Columbia (UBC) in addition to the first author; 2) separate analyses of digital images by two individuals working independently at UBC in addition to the first author; and 3) use of Image J and Acrobat PDF software to compare the results.

Discussion

Since some of the chromosomes in our specimen were difficult to classify either as metacentric, submetacentric

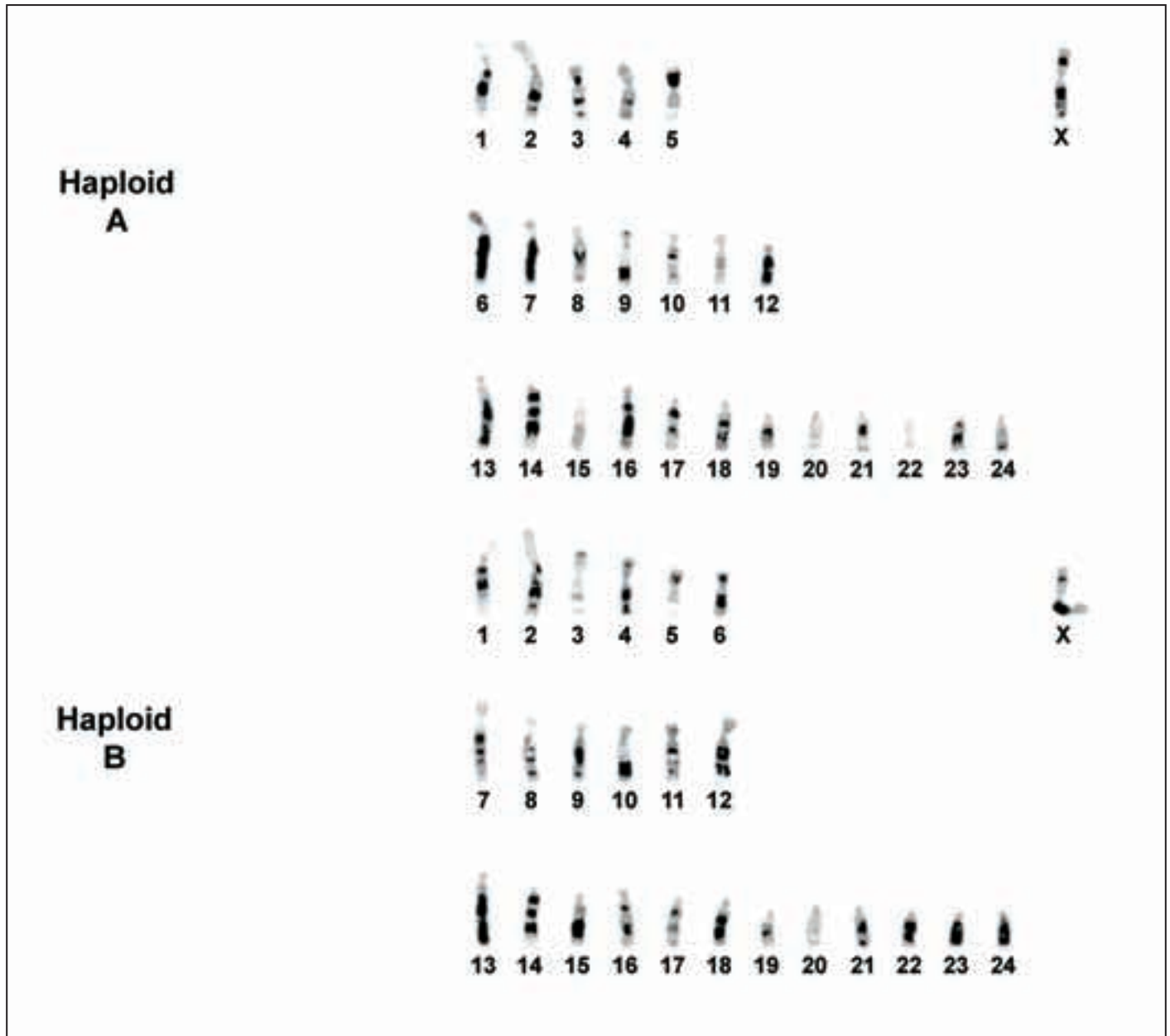


Figure 1. G-banding karyotype of the Maipures specimen with 50 chromosomes. The X chromosomes are at the right corner of Haploid A and Haploid B complements each one with 25 chromosomes. The chromosomes in both haploid complements are arranged in metacentric, submetacentric and acrocentric order.

or acrocentric, we used ImageJ and Acrobat PDF software to obtain digital measurements of long and short arms. This technique allowed us to classify each of the chromosomes of the karyotypes not only by visual observation of the G-band pattern but also more accurately based on quantitative values. We digitally plotted the bands of each chromosome and calculated the length of the short and long arms and bands. Their relative lengths helped us to determine if chromosomes were homologous. With these measurements we found that five chromosomes in the haploid complement “A” and six in the haploid complement “B”, and X-chromosomes of both complements, fell into the category of metacentric, with values less than 2.0. Seven chromosomes in the haploid complement “A” and six in the haploid complement “B” fell into the category of submetacentric, with values higher than 2.0. Finally, twelve chromosomes in haploid complements “A” and “B” fell into the category of acrocentric, with values higher than 4.0.

Our finding of odd numbers of metacentric and submetacentric chromosomes in this specimen, in addition to the presence of a diverse pattern of G-band chromosomes that are expected to be homologous, supports the hypothesis that this specimen is a hybrid. Our study sample may represent the karyotype of a natural hybrid resulting from the cross-breeding of *Aotus brumbacki* and another species. This second species should be searched for in eastern Colombia and probably at least partially overlaps with the distribution of *Aotus brumbacki*.

Our study suggests that one of the haploid complements may come from the population that Brumback (1974) described as having five pairs of “median-submedian” autosomal chromosomes, seven pairs of “subterminal” autosomal chromosomes and twelve pairs of “terminal” autosomal chromosomes in a male *Aotus brumbacki*.

We compared the Q-bands of the night monkey referred to as *Aotus trivirgatus trivirgatus* by Yunis *et al.* (1977) to the G-band patterns of our specimen. Depending on the particular staining technique the alternating light and dark or fluorescent and non-fluorescent bands in chromosomes can be seen under a microscope. A fluorescent band will be seen in a specific region of a chromosome using Q-band techniques while a dark band will be seen in the same region when using G-band techniques. None of the haploid complements of our specimen corresponded to those reported by Yunis *et al.* (1977) when we used ImageJ “invert” to digitally convert the G-band patterns of our specimen sample to Q-bands. Thus, the distribution of metacentric, submetacentric, and acrocentric chromosomes in our sample did not match the numerical distribution found in the *Aotus trivirgatus trivirgatus* reported by Yunis *et al.* (1977); a specimen considered by Hershkovitz (1983) to be synonymous with his *brumbacki*.

We did not find the metacentric, submetacentric nor acrocentric chromosome pair distribution that Torres *et al.* (1998) found in specimens with a diploid number of 50 chromosomes in Colombian *Aotus* specimens. That karyomorph study indicated five pairs of metacentric and submetacentric

and fourteen pairs of acrocentric chromosomes in the specimens from Meta (Colombia) and nine pairs of metacentric, three pairs of submetacentric and twelve pairs of acrocentric chromosomes in one specimen from Quindío, Colombia (later attributed to a new species, *Aotus jorgehernandezi* Defler and Bueno, 2007).

Our analyses of two karyotypes in our specimen do not support the interpretation offered by Defler and Bueno (2007). Digital chromosome G-band measurements as well as digital arm-ratio analysis was not done in our earlier work with the karyotype of the *Aotus* specimen. The novel methodological approach used in this study ensures a clear conclusion that our specimen is an *Aotus brumbacki* hybrid, and allows convincing classification of chromosomes otherwise difficult to classify using visual observation of banding patterns. This is of particular interest for hybrid specimens where chromosomes are difficult to pair as homologous.

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Photographic Maps of the Primates of Kenya and Tanzania: A Tool for Identification and Conservation

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Abstract: The design and implementation of effective conservation measures for primates requires an efficient and accessible resource for the identification of species and subspecies. A total of 487 photographs (June 2010) on five on-line maps, called ‘Photographic Maps’ (or ‘PhotoMaps’), present the phenotypic characters for 15 species and 26 subspecies of primates at 82 sites in Kenya and Tanzania. The PhotoMaps, at <wildsolutions.nl>, provide a ‘living’ collection of photographs. More photographs will be uploaded as they become available. PhotoMaps are a practical tool for documenting and discussing primate diversity, taxonomy, biogeography, distribution and conservation status and, therefore, for developing and implementing actions for primate conservation. The use of photographs to document phenotypic characters will become increasingly important as the collection of specimens for hands-on assessments becomes ever more difficult.

Key words: Photographic maps, primates, identification, diversity, biogeography, conservation, Kenya, Tanzania

Introduction

The degree of phenotypic variation within a species can vary widely, often being highest in geographically distant populations or those in very dissimilar ecological conditions. Consistent phenotypic differences among populations may provide the foundation for species and subspecies designations (Mayr 1969; Meffe and Carroll 1997). Likewise, phenotypic similarities among populations, or the identification of phenotypic clines, may signal invalid species and subspecies. Species and subspecies are often used as the basis for assessing and comparing levels of biodiversity and for determining priorities for conservation actions. As such, to design adequate measures to conserve biological diversity, sampling geographic variation within and among populations is necessary. This means that efficient and accessible resources for the designation and identification of species and subspecies are required. Many species of primates show considerable morphometric and phenotypic variation (for example, in body size, skin color and pattern, pelage color and pattern), both among and within populations (Groves 2001; Struhsaker 2008). Visual comparisons using photographs can often be used to determine and evaluate phenotypic characters in support of species and subspecies designations.

For centuries naturalists have obtained specimens for museum collections from almost all primate taxa. Museum collections around the world constitute a vital source of natural history information. In time, these collections will become increasingly valuable; museum collections have always been the most important tool for identifying and describing species and subspecies of primates. Nowadays, collecting primates for museums is, however, often considered unethical and/or impractical. Additionally, specimens are not always well-prepared, pelage color changes (fades) with time, skin color often changes drastically after death due to drying and preservation processes, and details of the provenance of specimens are sometimes vague, questionable, or lacking.

Photography and video are valuable means by which to collect visual research data (Nowe and Myers 2003). Advanced digital cameras, computers, and computer software, combined with precise spatial or geographic data, have become increasingly powerful and useful tools for exhibiting variation within and among species, and, thus, for recording and assessing biological diversity. Although photographs cannot replace the value of an adequate museum collection, photographs can be practical means by which field workers and naturalists can collect, store and access descriptive data for primate species and subspecies.

Photographic maps

As part of our program to document and describe primate diversity in Kenya and Tanzania, we designed five online maps (De Jong and Butynski 2010). These maps, called photographic maps (or 'PhotoMaps'), present the phenotypic characters of primate populations over large parts of their geographic ranges in Kenya and Tanzania. In June 2010, these PhotoMaps held 487 photographs of 15 species and 26 subspecies of primates at 82 sites. The photographs were taken during our field surveys (2003 to present) and are divided into five taxonomic groups (Galagonidae, *Papio*, *Cercopithecus mitis*, Colobinae, and *Chlorocebus pygerythrus*). Photographs are uploaded to the PhotoMaps soon after they become available and serve as an online 'living' photographic collection of the primates over our extensive study region. All PhotoMaps have open access on <wildsolutions.nl>.

Methods

When possible, photographs were taken by both authors of all primate groups and individuals encountered during field surveys over large parts of Kenya and Tanzania. The authors used digital Nikon or Canon SLR cameras fitted with 100–300 or 80–400 mm lenses. When primate groups were encountered, the following data were collected: date, time, GPS coordinates (Garmin GPSmap 60Cx), altitude (by GPS or altimeter), primate species/subspecies, habitat type, and tree density (by visual assessment). The primary aims during each primate encounter were to (1) obtain a detailed description of as many individuals of the group as possible and (2) take photographs of as many individuals of the group as possible.

Photographs, usually shot in 'RAW' or 'JPEG' format, were 'geotagged' (the process of adding geographical identification metadata to digital media such as photographs, video, websites; Wikipedia 2009). The associated coordinates were either obtained automatically with a phototracker GPS (Gisteq PhotoTracker), or by hand-held GPS with the aid of Picasa software (Version 2.7 and higher; Google Inc.) and Google Earth software (version 4.3 and higher). Photographs were automatically plotted onto a Google map by uploading them to a Picasa Web Album using Picasa software. The proposed subspecies, locality, altitude, habitat type, date and any notes/comments were linked to all photographs.

How to use the PhotoMaps

To access the PhotoMaps, go to <wildsolutions.nl> and click on the name of the taxonomic group you want to view. What opens is an overview of thumbnails of all the photographs included on that PhotoMap (Fig. 1). To view the map that gives an overview of all the localities at which photographs were taken, click 'View Map' on the lower right corner. Scroll with the mouse over the map and the photographs will

enlarge when you reach them (Fig. 2). To adapt the PhotoMap to your own preferences, you can select a 'road', 'terrain', or a 'satellite' map and then zoom in or out on specific areas. Photographs can be enlarged and viewed separately on a detailed map. Viewers can change from 'View Map' to 'Album View' which brings you back to the overview of all photographs present on the PhotoMap.

Visitors to a PhotoMap can read comments given with photographs by the authors or by visitors. Anyone logged in with a Google or Gmail account can add their own comments concerning a specific photograph.

Who could make use of the PhotoMaps

PhotoMaps might be used by anyone interested in the biogeography, diversity, taxonomy, or conservation of the primates of Kenya and Tanzania. More specifically, the PhotoMaps are useful to those who want to:

- identify primate species/subspecies;
- know which primate species/subspecies occur in which areas;
- obtain primate species/subspecies photographs; and
- describe variation within a species/subspecies, especially as it relates to geographic distribution.

Example 1: Phenotypic diversity within the Zanzibar Sykes's monkey *Cercopithecus mitis albogularis* Sykes, 1831

The Zanzibar Sykes's monkey *Cercopithecus mitis albogularis* is a medium-size, arboreal, forest or woodland guenon. The taxonomy and geographic range of this taxon have been debated for many years and remain unresolved. According to Kingdon *et al.* (2008a) and Lawes *et al.* (in press), this subspecies occurs from Gedi Ruins (central coast of Kenya), southwards along the coast to northern Tanzania (including Unguja Island [Zanzibar] and Mafia Island), and west to Mt. Kilimanjaro and Mt. Meru in north-eastern Tanzania. Hill (1966), Kingdon (1971), Dandelot (1974) and Groves (2001), however, restrict *C. m. albogularis* to Unguja Island. They accept *C. m. kibonotensis* as the mainland subspecies, for which Groves (2001) gives the geographic range as from Kilifi Creek (just north of Mombasa) and the Taita Hills in south-eastern Kenya to the coast of northern Tanzania inland to Mt. Kilimanjaro and Mt. Meru.

Booth (1968) opposes the above designations and argues that the only subspecies of *C. mitis* east of the Eastern (Gregory) Rift Valley is *albogularis* and that phenotypic differences within this subspecies occur as a cline that runs from the Kenya Highlands to the coast of Kenya and north-western Tanzania to Unguja Island.

We encountered 149 groups of *C. mitis* in Kenya and Tanzania; 52 of them within the range of *C. m. albogularis* as described by Kingdon *et al.* (2008a) and Lawes *et al.* (in press). As of June 2010, the '*C. mitis* PhotoMap' held 62 photographs, of which 43 were taken within the range of

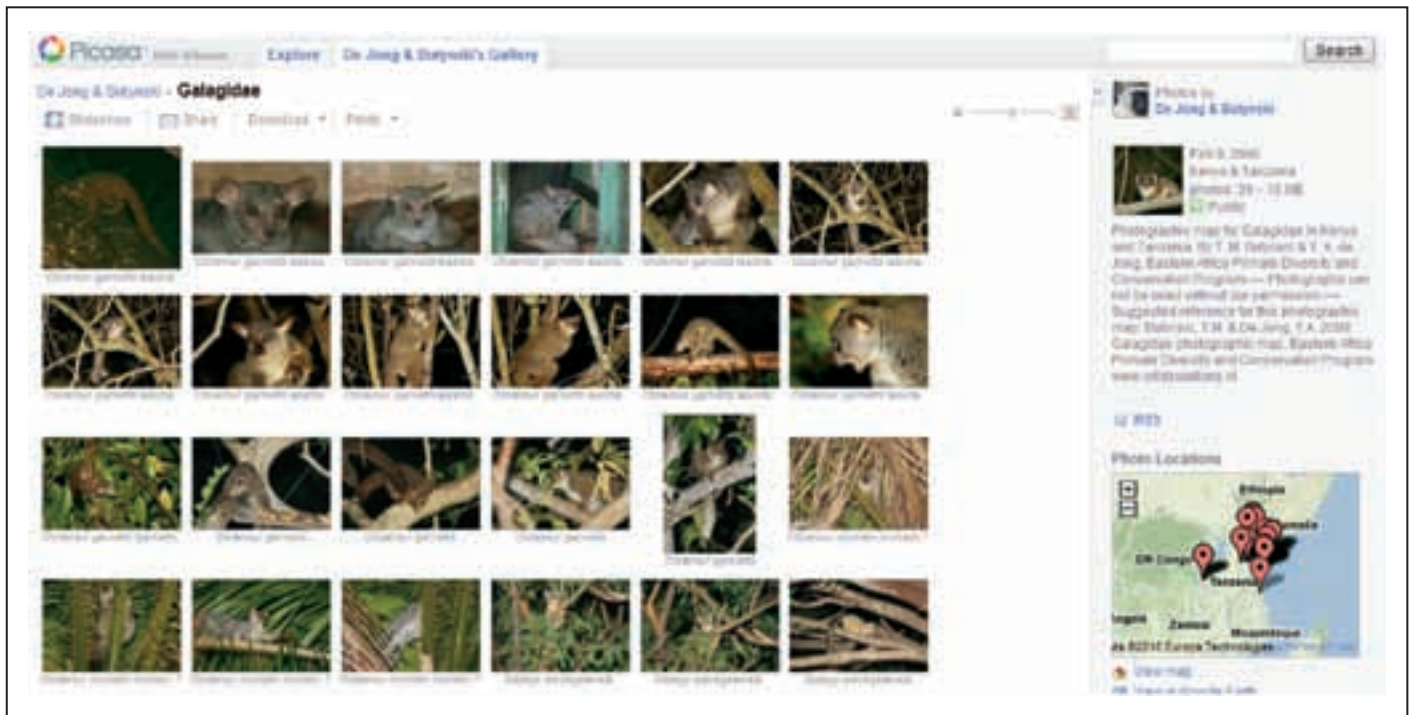


Figure 1. Screenshot of the 'Album View' of the 'Galagidae PhotoMap'. The bar at the top right enlarges the thumbnails. The 'View Map' button below the thumbnail map enlarges the map and shows all photographs that are plotted on the interactive Google map.

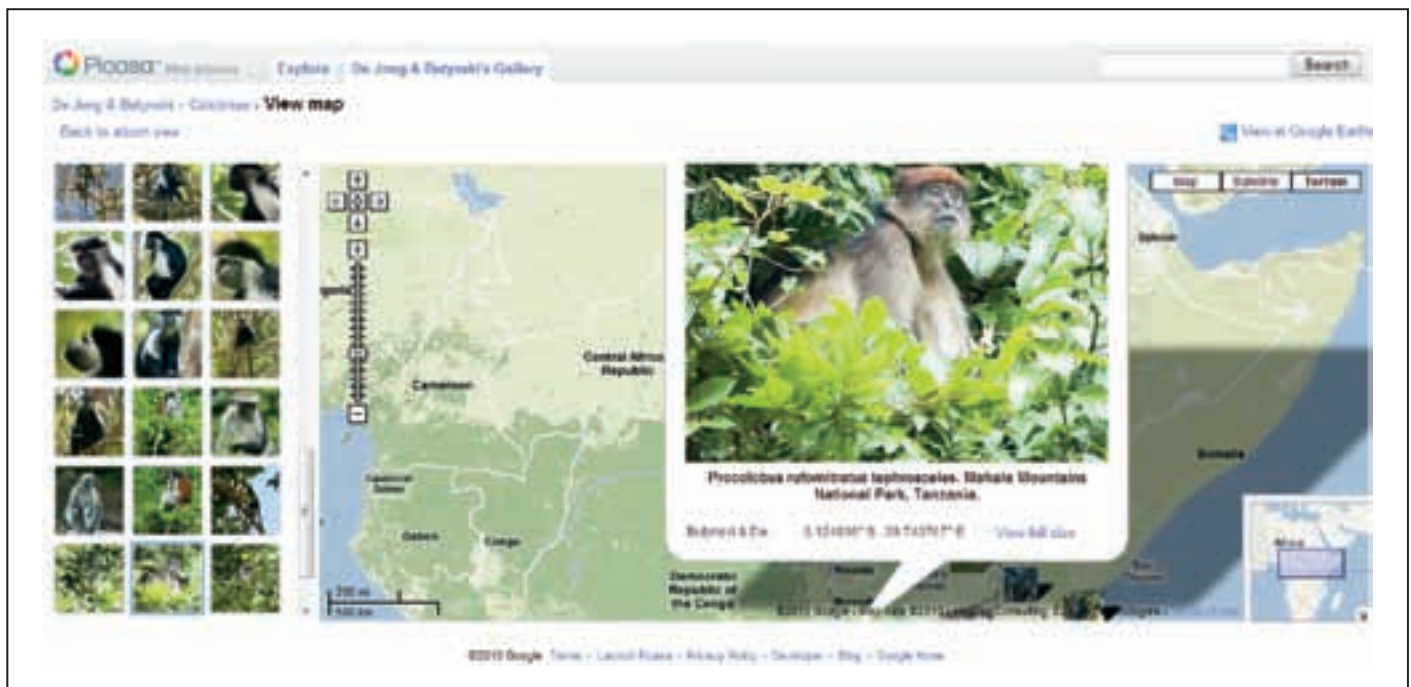


Figure 2. Screenshot of the 'View Map' of the 'Colobinae PhotoMap'. The buttons at the top right activate either the 'Map', 'Satellite', or 'Terrain' Google map. Clicking on the photographs enlarges them and details appear, accompanied by the discussion section.

C. m. albogularis as described by Kingdon *et al.* (2008a) and Lawes *et al.* (in press). Figure 3 presents six photographs of *C. m. albogularis* from six groups selected from the ‘*C. mitis* PhotoMap’. We have yet to analyze, in detail, the phenotypic differences among these individuals. There is, however, obvious phenotypic variation among them. The colour of the ventrum, inner arms, and inner legs, ranges from pale grey on animals on the northern coast of Kenya to blackish or dark grey on the animals of north-eastern Tanzania and Unguja Island. The cheek-ruffs on the Kenya animals are more slender than those of the Tanzania animals. The white collar on the Kenya animals is *ca.* 60–80% complete and *ca.* 55–60% complete on the Tanzania animals. Compared to the Tanzania animals, the collar on the Kenya animals is more sharply demarcated, runs through the line of the jaw, and lies closer to the ears. Unlike the Tanzanian animals, those in Kenya have a distinct reddish wash on the back of the upper hind legs (De Jong and Butynski 2009).

Of the 149 groups of *C. mitis* encountered, seven were on Unguja Island. As stated above, Hill (1966), Kingdon (1971), Dandelot (1974) and Groves (2001) restricted *C. m. albogularis* to Unguja Island and took *C. m. kibonotensis* as the mainland subspecies. The ‘*C. mitis* PhotoMap’ shows some of the similarities and differences between an adult male *C. mitis* from Unguja Island and a sub-adult male *C. mitis* male in Saadani National Park on the north-eastern coast of mainland Tanzania. These two animals are separated by a 43-km-wide ocean channel. Groves (2001) accepts *C. m. kibonotensis* but acknowledges that it is ‘hardly different’ from *C. m. albogularis* from Unguja Island. The PhotoMap shows that the extent of the white collar of the Saadani male is substantially less than for the Unguja male. The differences between *C. mitis* on

Unguja and at Saadani, however, are less than, for instance, the difference between *C. mitis* at Usa River (southern slope of Mt. Meru) and Ndarakwai (west of Mt. Kilimanjaro) (Fig. 3 and ‘*C. mitis* PhotoMap’). Usa River and Ndarakwai are only about 40 km apart and an obvious natural boundary between the two sites is absent.

It appears that the ‘*C. mitis* PhotoMap’ can serve as a tool in answering some of the many questions related to the taxonomy of *C. mitis* over the region where the 149 groups were encountered.

Example 2: Phenotypic diversity within Hilgert’s vervet monkey *Chlorocebus pygerythrus hilgerti* (Neumann, 1902)

Hilgert’s vervet monkey *Chlorocebus pygerythrus hilgerti* is a medium-size, semi-terrestrial, woodland guenon. The geographic range of this taxon is said to extend from southern Sudan, southern Ethiopia (east of the Eastern Rift Valley) and eastern Uganda, through Kenya into northern Tanzania (Groves 2001; Kingdon *et al.* 2008b). Throughout its range, *C. pygerythrus* is patchily distributed but often locally abundant.

We encountered 156 groups of *C. pygerythrus*, of which 136 were within the geographic range described above for *C. p. hilgerti*. The ‘*C. pygerythrus* PhotoMap’ holds 145 photographs, of which 133 were taken within the above-described range for *C. p. hilgerti*. Figure 4 presents six *C. p. hilgerti* photographs selected from the ‘*C. pygerythrus* PhotoMap’. During our primate surveys we found (surprisingly) little phenotypic variation for *C. p. ‘hilgerti’*.

Some geographic variation among adult and subadult male *C. p. ‘hilgerti’* is, however, present, particularly in (1) the intensity of pelage color, (2) the length of the whiskers,



Figure 3. *Cercopithecus mitis* ‘*albogularis*’ adult/subadult males over the geographic range in Kenya and Tanzania surveyed during this study. **Top row**, left to right: Gedi Ruins, central coast of Kenya; Saadani National Park, northern coast of Tanzania; Mrima Hill, southern coast of Kenya. **Bottom row**, left to right: Usa River, northeastern Tanzania; Unguja Island, eastern Tanzania; Ndarakwai, northeastern Tanzania.

(3) the expression of the whitish lateral stripe, and (4) the presence or absence of a red patch under the base of the tail. Of the *C. pygerythrus* encountered, the most distinctive (by far) were those in the one group observed at Lake Naivasha, south-central Kenya (Fig. 4). The adult male of this group appeared smaller yet more robust with a shorter neck, rounder face, longer hair, and a cap and dorsum that are more rufous-grey. Hollister (1912) described and named *Lasiopyga pygerythra callida* from a specimen collected at Lake Naivasha. Although Hill (1966) accepted the validity of *callida*, Kingdon (1971), Groves (2001, 2005) and Grubb *et al.* (2003) placed *callida* as a synonym of *C. p. hilgerti*. Hill (1966) gives the distribution of *callida* as Lake Naivasha west to the eastern shore of Lake Victoria, north to Mt. Elgon, and south to Ikoma and the Wembere Steppe, north-western Tanzania. *Chlorocebus pygerythrus* at Lake Naivasha occurs at about 2,000 m above sea level, the highest altitude reported for this species (De Jong and Butynski unpubl. data). This population spends 20% of the time on the ground (Rose 1974) compared to 60% for *C. p. hilgerti* on Segera Ranch, Laikipia, central Kenya (Enstam and Isbell 2002). Additionally, *C. pygerythrus* occurs in single-male/multi-female groups at Lake Naivasha, but in multi-male/multi-female groups elsewhere (Isbell and Enstam Jaffe in press). In this case, the '*C. pygerythrus* PhotoMap' allowed for recognition of the substantial phenotypic difference of *C. pygerythrus* at Lake Naivasha relative to the minor phenotypic diversity found throughout the supposed range of *C. p. hilgerti*. This, in turn, led to a preliminary review of the literature on the taxonomy, ecology and behaviour of *C. pygerythrus* at Lake Naivasha, and to the review of

photographs taken by others of *C. pygerythrus* from this area (which corroborate the phenotypic differences that we mention above). The question raised by these enquiries is whether *callida* might, after all, be a valid subspecies. Further investigations are now warranted and will be undertaken.

Discussion

To design adequate conservation action plans, an accessible source is often required for the identification of species and subspecies. Although photographs cannot replace an adequate museum collection as a resource for assessing species variation, geotagged photographs presented in PhotoMaps are a fast, inexpensive, convenient, and unobtrusive means for detecting and assessing phenotypic variation within primate taxa over large areas. In their current state the PhotoMaps are, however, far from complete. We expect to expand the PhotoMap collection (1) by including other primate taxonomic groups, (2) by increasing the geographic coverage, and (3) by including a large number of geotagged photographs taken by others.

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Figure 4. *Chlorocebus pygerythrus* '*hilgerti*' adult males over the geographic range in Kenya and Tanzania surveyed during this study. **Top row**, left to right: Malindi, northern coast of Kenya; Majengo, north of Mombasa, southern coast of Kenya; Tanga, northern coast of Tanzania. **Bottom row**, left to right: South Horr, north-central Kenya; Lake Naivasha, south-central Kenya; Lake Manyara, north-central Tanzania.

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New Range Limits of the Sun-tailed Monkey, *Cercopithecus solatus*, in Central Gabon

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Abstract: *Cercopithecus solatus* is a recently discovered monkey endemic to Gabon, present in parts of the Lopé National Park and the *Forêt des Abeilles* in the center of the country. It is listed as Vulnerable on the IUCN Red List (2010) due to its restricted extent of occurrence and continuing decline in population caused by high hunting pressure. All known field observations of this species are compiled here. Data collected since 1999 show that *C. solatus* occurs further to the south, east, and west than was previously known, and that its extent of occurrence almost certainly includes three national parks, rather than one.

Key Words: Gabon, Sun-tailed monkey, *Cercopithecus solatus*, distribution, protected areas, Red List

Introduction

Cercopithecus solatus was first described in 1988 (Harrison 1988), following sightings in 1984 in the *Forêt des Abeilles*, a large block of what was then mostly undisturbed primary forest in Central Gabon, north of the Ogooué River. *Cercopithecus solatus* is a member of the *lhoesti* super-species, and characterized by a bright yellow-orange on the distal half of its tail (Harrison 1988). The range of *C. solatus* is thought to be among the smallest of any African primate (Brugière and Gautier 1999). It was originally believed to be endemic to the *Forêt des Abeilles* forest block, but was later found in the contiguous Lopé Reserve to the west (White and Mackanga-Missandzou 1995). *Cercopithecus solatus* is threatened by hunting (Brugière and Gautier 1999), and being semi-terrestrial is sensitive to ground snares. Commercial hunting is likely to become a growing threat (Brugière and Gautier 1999), and could lead to population declines (IUCN 2010). Due to its restricted distribution, and the hunting pressure on the population, *C. solatus* is listed as Vulnerable on

the IUCN Red List (IUCN 2010). It is also on Appendix II of CITES (CITES 2010), and was declared a fully protected species by the Gabonese government in 1994 (Brugière and Gautier 1999).

The range and habitat requirements of *C. solatus* have been further clarified since its original description in 1988 from the *Forêt des Abeilles*. In 1992, hunter surveys in 102 villages in the predicted range of *C. solatus* found that hunters did not encounter the species north of the Ogooué River nor west of the Offoué River. The species was not found south of the village of Popa, even though there was no obvious southern barrier (Gautier *et al.* 1992). In 1994, however, *C. solatus* was encountered in the center of the Lopé Reserve, west of the Offoué River (White and Mackanga-Missandzou 1995), providing the first sighting of the species in a protected area. Finally, surveys have shown that the density of *C. solatus* declines at higher elevations (Brugière *et al.* 1998), suggesting that the southern limit of the distribution may be limited by mountainous terrain—specifically by the lower density of the understorey (Brugière and Gautier, 1999).

In the last ten years, wildlife and bushmeat studies have been carried out in Central Gabon, both in and outside of protected areas. Many of these studies recorded sightings of *C. solatus*, either alive in the forest or as components of hunter catches. A collation of this data is presented here, which increases our understanding of the distribution of this species.

Methods

We contacted researchers working in Gabon, and asked them for any presence/absence information for *C. solatus*. We accepted presence/absence data from studies that used faunal transect surveys (visual and camera-trapping) inside and outside of protected areas, and from village bushmeat surveys and village interviews, as well as opportunistic sightings from experienced field researchers. Data on presence/absence of *C. solatus* were compiled (Table 1), and combined with data from the literature to create an updated range map (Fig. 1).

Results

We have listed (Table 1) and mapped (Fig. 1) all sightings and bushmeat records from the literature and from unpublished work since 1999.

Sightings in and around Lopé National Park (Location Number (LN) 39–41, 61, Table 1)

In August 1995, a group of about 12 *C. solatus* were clearly seen by Kate Abernethy in trees next to the road in the SOFORGA logging concession. The observers (4) were on foot, and the monkeys travelled for several minutes in low vegetation near to the road. At one point an adult male walked several metres along a large branch in full view and was clearly identifiable, with the blue coloration of the scrotum easily visible. They were observed with 10×42 binoculars at a range of about 20 m. In 1993, on the road from Offoue to Booue, at the north-eastern border of the Lopé reserve, Lee White observed a group of 4 or 5 *C. solatus* on the ground crossing the road. The group was in clear view for 5 minutes,

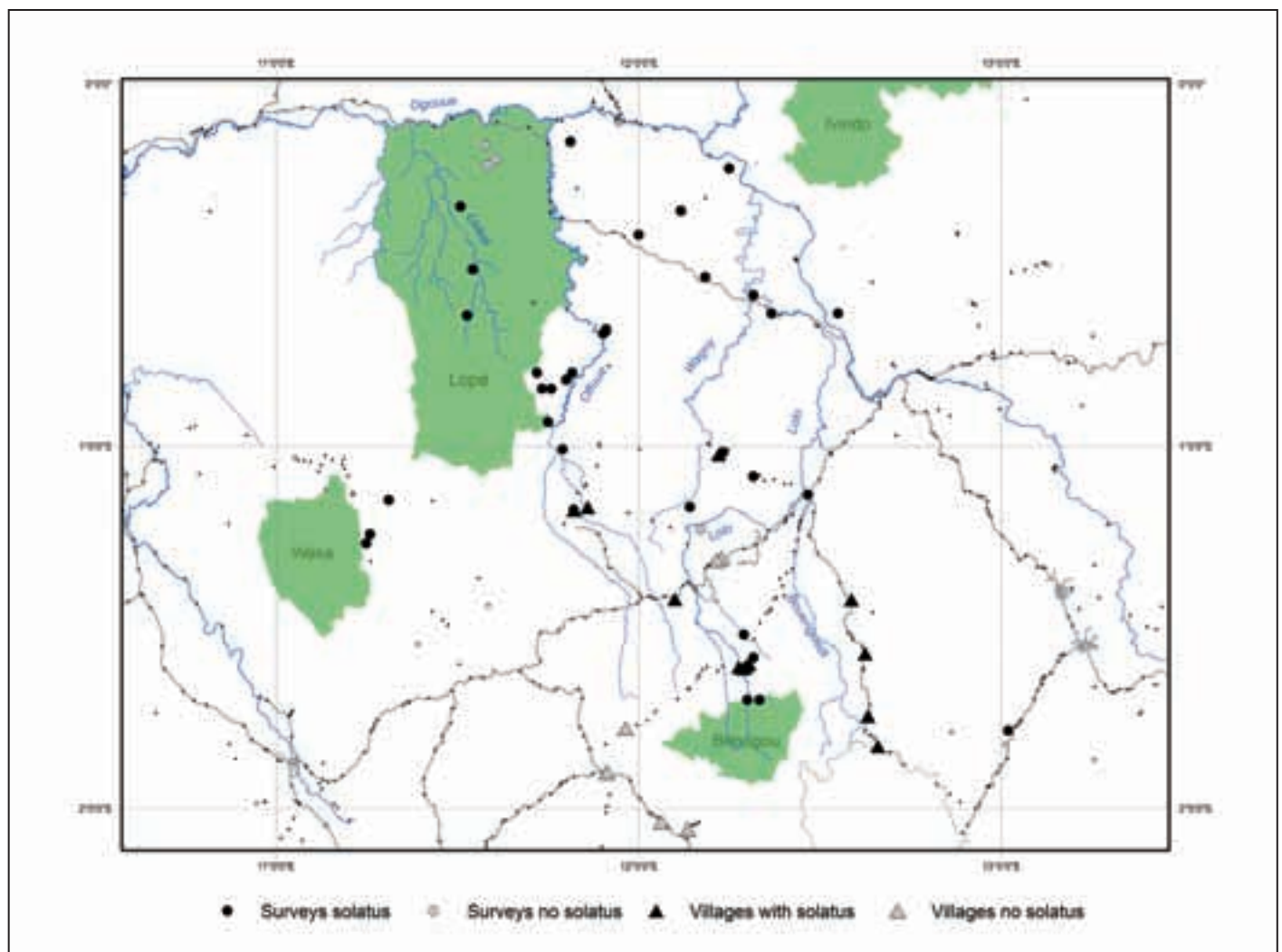


Figure 1. Known distribution of *Cercopithecus solatus*, including published data to 1999, subsequent field sightings, village interviews and village hunting information collected from 1984–2006. Small black dots = villages, blue lines = major rivers, black lines = major roads, green shading = national parks.

about 30 m from the vehicle. In 1994, Lee White met a hunter in Iwatsi village (close to the meeting-point of the Offoue and Onoy rivers) who had just arrived with an adult male sun-tailed guenon that he had shot. From 1989 to 2004, Kate Abernethy and Lee White carried out weekly transect surveys in the forest surrounding the Station d'Etudes des Gorilles et

Chimpanzés, in the north of the Lopé reserve. No *C. solatus* were encountered during that time.

Sightings around the Makande study site (LN 29–38, Table 1)

A research camp (Makande), jointly run by the Institute for Tropical Ecological Research in Gabon (IRET) and the

Table 1. Published and new sightings of *Cercopithecus solatus* in Gabon.

LN	Paper/ researcher	Date of sighting	Site coordinates (lat/long)	Method	Site Description	Additional information
Specific sightings or specimens:						
1	Gautier <i>et al.</i> 1992	20/12/1984	12°07'E 0°21'S	Hunter interviews on where wild- caught living and dead monkeys were found	Maki	Male Juvenile: 2.7 kg Collector: M. Harrison
2	Gautier <i>et al.</i> 1992	18/06/1985	12°19'E 0°35'S		La Wagny	Female Infant (2): 1.5 kg Collector: Moysan
3	Gautier <i>et al.</i> 1992	14/06/1986	2°11'E 0°32'S		La wonbou	Male Infant (1): 0.7 kg Collector: Moysan/J.N. Loireau
4	Gautier <i>et al.</i> 1992	19/06/1986	12°07'E 0°21'S		Maki	Female Infant (2): 1.8 kg Collector: Moysan/J.N. Loireau
5	Gautier <i>et al.</i> 1992	20/05/1986	12°07'E 0°21'S		Maki	Male Subadult: 4.4 kg Collector: Moysan/J.N. Loireau
6	Gautier <i>et al.</i> 1992	11/04/1986	12°07'E 0°21'S		Maki	Female Juvenile: 2.6 kg Collector: J.N. Loireau
7	Gautier <i>et al.</i> 1992	18/05/1986	12°28'E 01°08'S		Koulamoutou	Male Infant (1): 0.6 kg Collector: Moysan/J.N. Loireau/ Feist
8	Gautier <i>et al.</i> 1992	23/02/1989	12°19'E 0°35'S		La Wagny	Female Infant (1): 0.7 kg Collector: J.P. Gautier
9	Gautier <i>et al.</i> 1992	04/03/1989	12°28'E 0°08'S		Koulamoutou	Male Infant (1): 0.5 kg Collector: J.P. Gautier
10	Gautier <i>et al.</i> 1992	08/03/1984	12°15'E 0°14'S	Dead monkeys collected; specimens kept in the British Museum of Natural History, London, Uk 020 7498 4533; Museum National d'Histoire Naturelle, Paris, France; Biological Station of Paimpoint, Rennes University, France	Bali River	Male Adult. Collector: M. Harrison
11	Gautier <i>et al.</i> 1992	30/03/1984	12°15'E 00°14'S		Bali River	Male Adult Collector: M. Harrison
12	Gautier <i>et al.</i> 1992	23/12/1984	12°00'E 00°25'S		Mbiga	Female Adult Collector: M. Harrison
13	Gautier <i>et al.</i> 1992	25/01/1986	12°22'E 00°38'S		Mite. Mik.	Male Adult: 6.7 kg Collector: J. P. Gautier
14	Gautier <i>et al.</i> 1992	25/01/1986	12°22'E 00°38'S		Mite. Mik.	Female Adult: 4.2 kg Collector: J.P. Gautier
15	Gautier <i>et al.</i> 1992	25/01/1986	12°22'E 00°38'S		Mite. Mik.	Male Juvenile: 1.7 kg Collector: J.P. Gautier
16	Gautier <i>et al.</i> 1992	10/03/1986	12°11'E 00°32'S		La Wonbou	Female Adult Collector: J.N. Loireau
17	Gautier <i>et al.</i> 1992	02/04/1986	12°11'E 00°32'S		La Wonbou	Male Adult: 8.7 kg Collector: J.N. Loireau
18	Gautier <i>et al.</i> 1992	13/04/1986	12°11'E 00°32'S		La Wonbou	Female Adult: 3.5 kg Collector: J.N. Loireau
19	Gautier <i>et al.</i> 1992	28/02/1989	12°19'E 00°35'S		La Wagny	Female Adult: 3.5 kg Collector: J.P. Gautier
20	Gautier <i>et al.</i> 1992	04/03/1989	12°14'E 01°01'S		Mogabo 1	Male Juvenile: 2.8 kg Collector: J.P. Gautier
21	Gautier <i>et al.</i> 1992	06/03/1989	12°19'E 01°05'S		Moukoumou	Male Adult: 5.8 kg Collector: J.P. Gautier
22	Gautier <i>et al.</i> 1992	06/02/1989	12°19'E 01°05'S		Moukoumou	Male Adult. Collector: J.P. Gautier
23	Gautier <i>et al.</i> 1992	22/02/1989	12°19'E 01°35'S		La Wagny	Male Sub Adult Collector: J.P. Gautier
24	Gautier <i>et al.</i> 1992	24/02/1989	12°19'E 01°35'S		La Wagny	Female Sub Adult Collector: J.P. Gautier
25	Gautier <i>et al.</i> 1992	24/02/1989	12°19'E 01°35'S		La Wagny	Male Sub Adult Collector: J.P. Gautier

LN	Paper/ researcher	Date of sighting	Site coordinates (lat/long)	Method	Site Description	Additional information
26	White and Macka- nga 1995	18/09/1994	11°32'34"E 00°30'44"S	Explorations of the reserve	In the Lopé Reserve	At least four individuals, includ- ing juveniles
27	White and Macka- nga 1995	18/09/1994	11°32'34"E 00°30'44"S	Explorations of the reserve	In the Lopé Reserve	At least four individuals, includ- ing juveniles
28	White and Macka- nga 1995	12/1994	11°20'E 01°42'S	Explorations of the reserve	In the Lopé Reserve	1 male adult, associated move- ment suggested presence of a group
29	Brugière <i>et al.</i> 1998	12/1996–09/1997	11°43'10"E 00°47'50"S	Line transect survey	13.8 km from the left bank of the Offoue River, close to the eastern border of the Lopé Reserve	Altitude: 450–550 m Coordinates given in Brugière <i>et al.</i> (1998)
30	Brugière <i>et al.</i> 1998	12/1996–09/1997	11°49'E 00°47'50"S		Left bank of the Offoue River, close to the eastern border of the Lopé Reserve	Altitude: <450 m Coordinates estimated from map provided by Brugière <i>et al.</i> (1998)
31	Brugière <i>et al.</i> 1998	12/1996–09/1997	11°45'32"E 0°50'30"S		8.7 km from the left bank of the Offoue River, close to the eastern border of the Lopé Reserve	Altitude: 450–550 m Coordinates given in Brugière <i>et al.</i> (1998)
32	Brugière <i>et al.</i> 1998	12/1996–09/1997	11°44'E 00°50'30"S		Left bank of the Offoue River, close to the eastern border of the Lopé Reserve	Altitude: 450–550m Coordinates estimated from map provided by Brugière <i>et al.</i> (1998)
33	Brugière <i>et al.</i> 1998	12/1996–09/1997	11°45'E 00°56'S	Chance observation	Left bank of the Offoue River, close to the eastern border of the Lopé Reserve	Altitude: <450 m Coordinates estimated from map provided by Brugière <i>et al.</i> (1998)
34	Brugière <i>et al.</i> 1998	12/1996–09/1997	11°45'E 00°56'S		Left bank of the Offoue River, close to the eastern border of the Lopé Reserve	Altitude: <450 m Coordinates estimated from map provided by Brugière <i>et al.</i> (1998)
35	Brugière <i>et al.</i> 1998	12/1996–09/1997	11°48'E 00°49'S		Very close to the left bank of the Offoue River, close to the eastern border of the Lopé Reserve	Altitude: <450 m Coordinates estimated from map provided by Brugière <i>et al.</i> (1998)
36	Brugière and Gautier 1999	1996?	11°54'35"E 00°40'39"S	Population density estimate along two line transects	Makande Field Research Station	
37	This study, FM	1993	11°54'36"E 00°40'55"S	Field sightings	Makande study area	
38	This study, FM	1993	00°41'22"S 11°54'08"E	Field sightings	Makande study area	
39	This study, LW	1993	00°09'34"S 11°48'42"E	Field sightings	The road from Offoue to Booue	Group of 4–5 individuals
40	This study, LW	1994		Field sightings	Village: Iwatsi.	1 male adult shot. Village loca- tion at the point where the Ofoue and Onoy rivers converge.
41	This study, KA	1995	11°30'30"SE 0°20'25"S	Field sightings	SOFORGA logging concession east of Leledi River	Group of >12 individuals includ- ing a large adult male
42	This study, MF	1999–2001	00°38'20"S 11°34'06 E	Observations during the 'megatransect'		
43	This study, MF	1999–2001	01°08'54"S 11°18'40"E	Observations during the 'megatransect'		
44	This study, MF	1999–2001	01°14'34"S 11°15'32"E	Observations during the 'megatransect'		
45	This study, MF	1999–2001	01°16'06"S 11°14'55E	Observations during the 'megatransect'		
46	This study, MS	2000		Hunting study	Village: Banyati	1 individual killed
47	This study, OSGP	21/07/2001	Very near to 01°08'42"S 11°46'48"E	Observed during herpetological field survey	Eastern flank of Mount Iboundji	At least 3 in a tree, clearly ob- served. Altitude: <i>ca.</i> 550 m

LN	Paper/ researcher	Date of sighting	Site coordinates (lat/long)	Method	Site Description	Additional information
48	This study, NB	June 2003	12°58'57.612"E 01°46'52.778"S	Field sighting during mandrill tracking	Lékédi Park. Hilltop overlooking the canopy of the rainforest, closed canopy forest with some forest-savannah mosaic	Group counted 4 adults and 3 sub-adults/infants
49	This study, MP	March–June 2004		Hunting study	Village: Mbegho	10 individuals killed in 45 days. Villagers say that <i>solatus</i> some- times raids plantations
50	This study, MP	March–June 2004		Hunting study	Village: Rongassa	1 individual (shot by a hunter on 4 June) in 90 days
51	This study, JJT	2004	12°17'24"E 01°31'12"S	Field sighting	Roadside, Popa village	335 m altitude single adult in tree
52	This study, PH	2005	12°08'29"E 01°10'04"S	Camera trapping stud- ies: 8 cameras over 50 km ² , for 48 days	A logging concession area south of Mount Mimongo	A mountain range between Mount Iboundji and Mbégbo. Seven images of <i>C. solatus</i> (see Fig. 4)
53	This study, YM	August 2006	Between the vil- lages of Ngoungou 01°31'59"S 12°19'09"E) and Popa (01°36'04"S 12°18'14"E)	Field study to collect duiker faeces for genetic study	<i>C. solatus</i> seen in a Mora- ceae tree	
54	This study, YM	2006	12°18'15"E 01°42'12"S	Field sightings	Birougou National Park (northern section)	
55	This study, JJT	2006	12°18'13" E 01°42'25"S	Field sightings	Birougou National Park (northern section)	

Village interviews:

56	Gautier <i>et al.</i> 1992	1992		Hunter interviews in 102 villages to determine presence/ absence, and estimate distribution		
57	This study, OSGP	2001	01°10'32"S 11°49'16"E	Village and hunter interviews	Villages: Boussimbi vil- lage, alt. 485 m	Said to be common on Mount Iboundji; groups often venture into village plantations. The species is well known by the villagers of Boussimbi
58	This study, MP	March–June 2004		Hunting study	Villages: Imeno-Plateau, Mbégbo, Rongassa	Abundant in Mbégbo, present in Imeno-Plateau and Rongassa. Local names given for species
59	This study, JJT	2004–2005		Village and hunter interviews	Villages: Lémengué, Koumbi, Siono and Grand Village	Species is said to be present, although uncommonly seen, and always in small groups
60	This study, JJT	2004–2005		Village and hunter interviews	Villages: Popa, Mambadi, Iwatsi, Missimba	Species is well known and was at once recognized on the poster and on digital pictures. Said to be locally common. Highest densi- ties occur in the hills between Lolo and Bouengué rivers

Surveys where *C. solatus* were not encountered:

61	This study, KA, LJTW	1989–1994		SEGC Study area	Ecological field research area in Lopé National Park	LJTW PhD thesis
62	This study, JJT	2004–2005		Village interviews	Villages: Moudouma, Itsiba, Mbigou and Le- vinda villages, west of the Onoye River	Species not thought to be present Hunters did not recognise the species, and did not have a name for it
63	This study, LC	2005–2007		Hunting returns and village interviews over 2 year study (Coad 2007)	Villages: Kouagna, Dibouka, up to the Lolo River	Species not thought to be present Villagers knew the monkey by a local name 'Mbaya', and said that it did not occur in these villages, but was present in villages closer to Iboundji
64	This study, PH	2005–2007		Camera trapping stud- ies: 15 cameras over 30 km ² for 54 days	Southern bank of the Lolo River	No <i>C. solatus</i> images obtained

University of Rennes, hosted studies from 1992 to 1997 on the east side of the Offoué River. Much of the published literature on the species comes from this site or nearby.

Sightings during the “Megatranssect expedition” (LN 41–45, Table 1)

The “Megatranssect expedition” was a foot journey carried out between 1999 and 2001 by Mike Fay, from the northern Republic of Congo to the coast of Gabon. The trajectory passed through some of the most untouched forests remaining in Central Africa, and all wildlife and human sign was recorded along the way. Sun-tailed guenons were sighted on several occasions in October 2000, either in the Lopé Reserve (now Lopé National Park) or just to its southwestern border and at the limit of the Waka National Park (Fig. 1).

Sightings around Mount Iboundji (LN 47, 57, Table 1)

In the afternoons of 21 and 23 September 2001, Olivier Pauwels obtained good sightings of a group of 6–7 *C. solatus* feeding on a fruiting tree on the eastern slopes of Mount Iboundji (Offoué-Onoy Department, Ogooué-Lolo Province), in open forest, at an altitude of about 550 m. Using binoculars, he was able to identify the typical coloration of the species, and he approached the group until he was 60 m away. The species is well known by the villagers of Boussimbi, at the foot of the mountain (01°10'32"S, 11°49'16"E, altitude 485 m). They reported that *C. solatus* was common on the mount, and that groups often ventured into the village plantations.

Sightings around the Lekedi Sanctuary (LN 48, Table 1)

On 26 June 2003, Nicholas Bout radio-tracked a group of mandrills (*Mandrillus sphinx*) in the Lékédi Sanctuary. To search for the radio-collar signal he was positioned on a hill-top overlooking the canopy of the rainforest (approximately 01°47'05"S, 13°01'10"E). The position at the height of the canopy provided an unobstructed view of the forest. About 15 m from Bout, a slender and dark monkey, with a golden tail appeared and presented its profile on a large bare branch, offering a perfect view and was identifiable as *C. solatus*. It remained behind him for at least a minute. Seven monkeys also identified as *C. solatus* foraged in *Pentaclethra macrophylla* and *Musanga cecropioides* at 30 m above the ground in the canopy. They were not in the shadows, which allowed for good observation, and their long golden tails were clearly visible. The monkey closest to Bout suddenly rushed away and the group fled without calling. The entire group was counted—4 adults, 2 sub-adults and 1 infant. The local landscape is principally closed canopy forest with some forest-savannah mosaic, and is rich in all species of the local fauna found in southern and central Gabon, except the forest elephant (excluded from the sanctuary when it was fenced).

Village hunting returns in the Imeno Plateau and Ogooué-Lolo provinces (LN 46, 49, 50, 58, Table 1)

A study on subsistence hunting near logging concessions from 15 March to 20 June 2004 was carried out by Marielle

Puit and local assistants in the villages of Iméno-Plateau (90-day survey), Mbégbo (situated half way between Koulamoutou and Baniati, Lolo-Bouenguidi Department, Ogooué-Lolo Province; 45-day survey), and ROUNGASSA (about 15 km northeast of Koulamoutou; 90-day survey). Observations were made in the eastern distributional limits of *C. solatus*; local villagers killed 10 *C. solatus* over 45 days in Mbégbo (see Fig. 2). Six were shot, and four were caught by ground snares. Villagers of Mbégbo mentioned that *C. solatus* had previously raided plantations. In 90 days in ROUNGASSA, one *C. solatus* was shot (4 June 2004). During a previous hunting study carried out in 2000, Malcolm Starkey recorded that a sun-tailed monkey was killed by hunters in Banyati. Among the villages visited, Mbégbo was the only one where the species was said to be abundant. It was said to be seen only occasionally in the others. Local vernacular names noted included *bahia* (Pouvi language, Mbégbo), *mbahi* (Massango language, Iméno-Plateau) and *imbonga* (Nzebi language, ROUNGASSA).

Village interviews and sightings along the Baposso-Mbigou road (LN 51, 59, 60, 62, Table 1)

Bushmeat inquiries were led by Jean-Jacques Tanga in several villages along the roads from Baposso to Mbigou (01°53'47"S, 11°54'37"E, altitude 700 m; Boumi-Louétsi Department, Ngounié Province), Mbigou to Koulamoutou (Lolo-Bouenguidi Department, Ogooué-Lolo Province), and from Koulamoutou to Pana (Lombo-Bouenguidi Department, Ogooué-Lolo Province), i.e., the three roads respectively situated near the eastern, northern and western limits of Mount Birougou National Park (February–March 2004, July 2004, June 2005). Main localities and park delimitations are shown



Figure 2. Adult female *Cercopithecus solatus* trapped near Mbégbo on 7 June 2004. It shows the typical body coloration of the species: black legs, brown-reddish back and flanks, tail distal part yellowish. It is shown here along with a common pangolin *Manis tricuspis* that was caught in the same locality by the same hunter. Photograph by M. Puit.

by Anonymous (2002). The bushmeat markets of Koula-moutou, Mbigou and Pana were visited, and hunters from all the villages along these roads were interviewed and shown a poster illustrating 88 African primates (Kingdon 2001). These interviews show that the species was unknown in the villages situated west of the Onoye River (Moudouma, Itsiba, Mbigou and Lévida), where the hunters did not recognize the species on the poster, and did not have a name to designate it. In comparison, the species was said to be present in the eastern villages (Lémengué, Koumbi, Siono and Grand Village), although uncommon, and always in small groups. In the villages in the northeast of Mount Birougou National Park, near Lolo River (Popa, Mambadi, Iwatsi, Missimba), the species was well known and was at once recognized both on the poster and on digital pictures. It was said to be locally common. In all villages where the species was recorded from Tanga's study, a single common name was given to this monkey by the Nzébi, Massango and Pouvi ethnic groups; *mbaya*, a name also used by the Massango in Iboundji area. In the villages near Lolo River, the species was well known for its habit of crop-raiding, especially manioc and bananas. It was hunted locally to reduce its impact on cultivated fields, and also as bushmeat. According to the interviews, it was most abundant in the hills between Lolo and Bouenguidi rivers. As these sightings are south of the formerly known distribution of *C. solatus*, Tanga asked the villagers to bring a specimen in order to unambiguously document its occurrence. Popa



Figure 3. Young female *Cercopithecus solatus* captured in the buffer zone of Mount Birougou National Park, southern Gabon, in June 2005. Photograph by J.-J. Tanga.

villagers brought him a juvenile female in early June 2005 (Fig. 3). It had been caught in a ground snare in the northeastern buffer area of Mount Birougou National Park, in a hilly area (altitude 600 m). In the early afternoon of 8 March 2004, Tanga observed a single adult resting on a tree branch at the forest edge along the road between Popa and Mbigou Moréné (01°31'12"S, 12°17'24"E; altitude 355 m; Lolo-Bouenguidi Department, Ogooué-Lolo Province).

Camera trap study around Mount Mimongo (LN 52, Table 1)

During wildlife surveys conducted by Philipp Henschel between 14 April 2005 and 2 June 2005, *C. solatus* was photographed in a logging concession area south of Mount Mimongo (01°10'04"S, 12°08'29"E; altitude 675 m, Lolo-Bouenguidi Department, Ogooué-Lolo Province), a mountain range between Mount Iboundji and Mbégbo. Seven images of *C. solatus* were obtained from 18 remote camera traps distributed through a 50-km² study area over a 48-day trapping period (Fig. 4).

Camera trap study and hunting survey around the Lolo River (LN 63–64, Table 1)

Fifteen camera traps were deployed in a 30-km² study area over 54 days between 28 August and 21 October 2004 in an area about 10 km to the south of the southern bank of the Lolo River. No images of *C. solatus* were obtained. This indicates that the species is either absent or very rare south of the Lolo River. Lauren Coad and local field assistants conducted a hunting study from January 2004 to January 2005 in the same area in two villages, Dibouka (01°19'07"S, 12°12'54"E) and Kouagna (01°18'28"S, 12°13'45"E). Their results showed considerable hunting pressure that was highest within 5 km from the villages, but also extended up to hunting camps 12 km to the north, on the southern bank of the Lolo. During this study all hunting returns for the two villages were recorded, and no *C. solatus* were ever caught or seen. During a previous hunting study in these villages conducted by Malcolm Starkey from 2000 to 2002, no *C. solatus* were



Figure 4. *Cercopithecus solatus* photo taken using camera trapping, close to Mount Mimongo. Photo by P. Henschel.

observed or captured. Hunters from Dibouka could, however, identify *C. solatus* from Kingdon (2001) as *mbaya*, and said that it could be found around villages further south-west towards Iboundji.

Sightings between Popa and Ngoungou villages (LN 53, Table 1)

On 1 August 2006, in the forest surrounding Popa village, Yves Mihindou saw a single individual of *C. solatus* close to a group of *C. nictitans* in a *Musanga cecropioides* tree. As he approached, all the monkeys fled. This observation was made between the villages of Ngoungou (01°31'59"S, 12°19'09"E) and Popa (01°36'04"S, 12°18'14"E).

Sightings between Popa and Biroughou National Park (LN 54–55, Table 1)

In 2006, Yves Mihindou and Jean-Jacques Tanga reported separate sightings of individual sun-tailed guenons on the road from Popa to Birougou National Park, close to the northern boundary of the park.

Discussion

It is clear that the range of *C. solatus* extends further to the west, south, and east than was previously thought, and the extent of occurrence may be as great as 18,000 km² (previously the range was estimated at 11,000 to 12,000 km²; Brugière and Gautier 1999). Sightings of *C. solatus* very close to the limits of the national parks of Waka and Mount Birougou are particularly important, as the species was previously only known to occur in Lopé National Park. In addition, as both the Birougou and Lekedi areas are close to the Congolese border, it is possible that *C. solatus* may also occur in the Congolese part of the Massif du Chaillu. In that area of Congo, however, hunting pressure is considerably higher than on the Gabonese side of the border, and the single faunal survey carried out there in 2007 did not mention the species (Inkamba-Nkulu 2007). If present, the species is likely to be under considerable threat. The evidence from the Lolo area indicates that it may have been hunted to local extinction (as it occurs all around that area). The semi-terrestrial habits of the species render it vulnerable to wire snares, and when it encounters hunters with dogs it climbs and is then highly visible and vulnerable to hunters with guns.

Currently the IUCN Red List categorizes *C. solatus* as Vulnerable under the criteria B1ab(v). The criterion B concerns the geographic range, and B1 specifically the extent of occurrence, which, to qualify as Vulnerable, is considered to be less than 20,000 km². To qualify as Vulnerable under criterion B1, two further conditions (subcriteria) must apply in aspects concerning (a) a severely fragmented population or occurrence at no more than 10 locations, (b) decline in populations and range, or (c) extreme fluctuations in populations or range (see IUCN [2001] for the precise criteria). In the case of the current designation, *C. solatus* was considered to exist at no more than 10 locations (a) and is suffering from decline in

the numbers of mature individuals (b(v)) (Oates and Bearder 2008).

Oates and Bearder (2008) indicated that hunting was becoming an increasingly serious threat to *C. solatus*. Severe hunting pressure may be leading to local extinctions, and the number of mature individuals is undoubtedly decreasing. Most of the area of occurrence of the sun-tailed guenon apart from the protected areas is now under timber exploitation, with the result that the logging road network has penetrated almost all of its range. Roads provide easy access to local and commercial bushmeat hunters in the region and are strongly associated with wildlife depletion in Central Africa and in the range fragmentation of a number of species (Blake *et al.* 2008; Laurance *et al.* 2006; Minnemeyer *et al.* 2002; Stokes *et al.* 2010; Wilkie *et al.* 2000). Thus, the IUCN Red Listing status of the sun-tailed guenon should remain as Vulnerable B1ab(v), despite the increase in the size of its extent of occurrence detailed in this paper.

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Three Sykes's Monkey *Cercopithecus mitis* × Vervet Monkey *Chlorocebus pygerythrus* Hybrids in Kenya

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Abstract: Hybridization in the wild between broadly sympatric species has been reported for 13 species of African primates. Three guenons, believed to be Sykes's monkey *Cercopithecus mitis* × vervet monkey *Chlorocebus pygerythrus* hybrids, are reported here; two at Diani on the south coast of Kenya and one at Ngong Forest Sanctuary, Nairobi. These are the first records of hybridization between these broadly sympatric species, as well as between these genera. Most of the phenotypic characters of these hybrids are intermediate between the parent species. This paper (1) describes these hybrids and the environments in which they live; (2) briefly reviews hybridization among Africa's primates; (3) describes scent-marking behavior by one of the hybrids; (4) briefly reviews scent-marking among Africa's monkeys; (5) discusses the environmental circumstances that may weaken genetic barriers and facilitate hybridization; and (6) suggests topics for research on the ecology, behavior, and evolutionary significance of these three hybrids.

Key Words: *Cercopithecus mitis*, *Chlorocebus pygerythrus*, hybrid, Kenya, scent-marking, Sykes's monkey, taxonomy, vervet monkey

Introduction

Natural hybridization is increasingly recognized as potentially playing an important function in the evolution of new taxa, including primates (Dutrillaux *et al.* 1988; Jolly *et al.* 1997; Allendorf *et al.* 2001; Barton 2001; Jolly 2001; Detwiler *et al.* 2005; Arnold and Meyer 2006). Among Africa's primates, natural hybridization appears to occur most often along the edges of the geographic ranges of parapatric subspecies of the same species, or of parapatric species of the same 'species group' (i.e., 'superspecies'). In some instances of 'allopatric hybridization' there is but occasional contact and hybrids are rare (Struhsaker 1970), while in others the 'hybrid zone' is extensive (Jolly 2001; Detwiler *et al.* 2005; De Jong and Butynski 2009; Zinner *et al.* 2009).

Cases of natural hybridization between well-differentiated, broadly sympatric species that are behaviorally and ecologically distinct are far less often reported than are cases of parapatric or allopatric hybridization. The primary examples given for 'sympatric hybridization' in the wild for African primates are Stuhlmann's blue monkey *Cercopithecus mitis stuhlmanni* × Schmidt's red-tailed monkey *Cercopithecus*

ascanius schmidtii hybrids in southwest Uganda (Struhsaker *et al.* 1988) and southwest Kenya (L. Tranter pers. comm.; D. Black pers. comm.), and Doggett's silver monkey *Cercopithecus mitis doggetti* × *C. a. schmidtii* hybrids in northwest Tanzania (Detwiler 2002; Detwiler *et al.* 2005).

For African primates, we are aware of records for sympatric hybridization for only 11 other species (involving six species pair combinations). These are as follows: three probable gelada baboon *Theropithecus gelada* × olive baboon *Papio anubis* hybrids in the Bole Valley, Ethiopia (Dunbar and Dunbar 1974; Jolly *et al.* 1997); one presumed green monkey *Chlorocebus sabaeus* × western patas monkey *Erythrocebus patas patas* hybrid in Saloum Delta National Park, Senegal (Galat *et al.* 1993; Galat-Luong 1996); one probable mustached monkey *Cercopithecus cephus* × putty-nosed monkey *Cercopithecus nictitans* hybrid in Lopé Reserve, Gabon (Tutin 1999); two apparent Dent's monkey *Cercopithecus denti* × *C. m. doggetti* hybrids in Nyungwe National Park, southwest Rwanda (B. A. Kaplin pers. comm. in Detwiler *et al.* 2005); two mona monkey *Cercopithecus mona* × golden-bellied crowned monkey *Cercopithecus pogonias* hybrids at Indenau, Cameroon (Struhsaker 1970);

one *C. mona* × Gray's crowned monkey *Cercopithecus pogonias grayi* hybrid at Tinasi, Cameroon (Struhsaker 1970); and two apparent Sclater's monkey *Cercopithecus sclateri* × red-bellied monkey *Cercopithecus erythrogaster* hybrids in the Niger Delta, Nigeria (Oates and Baker in press; J. F. Oates pers. comm.).

This paper describes three new cases of natural hybridization between broadly sympatric genera/species in Kenya, some of the circumstances under which these hybridizations occurred, and some of the behaviors of these hybrids. Finally, this paper suggests topics for research on the ecology, behavior, and evolutionary significance of these hybrids.

***Cercopithecus mitis albogularis* × *Chlorocebus pygerythrus hilgerti* Hybrids at Diani, Kenya**

Six primate species occur in and around Diani on the south coast of Kenya; Zanzibar Sykes's monkey *Cercopithecus mitis albogularis*, Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti*, Ibean yellow baboon *Papio cynocephalus ibeanus*, Peter's Angola colobus *Colobus angolensis palliatus*, white-tailed small-eared galago *Otolemur garnettii lasiotis*, and Kenya coast galago *Galagoides cocos*. On 14 December 2008, De Jong observed and photographed a free-ranging adult male guenon on the grounds of the Leopard Beach Hotel, Diani (04.2848°S; 39.5913°E; Fig. 1). Despite brief daily searches, De Jong encountered the hybrid only this once during four days (14–17 December).

Based on the intermediate phenotypic characters of this adult male guenon (Table 1), and the fact that only two species of guenon occur in the eastern half of Kenya (Kingdon 1971,

1997; De Jong and Butynski 2009), we believe that this individual is a Sykes's monkey × vervet monkey hybrid (Fig. 2). Given the locality, and following the taxonomy of Grubb *et al.* (2003) for *C. mitis* and of Groves (2001) for *C. pygerythrus* (see below), this is a *Cercopithecus mitis albogularis* × *Chlorocebus pygerythrus hilgerti* hybrid.

On 7 October 2009, we visited Diani for 3 days to observe (7.5 h) and photograph the 'Diani hybrid', and to search (12.5 h) for other hybrids on and around the extensive grounds of Leopard Beach Hotel, Leisure Lodge Hotel, Leisure Lodge Beach and Golf Course, and The Sands at Nomad.

As best as we can determine, the Diani hybrid represents the first record of hybridization (either in captivity or in the wild) between these two broadly sympatric species, and only the fifth record among African primates of a wild intergeneric hybrid (see above).

Table 1 presents a detailed comparison of the phenotypic characters of the Diani hybrid, adult male *C. m. albogularis* (Fig. 3), and adult male *C. p. hilgerti* (Fig. 4) at Diani. The phenotypic characters of the Diani hybrid are intermediate to the parent species in most respects, although the color of the face, neck collar, dorsum, back of the legs, sides, and tail appears to be slightly more like *C. mitis*, while body shape, and color of the iris, eyelids, shoulders, and ventrum appear to be slightly more like *C. pygerythrus*. The scrotum of the Diani hybrid is intermediate in size and color between *C. mitis* and *C. pygerythrus*. The muzzle of the Diani hybrid seems to be longer and more pointed than the muzzle of either *C. mitis* or *C. pygerythrus*. Interestingly, unlike either parent species, the Diani hybrid has a faint nose spot (recalling *C. nictitans* and members of the '*Cercopithecus cephus* species-group').



Figure 1. Location of Diani, south coast of Kenya, locality of the Zanzibar Sykes's monkey *Cercopithecus mitis albogularis* × Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti* hybrid.

Table 1. Comparison of the phenotypic characters of the adult male Diani hybrid with adult males of *Cercopithecus mitis albogularis* and *Chlorocebus pygerythrus hilgerti* at Diani, Kenya.

Body part	Diani hybrid	<i>Cercopithecus mitis albogularis</i>	<i>Chlorocebus pygerythrus hilgerti</i>
Nose	Sooty-grey with pale grey nose spot.	Sooty-grey.	Jet black.
Naked skin of face	Triangle-shaped, sooty-grey skin around eyes and muzzle.	Sooty-grey skin around eyes and muzzle.	Egg-shaped. Jet black skin around eyes and muzzle.
Whiskers	Short to medium length, heavily grizzled pale grey.	Long and dense, forming a ruff. Heavily grizzled grey and pale olive-yellow.	Not grizzled. White, long, sparse, sweeping upwards and backwards to cover base of ears.
Lips	Sparse, short, pale grey hairs on upper and lower lips.	Short, pale grey, hairs on upper and lower lips.	Without hairs.
Iris	Mahogany brown.	Amber.	Mahogany brown.
Eyelids	Pinkish-grey.	Pale yellow.	Pale grey.
Skin around eyes	Pinkish-grey.	Pinkish-grey.	Black.
Front of ears	Skin blackish. Lightly-furred, pale grey.	Skin dark grey. Moderately-furred, off-white.	Skin jet black. Lightly furred, white.
Ear fringe	Narrow. Very pale grey.	Narrow. Off-white.	None.
Brow-band	Straight and narrow. Distinct but not well-demarcated. Hair of moderate length, projecting slightly upwards and forwards. Same color as whiskers (i.e., grizzled grey and pale grey), but slightly lighter.	Shallow triangle in shape, narrower distally. Indistinct and poorly-demarcated. Hair of moderate length, projecting forward but longer at the distal edges of brow-band where they project laterally. Same color as whiskers (i.e., heavily grizzled grey and pale olive-yellow), but slightly paler.	Curves downwards at sides. Distinct and well-demarcated. Hairs short, projecting slightly upwards and forwards. White.
Crown	Grizzled olive-grey. Color increasingly intense towards top of crown.	Grizzled dark olive-grey with faint rufus wash.	Grizzled olive-grey. Color increasingly intense towards front of crown.
Throat	Off-white.	White.	Off-white.
Neck collar	Present but not well demarcated. Around front c. 50% of neck. Front off-white. Sides mouse grey, increasingly grizzled dorsally.	Distinct but not well demarcated. Around front c. 60% of neck. Front white. Sides grizzled light grey.	Absent.
Shoulders	Heavily grizzled olive-grey.	Grizzled dark grey and blackish.	Heavily grizzled pale olive-grey.
Dorsum	Grizzled pale olive-grey. Color extends onto base of upper tail.	Grizzled rufus-grey. Color extends onto base of upper tail.	Grizzled olive-grey. Color extends onto base of upper tail.
Upper outer arms	Grizzled grey with olive wash.	Blackish with grey flecking.	Grizzled olive-grey.
Upper inner arms	Light grey.	Grey.	Off-white.
Lower outer arms	Blackish with grey flecking.	Black.	Grizzled grey.
Lower inner arms	Blackish with grey flecking.	Black.	Off-white.
Upper outer legs	Grizzled grey with olive wash.	Grizzled charcoal.	Grizzled olive-grey.
Upper inner legs	Light grey.	Grey.	Off-white.
Lower outer legs	Grizzled grey.	Grizzled charcoal.	Grizzled grey.
Lower inner legs	Grizzled grey with olive wash.	Grizzled grey.	Off-white.
Hands and feet	Blackish.	Blackish.	Black.
Back of legs	Hair moderately long. Cream to pale grey.	Hair long. Cream.	Hair short. Off-white to pale grey.
Ventrum	Pale grey.	Grey, paler towards center.	Off-white.
Sides	Like dorsum but paler and less grizzled.	Like dorsum but paler and less grizzled.	Like dorsum but brighter. Narrow off-white lateral stripe.
Upper side of tail	Grizzled pale olive-grey over proximal c. 10% grading into dark grey then blackish over distal c. 30%.	Grizzled rufus-grey over proximal c. 10% grading into black.	Grizzled olive-grey over proximal c. 10% grading into grizzled mouse grey with c. distal 10% blackish.
Subcaudal patch	Poorly developed. Pale russet.	Russet.	Bright red.
Scrotum	Medium-size. Skin blue. Readily observed from behind.	Small. Skin dark grey. Lightly covered with white hair. Difficult to observe from behind.	Large. Skin turquoise. Readily observed from behind.
Penis	Medium pink.	Pale pink.	Dark pink.
Overall	Grey animal with little contrast. Body shape most resembles <i>C. p. hilgerti</i> . Generally intermediate in color between <i>C. m. albogularis</i> and <i>C. p. hilgerti</i> .	Phenotypically like other populations of <i>C. m. albogularis</i> .	Phenotypically like other populations of <i>C. p. hilgerti</i> .

Additional photographs of the Diani hybrid, and of *C. m. albogularis* and *C. p. hilgerti* at Diani, can be viewed on the hybrid photographic map at: <www.wildsolutions.nl> (De Jong and Butynski 2010a).

In December 2008, the Diani hybrid was in association with two adult *C. mitis*, at least one of which was a male. The three animals moved over the grounds of the Leopard Beach Hotel feeding on human foods (including sugar in a rubbish bin) and indigenous and exotic plant parts. In October 2009, the Diani hybrid was encountered with a group of at least 20 *C. mitis* on the grounds of the Leopard Beach Hotel and the neighboring Leisure Lodge. The group was feeding on indigenous and exotic plant parts. In December 2008, the Diani hybrid exhibited no injuries or noticeable scars. In October 2009, however, he had a fresh, deep, about

10-cm-long wound in his left thigh, a slightly older cut on his right elbow, and new scars on his face and chest (Fig. 2). The two recent wounds caused him to limp on his left hind leg and right arm. During our observations the Diani hybrid frequently approached the group's resident adult male who always responded antagonistically. The resident male had a large fresh wound on the back of his right thigh (Fig. 3). It is likely that the wounds on the Diani hybrid and on the group's resident male were caused during fights between them.

Once, during our 7.5 h of observations, an adult female *C. mitis* presented herself to the Diani hybrid. Once, the Diani hybrid mounted an adult female but did not copulate. On at least three occasions, the Diani hybrid, while on the ground, actively 'scent-marked' by rubbing his chin, throat and chest in long strokes against tree branches (see below). The Diani hybrid once gave a 'pyow' loud call which was followed immediately by two 'ka-train' loud calls. These were presumably in response to a 'pyow' call produced by the group's resident adult male c. 20 m away. The 'pyow' is an intragroup rallying call and the 'ka-train' is an alarm call. On at least one occasion, the Diani hybrid produced a 'boom', a loud call given in response to various kinds of disturbance (for example, presence of other adult males), sudden loud noise (for example, falling trees or thunder claps), a female 'strained grunt-chorus', and sometimes for no discernable reason (Lawes *et al.* in press; T. Butynski pers. obs.). That the Diani hybrid produced 'pyow', 'ka-train' and 'boom' loud calls is interesting since, among the primate species present in eastern Kenya, these loud calls are only given by adult male *C. mitis*; none of these three calls is part of the vocal repertoire of *C. pygerythrus* (Gautier 1988; Gautier *et al.* 2002; T. Butynski pers. obs.).

There is a second apparent *C. m. albogularis* × *C. p. hilgerti* hybrid at Diani. A photograph (Fig. 5.) of this individual was presented by A. Hayes in a blog (6 August 2009, <colobus.wildlifedirect.org>) of The Colobus Trust (which has its headquarters in Diani). The hybrid in the photograph is a subadult (probably a female). We searched for this hybrid in October 2009 but did not find it. Based on the photograph, and the opinions of the staff of the Colobus Trust, this individual is similar in appearance to the adult male Diani hybrid. That is, it is phenotypically intermediate between *C. m. albogularis* and *C. p. hilgerti*.

In December 2010, The Colobus Trust conducted a primate survey at Diani. The adult male hybrid was encountered on the grounds of Leisure Lodge. He appeared to be alone and in good health. No other hybrids were found (A. Donaldson pers. comm.).

Cercopithecus mitis kolbi × *Chlorocebus pygerythrus hilgerti* Hybrid at Nairobi, Kenya

Ngong Forest Sanctuary (hereafter referred to as 'Ngong Forest'; 01.3171°S; 36.7452°E, 1800 m a.s.l.; Fig. 6) is a 7-km² lower montane dry forest southwest of Nairobi city. Ngong Forest is connected in the southeast to Nairobi National Park.



Figure 2. Adult male Zanzibar Sykes's monkey *Cercopithecus mitis albogularis* × Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti* hybrid at Diani, south coast of Kenya. Note the pale grey nose spot, the deep gash in the left thigh, and the blue scrotum. Photographs by Y. de Jong and T. Butynski.

Five primate species occur in and near Ngong Forest; Kolb's monkey *Cercopithecus mitis kolbi*, *C. p. hilgerti*, *P. anubis*, Kikuyu small-eared galago *Otolemur garnettii kikuyuensis*, and Kenya lesser galago *Galago senegalensis braccatus*.

Kenya Wildlife Service rangers at Ngong Forest reported a 'different looking' guenon that they believed to be a *C. mitis* × *C. pygerythrus* hybrid. In August 2009, P. Kahumbu informed us about this suspected hybrid and provided a photograph of the individual. On 2 November 2009, we visited Ngong Forest and encountered a female hybrid ('Ngong hybrid') near the southeast entrance (Fig. 7). The hybrid was

travelling in a group of *C. mitis*. The rangers are familiar with this semi-habituated group of *C. mitis* as it spends much time foraging, resting and sleeping in the vicinity of the ranger's camp. The rangers said that an adult male *C. pygerythrus*

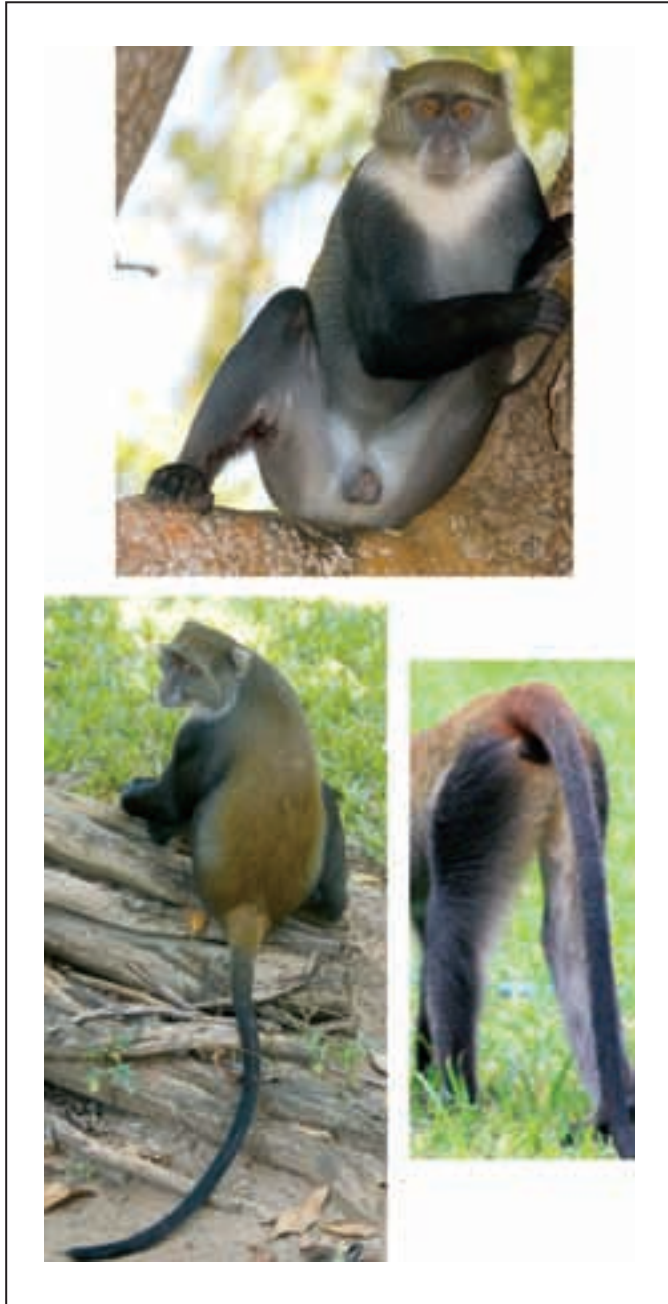


Figure 3. Adult male Zanzibar Sykes's monkey *Cercopithecus mitis albogularis* at Diani, south coast of Kenya. Note the absence of a greyish nose spot, the wound on the right thigh, and that the scrotum is small, dark grey, and not readily visible from behind. Photographs by Y. de Jong and T. Butynski.



Figure 4. Adult male Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti* at Diani, south coast of Kenya. Note the black nose and the large, turquoise scrotum. Photographs by Y. de Jong and T. Butynski.



Figure 5. Subadult Zanzibar Sykes's monkey *Cercopithecus mitis albogularis* × Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti* hybrid, south coast of Kenya. This is the second *C. m. albogularis* × *C. p. hilgerti* hybrid observed in Diani. Note the resemblance to the adult male Diani hybrid. Photograph by A. Hayes.

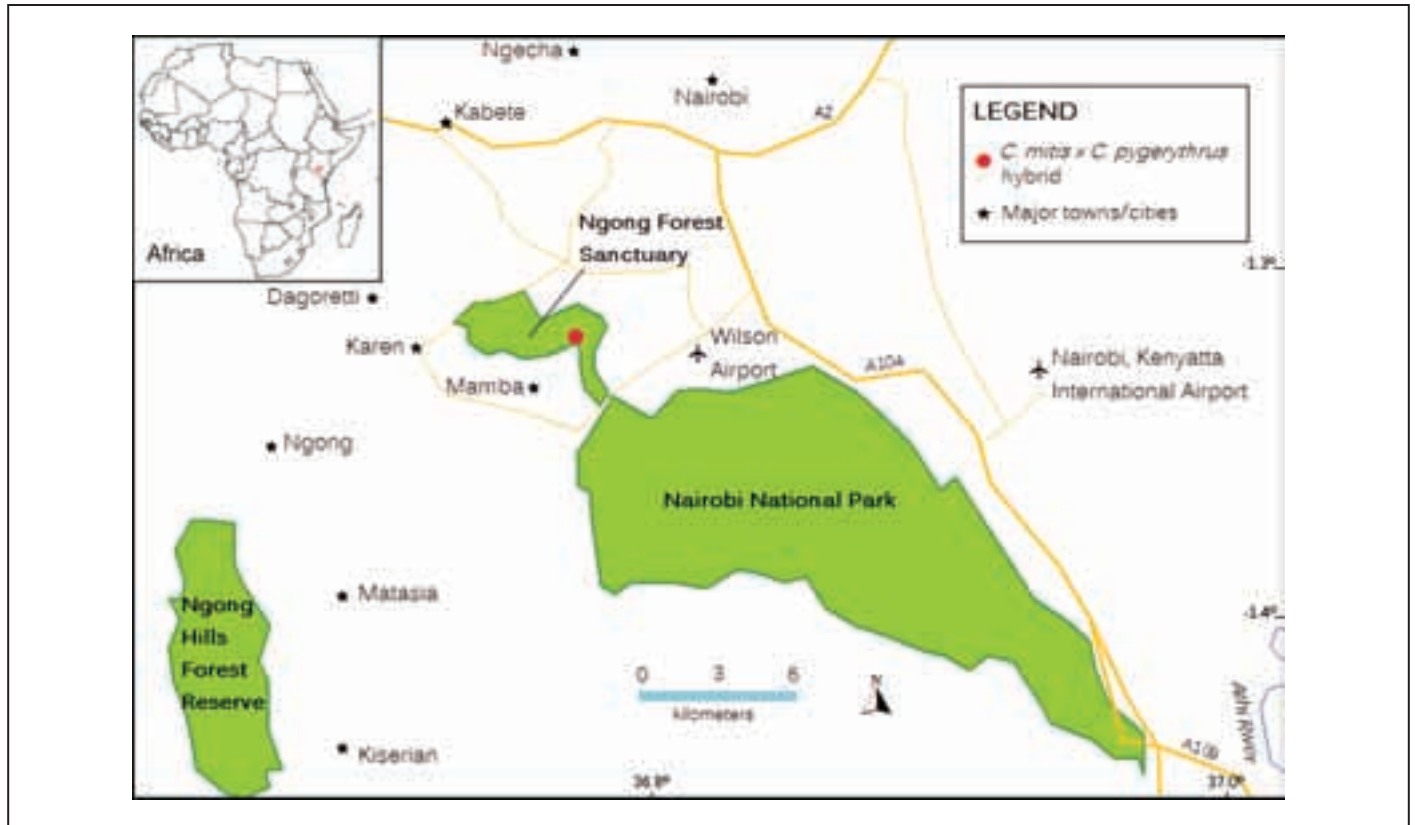


Figure 6. Location of Ngong Forest Sanctuary, Nairobi, Kenya, locality of the Kolb's monkey *Cercopithecus mitis kolbi* × Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti* hybrid.

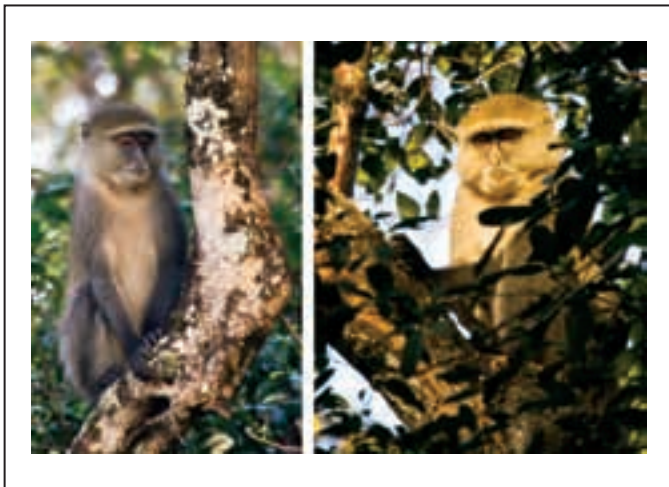


Figure 7. Subadult female Kolb's monkey *Cercopithecus mitis kolbi* × Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti* hybrid at Ngong Forest Sanctuary, Nairobi, Kenya. Note the pale grey nose spot. Photographs by Y. de Jong and T. Butynski.



Figure 8. Adult male (top) Kolb's monkey *Cercopithecus mitis kolbi* at Langata, Nairobi, and adult female *C. m. kolbi* at Nanyuki, Mount Kenya (00.0334°S; 37.1320°E, 2110 m a.s.l.). Photographs by Y. de Jong and T. Butynski.

Table 2. Preliminary comparison of the phenotypic characters of the subadult female ‘Ngong hybrid’ with adult females of *Cercopithecus mitis kolbi* and *Chlorocebus pygerythrus hilgerti*.

Body part	Ngong hybrid	<i>Cercopithecus mitis kolbi</i>	<i>Chlorocebus pygerythrus hilgerti</i>
Nose	Sooty-grey with pale grey nose spot.	Sooty-grey.	Jet black.
Naked skin of face	Sooty-grey skin around eyes and muzzle.	Sooty-grey skin around eyes and muzzle.	Egg-shaped, jet black skin around eyes and muzzle.
Whiskers	Long and dense, forming a full ruff. Heavily grizzled pale grey.	Long and dense, forming a full ruff. Heavily grizzled dark grey with a pale olive-yellow wash.	Not grizzled. White, long, sparse, sweeping upwards and backwards to cover base of ears.
Lips	Whitish hairs on upper and lower lips.	Whitish hairs on upper and lower lips.	Without hairs.
Iris	Amber.	Amber.	Mahogany brown.
Skin around eyes	Pinkish-grey above eyes.	Sooty-grey.	Black.
Ears	Skin sooty-grey. Lightly furred, white.	Skin dark grey. Heavily furred tuft, white.	Skin jet black. Lightly furred, white.
Brow-band	Curves downwards at sides. Distinct and well-demarcated. Hairs medium long, projecting slightly upwards and forwards. Heavily grizzled pale grey.	Same color as whiskers (i.e., heavily grizzled dark grey with a pale olive-yellow wash). Hairs long, projecting slightly upwards and forwards.	Curves downwards at sides. Distinct and well-demarcated. Hairs short, projecting slightly upwards and forwards. White.
Crown	Grizzled grey with faint olive wash. Color increasingly intense towards front of crown.	Grizzled dark olive-grey with faint rufus wash.	Grizzled olive-grey. Color increasingly intense towards front of crown.
Throat	Off-white with pinkish wash.	Bright white, heavily furred.	Off-white.
Neck collar	Absent.	Distinct, bright white, long hairs and well demarcated. Around front c. 90% of neck.	Absent.
Shoulders	Grizzled grey.	Covered by long bright white hairs of neck collar.	Heavily grizzled pale olive-grey.
Dorsum	Grizzled grey.	Grizzled rufus-grey that extends onto base of upper tail.	Grizzled olive-grey.
Outer arms	Grizzled grey, increasingly dark towards the hands.	Blackish with grey flecking, black towards the hands.	Grizzled olive-grey.
Inner arms	Off-white.	Blackish with grey flecking, black towards the hands.	Off-white.
Outer legs	Grizzled grey.	Grizzled dark grey.	Grizzled grey with olive-grey wash on upper outer legs.
Inner legs	Off-white.	Pale grey.	Off-white.
Hands and feet	Dark grey.	Hands black. Feet dark grey.	Dark grey.
Ventrum	Off-white with pinkish wash.	Chest with long off-white to grey hairs. Lower part of ventrum dark grey.	Off-white.
Sides	Like dorsum.	Grizzled grey, long hairs.	Like dorsum but brighter. Narrow off-white lateral stripe.
Tail dorsum	Dark grey, grading into blackish or black.	Grizzled rufus-grey over proximal c. 10% grading into black.	Grizzled olive-grey over proximal c. 10% grading into grizzled mouse grey with c. distal 10% dark grey.
Tail ventrum	Pale grey.	Dark grey over proximal c. 10% grading into black.	Grizzled mouse grey.
Overall	Grey animal with little contrast. Body shape most resembles <i>C. m. kolbi</i> . Generally intermediate.	Phenotypically like other populations of <i>C. m. kolbi</i> .	Phenotypically like other populations of <i>C. p. hilgerti</i> .

joined this *C. mitis* group about 3 years ago and that he is probably the father of the Ngong hybrid. The rangers observed the Ngong hybrid mating with a *C. mitis* male in September 2009 (S. Kamotho pers. comm.).

Based on the intermediate phenotypic characters of the Ngong hybrid (Table 2), the observations of the rangers, and the fact that there are only two species of guenon present in this region (Kingdon 1971, 1997; Y. de Jong and T. Butynski pers. obs.), we believe that this individual is a *Cercopithecus mitis kolbi* × *Chlorocebus pygerythrus hilgerti* hybrid (Fig. 7). To the best of our knowledge, this is the first record of hybridization between these sympatric subspecies, and only the seventh record among Africa’s primates of a wild intergeneric hybrid (see above).

Table 2 compares the phenotypic characters of the Ngong hybrid with those of *C. m. kolbi* (Fig. 8), and *C. p. hilgerti* (Fig. 4). The phenotypic characters of the Ngong hybrid are intermediate to the parent species in most respects, although the color of the nose, lips and eyes, the naked skin of the face, and body shape seem slightly closer to *C. m. kolbi*, while the absence of a neck collar, and the color of the brow-band, shoulders, ventrum, and inner limbs seem slightly more like *C. p. hilgerti*. Additional photographs of the Ngong hybrid, *C. m. kolbi* and *C. p. hilgerti* can be viewed on the hybrid photographic map at: <www.wildsolutions.nl> (De Jong and Butynski 2010a).

Current Taxonomy of *Cercopithecus mitis* and *Chlorocebus*

Here we have described three apparent instances of ‘natural’ hybridization between two broadly sympatric species that belong to different genera; two *Cercopithecus mitis albogularis* × *Chlorocebus pygerythrus hilgerti* hybrids at Diani, south coast of Kenya, and one *Cercopithecus mitis kolbi* × *Chlorocebus pygerythrus hilgerti* hybrid at Ngong Forest Sanctuary, Nairobi. Both parent species have a complicated and much debated taxonomy (Dandelot 1959; Lernoold 1988; Groves 2000, 2001, 2005; Grubb 2001; Butynski 2002; Grubb *et al.* 2003; Groves and Kingdon in press; Kingdon in press).

The ‘gentle monkey *Cercopithecus mitis/albogularis* subgroup’ of the ‘*Cercopithecus nictitans* species group’ (diploid chromosome number = 72; Dutrillaux *et al.* 1988; Romagno 2001) is extremely polytypic with all recent authorities recognizing no fewer than 16 subspecies (for example, Kingdon 1997, in press; Groves 2001, 2005; Grubb 2001; Grubb *et al.* 2003; Lawes *et al.* in press). In East Africa, west of the Eastern (Gregory) Rift Valley, *C. mitis* is most commonly referred to as ‘blue monkey’. To the east of the Eastern Rift Valley the vernacular ‘Sykes’s monkey’ is most frequently used. For *C. mitis* we apply the taxonomy of Grubb *et al.* (2003) and of De Jong and Butynski (2010b), both of which recognize *C. m. albogularis* as the subspecies that occurs along the south coast of Kenya, and *C. m. kolbi* as the subspecies that occupies the ‘Highlands’ east of the Eastern Rift Valley, including the Nairobi area.

The vervet monkey has most often been placed in the genus *Cercopithecus* (for example, Dandelot 1959; Kingdon 1971, 1997; Dandelot and Prévost 1972; Grubb *et al.* 2003). Molecular findings, however, indicate that the vervet and the Sykes’s monkey belong to different phylogenetic clades; the vervet in the ‘terrestrial guenon clade’ (with *E. patas*, Preuss’s monkey *Allochrocebus preussi*, l’Hoest’s monkey *Allochrocebus lhoesti*, and sun-tailed monkey *Allochrocebus solatus*), and Sykes’s monkey in the ‘arboreal guenon clade’ (with all of the other *Cercopithecus* spp.; Dutrillaux *et al.* 1988; Tosi *et al.* 2003, 2005; Xing 2007). This two-clade arrangement receives some support from craniodental (Martin and MacLarnon 1988; Groves 2000, 2001), vocal (Gautier 1988), protein (Sarich 1970; Ruvolo 1988), and ecological and behavioral studies (Gautier-Hion *et al.* 1988; Glenn and Cords 2002; Erhart *et al.* 2005). Furthermore, molecular data place the time of separation of these two clades at *c.* 8.1 mya (Tosi *et al.* 2005). Some of Africa’s most widely recognized genera of primate are estimated to have split from their common ancestor <6 mya (e.g., *Homo* and *Pan*), and some as recently as 3–4 mya (e.g., *Cercocebus* and *Mandrillus*; *Papio*, *Lophocebus* and *Theropithecus*; Jolly *et al.* 1997; Goodman *et al.* 1998; Groves 2001; Toshi 2003). As such, here we apply the taxonomy of Groves (2000, 2001, 2005; Groves and Kingdon in press) in which the vervet is removed from *Cercopithecus* and placed in the resurrected genus *Chlorocebus*. *Chlorocebus pygerythrus* is, together with five other species, a member of the ‘aethiops monkey *Chlorocebus aethiops* species group’

(diploid chromosome number = 60; Dutrillaux *et al.* 1988; Romagno 2001). Monkeys in this group are often referred to as ‘savanna monkeys’.

Natural *Cercopithecus mitis* Hybrids

Cercopithecus mitis is known to hybridize with (broadly sympatric) *C. a. schmidtii* at three widely spaced sites in southwest Uganda (Budongo Forest Reserve, Itwara Forest Reserve, and Kibale National Park; Struhsaker *et al.* 1988), in northwest Tanzania (Gombe National Park; Detwiler 2002; Detwiler *et al.* 2005), and in southwest Kenya (Masai Mara National Reserve; L. Tranter pers. comm.; D. Black pers. comm.). While these hybrids are rare at the three Uganda sites (Struhsaker *et al.* 1988) and in the Masai Mara, they are common at Gombe, comprising *c.* 18% of the combined population of *C. mitis* and *C. ascanius* (Detwiler 2002; Detwiler *et al.* 2005). The only other species reported to hybridize with *C. mitis* is *C. denti* in Nyungwe National Park, southwest Rwanda (B. A. Kaplin pers. comm. in Detwiler *et al.* 2005).

Are the ‘Blond Monkeys’ of Cape Vidal, South Africa, Hybrids?

Mike L. Lawes (pers. comm.) observed no fewer than four ‘blond monkeys’ living in at least three groups of samango monkeys *Cercopithecus mitis erythrarchus* at Cape Vidal, east South Africa (28.0667°S; 32.5333°E; Fig. 9). These four monkeys appear to be *C. m. erythrarchus* in all respects except for their coloration; the pelage of the dorsum is sandy-yellow

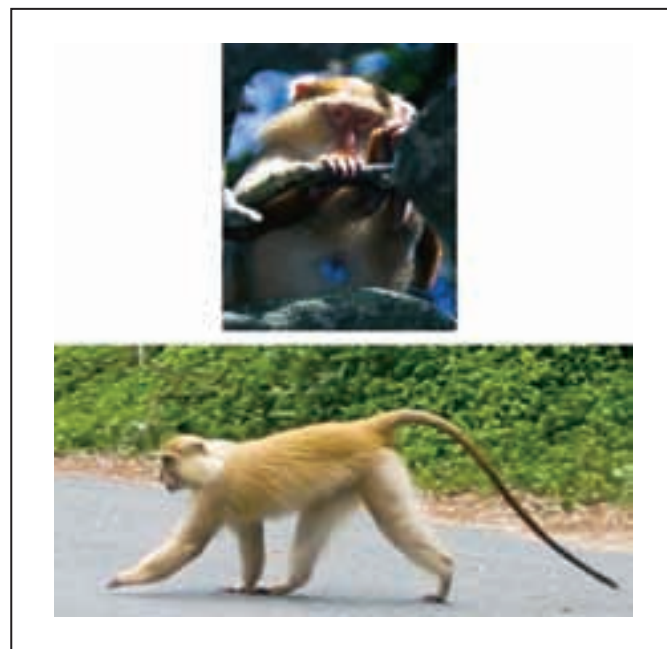


Figure 9. Adult male ‘blond monkeys’ at Cape Vidal, South Africa, that some suggest are samango monkey *Cercopithecus mitis erythrarchus* × southern vervet monkey *Chlorocebus pygerythrus pygerythrus* hybrids but which are probably erythristic or partial albino *C. m. erythrarchus*. Note the blue, small, scrotum in the top photograph. Photographs provided by C. Lehn (top) and M. Lawes. Photographers not known.

to blond, the skin is pinkish (as seen where the skin is bare, for example around the eyes and mouth, bridge of the muzzle, chin and digits), and the scrotum is blue and small. *Cercopithecus m. erythrarchus* and the southern vervet *Chlorocebus pygerythrus pygerythrus* are the only two species of guenon in southern Africa and both are common at Cape Vital. As such, and perhaps mostly because these blond monkeys have a blue scrotum, there has been some suggestion that they are hybrids. Overall, however, these blond monkeys look very different from the three apparent *C. mitis* × *C. pygerythrus* hybrids that we observed at Diani and Nairobi. If these blond monkeys are *C. mitis* × *C. pygerythrus* hybrids, it is expected that the scrotum would be intermediate in size. Instead, the scrotum is small, as for *C. mitis*. We, therefore, suggest that these blond monkeys represent erythristic or partial albino *C. mitis*, and that the blue scrotum is one effect of erythrism or partial albinism in this species.

Natural *Chlorocebus pygerythrus* Hybrids

The only previously reported cases of *C. pygerythrus* hybrids in the wild are with other members of the *C. aethiops* species group. *Chlorocebus pygerythrus* commonly hybridizes with (parapatric) *C. aethiops* over much of the southern one-third of Ethiopia (Dandelot 1959; Dandelot and Prévost 1972; Lernould 1988; Butynski and Kingdon in press) and with (parapatric) tamarin monkeys *Chlorocebus tantalus* over the southern half of Uganda (Kingdon 1971).

Captive-bred *Cercopithecus mitis* and *Chlorocebus pygerythrus* Hybrids

Captive-bred hybrids are reported between *C. mitis* and *C. mona*, lesser spot-nosed monkey *Cercopithecus petaurista*, DeBrazza's monkey *Cercopithecus neglectus*, *C. sabaes*, *C. aethiops*, *C. ascanius*, and red-capped mangabey *Cercopithecus torquatus* (Gray 1972; Lernould 1988; Erhart *et al.* 2005; Y. de Jong and T. Butynski pers. obs.). Erhart *et al.* (2005) report on two captive-bred *C. mitis* × *C. pygerythrus* hybrids, but these are probably *C. mitis* × *C. tantalus* hybrids (T. Rowell pers. comm.).

Chlorocebus pygerythrus is known to produce hybrids in captivity with *C. sabaes*, *C. aethiops*, toque macaque *Macaca sinica*, bonnet macaque *Macaca radiata*, and crab-eating macaque *Macaca fascicularis* (Gray 1972; Lernould 1988).

Intergeneric Sympatric Hybridization

With the discovery of the *Cercopithecus mitis* × *Chlorocebus pygerythrus* hybrids in Kenya, three of the seven species pair combinations for sympatric hybridization among primates in Africa are intergeneric (see above). This is unexpected and its significance remains to be explored.

A number of cases of sympatric hybridization are known for the edges of the range of one or both of the parental species

and may reflect a shortage of conspecific mates for one or both of the species (Jolly *et al.* 1997; Jolly 2001; Detwiler 2002; Detwiler *et al.* 2005). In these cases, hybridization is seen as increasing the options to reproduce when conspecific mates are scarce or absent. This appears to be the situation for the *C. mitis* × *C. ascanius* hybrids at Ngogo, Kibale Forest National Park (Struhsaker *et al.* 1988), where *C. mitis* is at the edge of its range, at very low density, adult females are uncommon, and solitary adult males are relatively abundant (Butynski 1990). This is not, however, the situation at Diani or Nairobi, where *C. mitis* and *C. pygerythrus* are both common. Our data from Diani are too few for calculating densities, but we would be surprised if either species were present at a density of <60 individuals/km². There are no data on the density of *C. mitis* or *C. pygerythrus* in the Ngong Forest area, but both species are common; *C. mitis* in the forest and *C. pygerythrus* in the residential areas around the forest and in the contiguous Nairobi National Park.

Cercopithecus mitis and *C. pygerythrus* occur throughout the extensive forest-woodland mosaic (that is one of the predominant vegetation types) of East Africa (Kingdon 1971, 1997; De Jong and Butynski 2009, 2010b). *Cercopithecus mitis* is a species of forests and dense woodlands, whereas *C. pygerythrus* is a species of forest edge, woodlands and lightly-wooded habitats. These two species are narrowly sympatric at the forest-woodland ecotone. The fact that the forest-woodland ecotone is a common 'habitat type' over this vast mosaic means that these two species meet frequently. Nonetheless, while *C. mitis* and *C. pygerythrus* 'associate' at common food sources along the ecotone (for example, large fig trees *Ficus* spp. with ripe fruit), these associations are usually localized, brief, and appear to be by chance. Groups of *C. mitis* and *C. pygerythrus* have not been observed to move together over long-distances as is often the case among species of forest-living monkeys. What does occur, however, is that young juvenile *C. pygerythrus* sometimes become well-integrated into *C. mitis* groups and probably grow up in them. In about 2001, L. A. Depew (pers. comm.) observed an apparent orphan *C. pygerythrus* (c. 6 months of age) in a *C. mitis* group at Bamburi (south coast of Kenya). This individual was in the *C. mitis* group for at least 5 months, at which time Depew moved from the area and observations ceased. It may be that such constant, long-term interspecific contact, especially for immature individuals, serves to reduce the behavioral barriers to interspecific mating.

The forest-woodland ecotone in East Africa has become considerably expanded and blurred during historic times through human activities that cause extensive habitat change and fragmentation, notably through farming, logging, establishment of settlements, construction of roads, and tourism (Anderson *et al.* 2007). As such, the forest-woodland 'ecotone' is much broader and more extensive today than in the past. This means that the area of habitat that *C. mitis* and *C. pygerythrus* share has increased greatly in historic times. In addition, *C. mitis* and *C. pygerythrus* come together particularly frequently at human residences and tourist facilities



Figure 10. Adult male Zanzibar Sykes's monkey *Cercopithecus mitis albogularis* x Hilgert's vervet monkey *Chlorocebus pygerythrus hilgerti* hybrid scent-marking a tree at Diani, south coast of Kenya. Photograph by Y. de Jong and T. Butynski.

(for example, lodges, hotels, beaches, and picnic areas) where food is often relatively abundant at all times of the year (for example, on shrubs and trees on well-watered compounds, on tables, in garbage bins and pits, and around lights that attract insects at night). Here there is also often water to drink, large trees in which to sleep, few predators, and relatively little harassment by people. Under these circumstances, *C. mitis* and *C. pygerythrus* may drastically change their foraging behavior as they 'hang around' in a relatively safe anthropogenic habitat that they both can effectively exploit. In this new habitat, *C. mitis* and *C. pygerythrus* probably spend much more time in close proximity than when in their natural habitats, become more 'familiar', and likely have more time for interspecific social and reproductive activities. One result may be that the usual barriers to gene flow between *C. mitis* and *C. pygerythrus* have weakened due to anthropogenic environmental modifications and, in the cases of the Diani hybrids and Ngong hybrid, broken.

Scent-marking Behaviour in the Diani Hybrid and Other Guenons

During our 7.5 h of observation, the Diani hybrid was seen to scent-mark three times (Fig. 10). During each of the three bouts of scent-marking he rubbed his chin, throat and chest against tree branches in long, gentle strokes for about 30–60 seconds.

Active scent-marking is rarely reported in *C. pygerythrus* (see Loireau and Gautier-Hion 1988). Gartlan and Brain (1968) observed scent-marking by *C. pygerythrus* on Lolui Island, Uganda, and described it as territorial behavior. Lynne Isbell (pers. comm.), P. Lee (pers. comm.), and T. T. Struh-saker (pers. comm.) all conducted long-term research on *C. pygerythrus* in Kenya and never observed scent-marking in this species. Scent-marking was also not observed in *C. m. stuhlmanni* by T. Butynski (pers. obs.) during >3,000 h of observations in Uganda. In short, the only record of scent-marking by *C. pygerythrus* is that of Gartlan and Brain (1968) and there are no records of scent-marking by *C. mitis*.

The only other guenons for which active scent-marking has been reported are *C. neglectus*, owl-faced monkey *Cercopithecus hamlyni* (captive), *C. sabaeus*, and Allen's swamp monkey *Allenopithecus nigroviridis* (Gautier and Gautier 1977; Gautier-Hion and Gautier 1978; Loireau and Gautier-Hion 1988; Kingdon 1997; Gautier-Hion *et al.* 1999; Gautier *et al.* 2002; Hart *et al.* in press). All of these are semi-terrestrial species.

Loireau and Gautier-Hion (1988) speculated that in *C. neglectus* olfactory marking is associated with a number of traits; (1) low development of visual and vocal signaling, (2) small group size, (3) cryptic behavior, and (4) small home ranges. None of these traits applies to *C. pygerythrus*. Loireau and Gautier-Hion (1988) conclude that 'no consistent socio-ecological correlates can be found among species which display olfactory markings'.

Diani Hybrid Attempting to Assume the Resident Adult Male Position

In guenons, males are the dispersing sex and they sometimes form all-male associations after they leave their natal group (Cords 1987). During our first encounter with the Diani hybrid in December 2008, he was in association with two adult *C. mitis*, of which at least one was a male. At that time the Diani hybrid was a subadult or young adult. When observed in October 2009, the Diani hybrid was fully adult and in a heterosexual group of *C. mitis*. At that time he was attempting to usurp the group's resident male. The behaviors observed were the same as those observed at other sites where a non-resident adult male *Cercopithecus* is attempting to replace the resident adult male of a heterosexual group (Butynski 1982; Macleod *et al.* 2002). The Diani hybrid was (1) constantly following the resident male and in close proximity to him; (2) the resident male aggressively threatened and chased the Diani hybrid; (3) the Diani hybrid mounted an adult female;

and (4) both males showed fresh (severe) wounds and scars of recent wounds (suggesting that they had been in fights over a period of at least some weeks). What was atypical about the Diani hybrid at this time is that he (1) scent-marked and (2) produced ‘pyow’ and ‘boom’ calls—two vocalizations that (among Kenya’s primate species) are given only by adult male *C. mitis* (T. Butynski pers. obs.).

Many (perhaps most) hybrids of parents that are not of the same species-group suffer from outbreeding depression and are aborted, stillborn, or die within hours, days, or weeks after birth (Gray 1972). This applies to both interspecific and intergeneric primate hybrids (Jolly 2001; Detwiler *et al.* 2005; Arnold and Meyer 2006). Those that survive to adulthood are often partially or completely infertile. According to Haldane’s Rule (Haldane 1922; Barton 2001), this is especially the case for the heterogametic sex. The Diani hybrid gave every behavioral indication that he is ‘interested’ in assuming the resident male position and in breeding with *C. mitis* females. Whether he is genetically capable of siring viable offspring is, however, questionable.

Hybrids and the Common Ancestor to *Cercopithecus* and *Chlorocebus*

Might hybrids provide clues as to the appearance, behavior, ecology and environment of the common ancestor, both at the species and genus levels? It is interesting, if not insightful, that the adult male hybrid at Diani exhibits some phenotypic characters (for example, pale grey nose spot) and behaviors (for example, active scent-marking), which are absent or rare in both parent species and in one of the parent genera. Might these be traits exhibited by the common (c. 8.1 mya) ancestor to *Cercopithecus* and *Chlorocebus*? Did that common ancestor have a grey or white nose-spot, as is present today in several *Cercopithecus* species and in the terrestrial eastern patas monkey *Erythrocebus patas pyrrhonotus* but absent in *Chlorocebus*? Did that common ancestor practice active scent-marking, as is present today in several semi-terrestrial species of guenon but in none of the arboreal species?

That the Diani hybrid has the capacity to utter ‘boom’ and ‘pyow’ calls is surprising, given that these two loud calls likely play roles in group cohesion and reproductive isolation (Struhsaker 1970; Gautier 1988). Both the ‘boom’ and the ‘pyow’ involve complex, highly stereotyped behaviors and require morphologically distinct, large, extralaryngeal annexes (Gautier 1971, 1988). The ‘pyow’ call is of particular interest in that this call is, otherwise, confined to the two species in the *Cercopithecus nictitans* species group (*C. nictitans* and *C. mitis*) and, hence, likely has important phylogenetic implications. It is, therefore, of interest that an intergeneric hybrid has the ability to utter a loud call that is believed to have evolved to prevent interspecific hybridization between broadly sympatric species. The significance of this remains to be determined, but this might suggest that both the ‘boom’ and the ‘pyow’ are primitive calls that were present in the

vocal repertoire of the common ancestor to *Cercopithecus* and *Chlorocebus*.

Research Questions and Recommendations

The three cases of intergeneric hybrids described here raise many questions related to hybridization. What are the conditions under which the usual mechanisms for reproductive isolation break down and allow hybridization? Is hybridization a viable reproductive strategy under some circumstances? What are the advantages and disadvantages of hybridization to the parents of the hybrid? What is the role of hybridization in evolution, especially in speciation (Barton 2001)? What can the study of hybrids tell us about phylogenetic affinities, and about the appearance, behavior, ecology and habitat of the common ancestor? How do anthropogenic environments affect rates of hybridization? What are the implications of ‘anthropogenic hybridization’ for the conservation of primate diversity (Allendorf *et al.* 2001; Jolly 2001; Detwiler *et al.* 2005)? The presence of these three apparent intergeneric hybrids also leads to questions related to cercopithecine taxonomy and phylogeny. Some light on a few of the above questions would be shed by comparative research on these three hybrids and their parental species. As such, here are a few recommendations for future research:

1. Produce a detailed description of the phenotypic characters of the Ngong hybrid, its behavior and its ecology.
2. Examine the molecular biology of the Diani and Ngong hybrids and of the parental species. Are these ‘really’ *C. mitis* × *C. pygerythrus* hybrids? Which is the maternal species? What is their karyotype?
3. Determine whether the Diani and Ngong hybrids are capable of successful reproduction? Do they copulate? Are there animals in the population of *C. mitis* and *C. pygerythrus* at both Diani and Ngong Forest that appear to be backcrosses?
4. Undertake surveys to determine if there are other *C. mitis* × *C. pygerythrus* hybrids in Kenya (or anywhere else). If so, what are the circumstances under which hybridization has occurred?
5. How does the behavior and ecology of these three hybrids differ from that of the parental species? How does their diet differ from that of *C. mitis* and *C. pygerythrus* at the same site? Is there evidence that the behavior and ecology of these hybrids make them better adapted than either of the parental species to exploiting the resources of the ‘forest-woodland ecotone habitat’? Does hybridization expand the ‘food niche’ beyond that of the parental species?

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First Physical Examination of the Horton Plains Slender Loris, *Loris tardigradus nycticeboides*, in 72 Years

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Abstract: We report here the first close examination in 70 years of the Horton Plains slender loris, *Loris tardigradus (lydekkerianus) nycticeboides*, previously known only from two collected specimens and a number of sightings from eye-shine. Photographic and morphometric data presented here enable a preliminary assessment of the possible distinctive endomorphic features of this loris in comparison to its sister species and subspecies. This loris clearly demonstrates adaptations to montane forest, as previously suggested from the preserved skins of the holotype and paratype. Confirmation of the continued existence of this loris raises familiar concerns over its taxonomic distinctiveness, its apparent low abundance in a highly fragmented and diminishing habitat, and the actions necessary to eliminate the threats to its survival.

Key words: *Loris tardigradus nycticeboides*, Horton Plains slender loris, Sri Lanka, montane forest, conservation, fragmentation, Sri Lanka.

Introduction

Here we report on the first clear observation, examination and photographs of the Horton Plains slender loris, *Loris tardigradus nycticeboides* since its discovery (Hill 1942). This loris had previously been recorded from just two specimens collected in 1937 after extensive searching by Tutein-Nolthenius in the Horton Plains region (Hill 1942), and a later sighting from eye-shine in 2002 (Nekaris 2003; Nekaris and Jayewardene 2003), totalling four recorded sightings in 72 years. The animals located in 1937 produced two offspring in captivity (Nicholls 1939), and one of these individuals is the holotype specimen held in the British Museum of Natural History, London. The considerable efforts of primatologists and fieldworkers over the past decade in search of this nocturnal primate indicate an extremely low detection probability, which may be a reflection of extreme rarity, patchy occurrence, and cryptic behaviour. The subspecies was noted as seriously threatened following an international review of the world's most threatened primates by the IUCN/SSC Primate Specialist Group in 2004 (Nekaris 2006; see also Nekaris and Perera 2007).

Location and Habitat

An individual was sighted in dwarf montane forest at an elevation of 1,940 m in the Conical Hill proposed forest reserve; a mountain rising to 2,165 m above sea level in the vicinity of Nuwara Eliya (06°91'086"N, 80°78'248"E). This altitude is consistent with that recorded for the site of capture of the holotype of *L. t. nycticeboides* held in the British Museum (Natural History) labelled "Below Horton Plains, 06°48'N, 80° 48'E, 6,000 ft. [1,828 m], May 1938". The sighting reported here was made in montane evergreen rainforest characterized by low canopy heights of approximately 5–15 m. Precipitation is high in this ecotype resulting in a less drought prone ecosystem than elsewhere on the island (Werner 1984). Temperatures there are also the lowest in Sri Lanka; frosts are not uncommon, the annual average temperature is 15.4°C, and the minimum recorded temperature is –4°C (Werner 1984). As recent sightings are limited to two confirmed reports it is not yet possible to judge habitat preferences or bias in occupancy but, assuming *L. t. nycticeboides* moves and sleeps in a similar manner to *L. t. tardigradus*, climbable vegetation complexity and dense foliage for day-time roosting are abundant in the vicinity of these sightings.

Morphology and Adaptation

The most striking feature of *L. t. nycticeboides* is the apparent endomorphy characterized by short limbs and long, dense pelage (Figs. 1 and 2). This is in contrast to the long, slender limbs and short ruddy-brown pelage of *L. t. tardigradus* (Fig. 3). Both fore- and hind limbs appear shorter and sturdier than the limbs of any of the other loris taxa found in Sri Lanka or southern India.

Morphometric measurements taken in the field were obtained quickly from the captured individuals, following the guidelines of Groves (2003). While being measured, the lorises were allowed to hold on to a small branch thus ensuring that they remained relatively still and composed. The animal reported here is an adult male, which recorded a head-body length (HBL) of 202 mm. The brachium (upper arm) length measured 56 mm and the anti-brachium (fore-arm) length was 64.8 mm. The thigh (upper leg) length measured 62.6 mm and cnemis (lower leg) length 66.7 mm.



Figure 1. *Loris tardigradus nycticeboides*, Newara Eliya, Sri Lanka. The animal was photographed after being pursued by observers through understory vegetation. Photograph by C. Mahanayakage.

Body weight was 220 grams. To date, we have collected only limited morphometric data for other loris taxa, as the field program is still continuing, and we have as yet insufficient data to allow an adequate comparison of HBL between the subspecies. Three adult male *L. t. tardigradus* that we have measured had an average HBL of 208 mm (7.2 SE, $n=3$), the brachium averaged 58.1 mm (0.4 SE, $n=3$), the antibrachium 70 mm (0.5 SE, $n=3$), the thigh 70.3 mm (1.7 SE, $n=3$) and the cnemis 69.6 mm (0.6 SE, $n=3$). Body weight mean for three adult male *L. t. tardigradus* was 175.3 grams (8.8 SE, $n=3$). These data indicate that *L. t. nycticeboides* is shorter limbed than *L. t. tardigradus* and, considering similar HBL, also heavier in this instance.

The pelage of *L. t. nycticeboides* is striking in being longer and thicker than in other lorises, as described by Nekaris (2003). Circumocular patches are deep chestnut, with pre-auricular hairs tipped white but turning into a bold white, vertical interocular stripe. The dorsal fur is greyish brown with white frosting and a darker fine-haired undercoat. The fur is thick and considerably longer than in other Sri Lankan lorises. The ventral fur is notably long and a pale sandy orange. There is limited cutaneous pigmentation on the ear rims, and in the individuals we observed eyelid margins do not appear as deeply pigmented as reported by Hill (1942). Nose and digits are pinkish. The specimen recorded conforms to the phenotypic distinctiveness described by Groves (1998) and commented on by Nekaris (2003).

Ecology, Conservation, and Threats

We found this loris only after more than 200 hrs of nocturnal transect surveys in the known habitat, on a 2-km transect which we had walked repeatedly (18 hours over a 9-day period). The Horton Plains slender loris is evidently extremely rare. Our surveys were part of an on-going Wet Zone-wide occupancy study of lorises for conservation management planning (Gamage, Reardon and Padmalal unpubl.; Mackenzie *et al.* 2003). Our methods involve teams of two field biologists systematically searching the forest habitat visible from the predetermined transect track. They walk at a slow pace of about 1 km per hour, looking for eye shine with dimmed, wide-beam and heavily red-filtered head torches (LED lenser™ H7). It is not helpful to compare frequency of encounter data with previous studies because of differences in data collection methods. Also, because our surveys covered a number of different forest types, the encounter frequency may be a poor metric to measure anything other than within site changes in loris detection.

Loris tardigradus is listed as Endangered on the IUCN Red List of Threatened Species (EN, C2a(i); Nekaris 2008). The rarity of *L. t. nycticeboides* resulted in it being listed as one of the world's 25 most endangered primates for the periods 2006–2004 and 2004–2006 (Nekaris 2004; Nekaris and Perera 2007). Nekaris and Perera indicated that the geographical range of *L. t. nycticeboides* was less than 40,000 ha (Nekaris 2003). We are continuing to survey sites across this



Figure 2. *Loris tardigradus nycticeboides*, lateral view, Newara Eliya, Sri Lanka. Photograph by C. Mahanayakage.

area in the hope of determining the full extent of the subspecies' range. Continued fragmentation due to agricultural development, die-back of forest believed to be due to climate change (Werner 1984) and, more insidiously, the degradation of montane forest due to firewood collection and cardamom production, may put the area of available suitable habitat at a significantly lower figure. The anthropogenic pressures on the environment in Sri Lanka, which is among the top three biodiversity hotspots threatened by population pressure (Richard *et al.* 2000), suggest that any organism requiring extensive, non-degraded natural habitat is likely to be threatened with extinction. Regarding the threats to *L. t. nycticeboides*, Molur *et al.* (2003) wrote "Local and commercial trade for eyes and meat by tea plantation workers. Possible village level trade for folk medicine" (p.87). We found no evidence, however, of such exploitation of lorises in Sri Lanka. Electrocutation, a common cause of death of lorises in the dryer regions of central northern Sri Lanka, is also largely absent in the montane habitat of *L. t. nycticeboides* due to the lack of power lines.

Currently, habitat fragmentation and degradation outweigh all other threats to this subspecies. Being an apparent montane specialist, climate change effects on high altitude forest ecology can only exacerbate this threat. Forest fragmentation may be of special concern to the movement and dispersal of *L. t. nycticeboides* as denseness of its montane forest habitat to which it is adapted may make this subspecies less inclined than other lorises to traverse simplified vegetation such as heavily disturbed or early succession forest (Williams *et al.* 2002). The regeneration of forest in the montane zone is also inhibited by a number of climatic factors, and montane forests in Sri Lanka are more susceptible to long-term damage due to fragmentation than sub-montane and lowland



Figure 3. *Loris tardigradus tardigradus*, for comparison. Kanneliya, Sri Lanka. Photograph by J. T. Reardon.

rain forest systems, where regeneration can be relatively rapid (Wade 1984; Wikramanayake *et al.* 2001).

Further morphometric, molecular and behavioral data will be gathered to enable a review of the systematics of the subspecies of *L. tardigradus*. An on-going research, conservation, and management programme will incorporate the findings to ensure that adequate effort is focused to describe the extent of occupancy of *L. t. nycticeboides* so that necessary recommendations for threat-reducing management may be delivered to the resource management agencies. Key questions that must now be addressed besides determining the true extent of this subspecies' montane forest occupancy include assessing the abundance of *L. t. nycticeboides* where present to enable rudimentary assessment of population viability and an investigation of the extent to which it is able to disperse through and use degraded or regenerating forest.

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A Review of François' Leaf Monkey *Trachypithecus francoisi* (*sensu lato*) in Lao PDR

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Abstract: A monkey population allied to François' leaf monkey *Trachypithecus francoisi* discovered in 1920 constitutes the taxon *laotum*, endemic to Lao PDR. The next seven decades provided very little additional information about it. Wildlife surveys in the 1990s found a large population of *T. (f.) laotum* in Phou Hinpoun (=Khammouan Limestone) National Protected Area (NPA) and north into southern Nam Kading NPA, and a large population in and around Hin Namno NPA of *T. (f.) ebenus*, known outside Lao PDR only from adjoining Vietnam. Detailed here are confirmed records of smaller and more localized populations of leaf monkeys of the *T. francoisi* group (*sensu* Groves 2001, 2005, p.175) from two other areas (Nakai–Nam Theun NPA and a region outside the protected area system, Muang (=District of) Vilabouli, in Savannakhet province), highly plausible reports from one more site, and records of *T. (f.) ebenus* from southern Phou Hinpoun NPA. Animals from Nakai–Nam Theun NPA and Muang Vilabouli differ in pelage from reported forms, and further information is required to resolve their taxonomy in relation to the named forms *hatinhensis* and *ebenus*. All Lao records of the *Trachypithecus francoisi* group leaf monkeys are within the latitudinal band of 16°58'N (probably 16°49'N) to 18°17'N, but reports from local people suggest the possibility of occurrence north of this latitude, and perhaps (parallel with the complex's distribution in Vietnam) north to the Chinese border. Populations in large karst landscapes remain healthy but cannot be assumed to remain so, and those in smaller karst and non-calcareous ranges are highly vulnerable to hunting-induced local extinction. Many uncertainties remain concerning the species-complex in Lao PDR: its overall distribution, the number of forms present, their distribution, and their taxonomy. Undescribed forms may yet be found, most likely to the north of the known range, where threats are much higher, adding to the urgency for surveys in this region.

Key Words: Conservation status, distribution, habitat, *Trachypithecus (francoisi) ebenus*, *Trachypithecus (francoisi) hatinhensis*, *Trachypithecus (francoisi) laotum*

Introduction

Since the description of François' leaf monkey (François' langur) *Semnopithecus francoisi* Pousargues, 1898, six additional, closely related taxa have been proposed: *Semnopithecus poliocephalus* Trouessart, 1911, of Cat Ba island (north-east Vietnam); *Pithecus laotum* Thomas, 1921 of Central and, marginally, North Lao PDR; *Pithecus delacouri* Osgood, 1932, of northern Vietnam (to the south of *francoisi*); *Trachypithecus leucocephalus* Tan Bangjie, 1957, of south-east China; *Presbytis francoisi hatinhensis* Dao Van Tien, 1970, of central Vietnam; and *Semnopithecus auratus ebenus* Brandon-Jones, 1995, of Central Lao PDR and, perhaps only marginally, adjacent Vietnam (*contra* the original hypothesized type locality of the vicinity of Lai Chau, in north-west Vietnam); nominate

francoisi itself inhabits southern China and northern Vietnam. The range of all these taxa lies entirely east of the Mekong, in northern and central Vietnam, Central and, marginally, North Lao PDR, and southeastern China. This is a relatively small area for even a single primate species, let alone, potentially, seven, increasing the chances that at least some of the taxa will be highly threatened with extinction (Brandon-Jones 1995; Groves 2001, 2005; Nadler *et al.* 2003; Brandon-Jones *et al.* 2004).

The inter-relationships of these monkeys are unresolved. In the latter decades of the 20th century they tended to be regarded as conspecific under *Trachypithecus* (or *Presbytis* or *Semnopithecus*) *francoisi* (for example, Eudey 1987; Corbet and Hill 1992). Recently some or all forms have been considered distinct species, but there remains no consensus view

(contrast Groves 2001, 2005; Brandon-Jones *et al.* 2004; Roos *et al.* 2007). Although Brandon-Jones (1995) even dispersed the taxa among multiple other species, Groves (2001, 2005) re-affirmed the conventional view that these taxa form a cohesive phylogenetic group, which he called the “*Trachypithecus francoisi* group”. Within this group there seem to be two groupings, a northern and a southern (for example, Roos *et al.* 2007). It is unclear whether all named forms represent discrete taxa: it has been argued that *T. (f.) leucocephalus* and *T. (f.) ebenus* may be morphs of *T. francoisi* (*sensu stricto*) and of *T. (f.) hatinhensis*, respectively (Brandon-Jones 1995; Nadler *et al.* 2003; Roos *et al.* 2007). Overlap in geographic range has been suggested in two cases, both discussed below: *ebenus* with *hatinhensis*, and *ebenus* with *laotum*. There is no evidence in Lao PDR for large-scale overlap, but the areas where such overlap might be most expected remain insufficiently investigated.

The IUCN/SSC *Action Plan for Asian Primate Conservation* (Eudey 1987) ranked *Trachypithecus francoisi* (*sensu lato*) as “a very high conservation priority.” Despite this, and the long-term listing of the taxa in Lao PDR as globally threatened or at least Data Deficient by the IUCN Red List (Le Xuan Canh *et al.* 2008; Timmins and Boonratana 2008), little information is readily available on the status of these monkeys in Lao PDR. Before the early 1990s, there were only a handful of records (detailed below), but from 1992 onwards many areas across the country were surveyed for large mammals, including primates (effort per site presented in Timmins and Duckworth 1999, 2008). Two national protected areas (NPAs) in the newly-created NPA system (see Berk Müller *et al.* 1995a, 1995b; Robichaud *et al.* 2001) were found to support large populations of these monkeys: Phou Hinpoun (=Khammouan Limestone) NPA, with *T. (f.) laotum* over much of it but *T. (f.) ebenus* in the south (Steinmetz *et al.* in press) and Hin Namno NPA, holding *T. (f.) ebenus* (Timmins and Khounboline 1996; Walston and Vinton 1999; P. Phiapalath pers. comm. 2008). Additional information was gathered in several sites away from the immediate vicinity of these two NPAs. The conservation status of *T. (f.) laotum* is detailed in Steinmetz *et al.* (in press). The dual purposes of the present compilation are (1) to detail Lao records known to the authors of these monkeys other than *T. (f.) laotum*, but excluding those from Hin Namno NPA and its surroundings because there are many records from other observers; and (2) to provide a national status overview of the entire complex in Lao PDR. Most of these records have appeared previously only in internal project reports of limited circulation, or not at all.

Conventions

Areas and sites referred to in the text are marked on Fig. 1. Place names are based on the 1985–1987 series of 1:100,000 maps of the RDP Lao Service *Géographique d'État* (RDPL SGE) maps with the minor modifications of Thewlis *et al.* (1998), except that the Nakai plateau and derivatives are spelled thus, not as Nakay, reflecting widespread current

usage. Where there is no RDPL SGE map-name, the name in local usage is given, transliterated according to the original observer. Coordinates and altitudes, except where stated, are derived from the RDPL SGE maps. The division of Lao PDR into North, Center and South is defined in Duckworth *et al.* (1999). Considerable detail accompanies the distributional data, following the urging of Brockelman and Ali (1987) for such precision in primate records, and which is particularly important in a situation where multiple morphological forms occur in close proximity. With the taxonomic lability and ongoing instability, and a general lack of attention given to English names in mammalogy (see Grubb 2006), these monkeys have been referred to under various English names. The present paper uses a single explicitly general name, “François’-group leaf monkey”, for the entire group (*T. francoisi* [*sensu lato*]), because neither the taxonomic identity of some populations nor the number of species involved are clear.

Lao words incorporated in place-names: *Ban*=village (here, meaning the area surrounding the village, rather than the village itself); *Daan*=rocky flat; *Hinpoun*=limestone; *Muang*=administrative district; *Na Pha*=cliff face; *Nam*=river; *Pak*=river-mouth; *Pha*=cliff-girt massif, often but not invariably of karst; *Phou*=mountain or hill; *Sayphou*=hill or mountain range.

Methodological Background

Direct-observation mammal surveys undertaken across Lao PDR during 1992–2007 were characterized by Timmins and Duckworth (1999, 2008) citing the original, often internal, reports from each. Most consisted of a few weeks to a few months of direct observation to assess general habitat type and condition, and to seek by direct observation (mostly during daylight) birds and large mammals (generally, those identifiable without the need for specimen procurement) of elevated national and, especially, global conservation concern. Monkeys were thus among the best covered groups of mammals. The loud, far-carrying, calls of François’-group leaf monkey, even if their identity is not known when first heard, make it likely to be well recorded when present. However, because it seems fairly to highly localized when outside large karst landscapes, it can be overlooked by even quite lengthy surveys of a general area (most NPAs are of 1,000–2,000 km² and on any given survey only a small portion could be covered). While karst itself attracted specific survey because of its various specialist birds (Thewlis *et al.* 1998; Duckworth *et al.* 1999; Alström *et al.* 2009; Woxvold *et al.* 2009) as well as these monkeys, precipitous non-calcareous terrain was rarely a survey target: in most areas it is not extensive, and in general it has relatively low conservation potential and priority.

Of the surveys here reviewed, only in Muang Vilabouli (2008) and in the region east of Nam Kading NPA (1995 and 2005) was a focused effort made to find François’-group leaf monkeys using village information, because such species-specific use of time was inappropriate to the surveys’ more general remit.

Historical Records

The first Lao record of François'-group leaf monkey comprised three animals collected in February 1920, of which one constituted the holotype for *Pithecus laotum* Thomas, 1921 (Weitzel *et al.* 1988; Brandon-Jones 1995). The collection site, given at the time as "Camp 42", "Ban Sao", and "Ban Na Sao", has been interpreted variously, with Thomas (1921, p.182) giving it as "on the French side of the Mekong,

in latitude about 17°30'N", and Kloss (1921, p.75) as "about 40 miles north-east of the town of Pak-Hinboun [17°35'N 104°37'E] on the Mekong" (i.e., about 18°02'N, 105°01'E; but this takes it outside the major limestone belt of the region); while Brandon-Jones (1995), having consulted the expedition's detailed diary, compiled by Day (1920), concluded that Ban Na Sao lay near the coordinates of today's Ban Phontiou (17°53'N, 104°37'E). This is a trifling readjustment by comparison with some errors of location made by Thomas in other

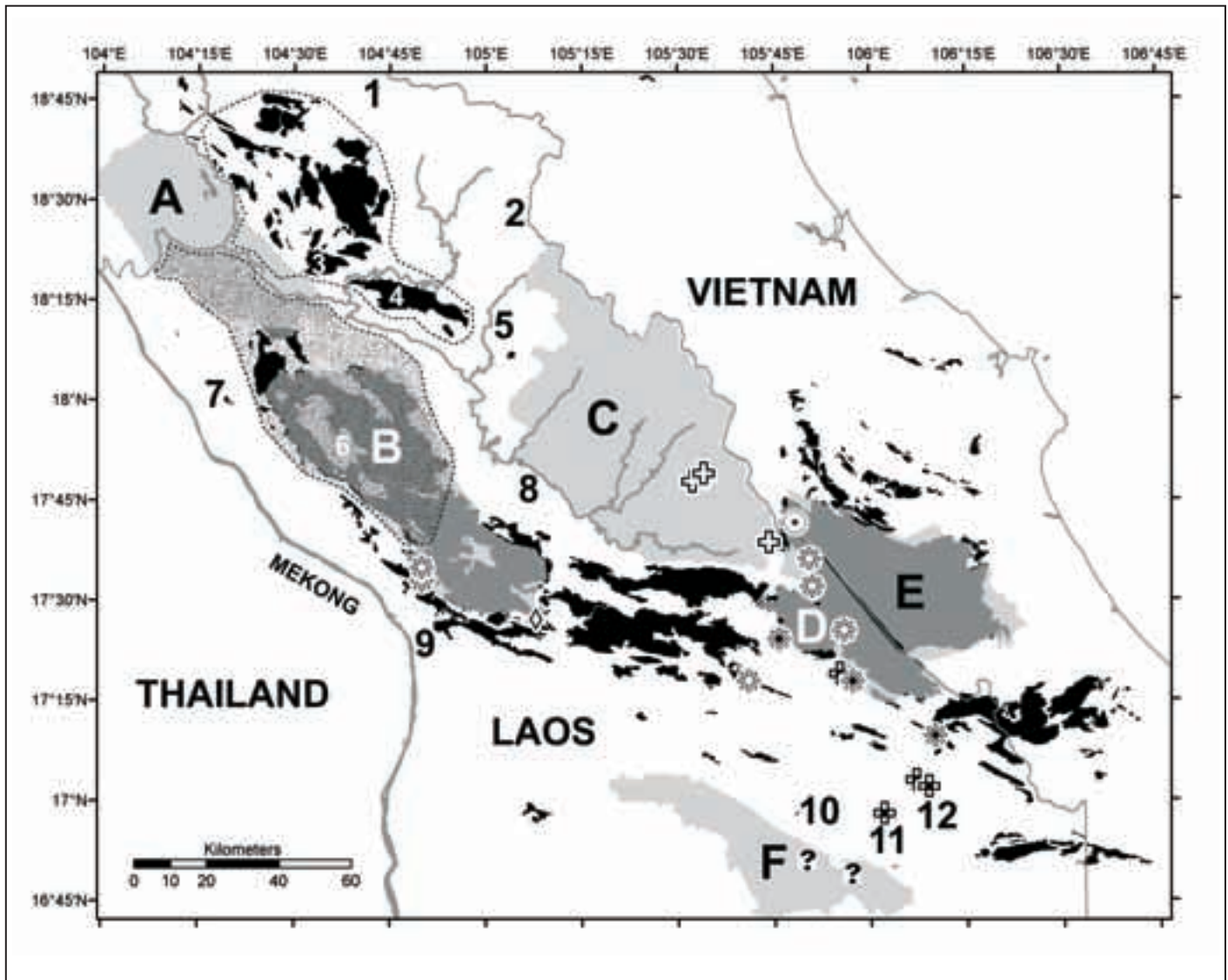


Figure 1a. Lao PDR, showing locations of records of François'-group leaf monkey and other sites and areas mentioned in the text. Black = karst, pale gray = national-level protected areas (not comprehensive for Vietnam), dark gray = karst within national-level protected areas.

Known range. *T. (f.) laotum* within dashed line of A and B, south of the Nam Theun (from Steinmetz *et al.* in press). Other taxa marked as points: diamond = vocal record far from any sighting; white-centered asterisk = black-headed animals (those from in and around area D, from Timmins and Khounboline 1996, and Walston and Vinton 1999); black-centered asterisk = apparently black-headed animals (after Walston and Vinton 1999); white-centered cross = animals with white-cheek band; black-centered cross, animals with dark head but white pinna-stripe; ringed dot = typical *T. (f.) hatinhensis* (Vietnam; from Timmins *et al.* 1999); question-mark = apparent *T. (francoisi)* (ssp).

Dashed line around karst north of the Nam Kading and east of the Nam Mouan = Interview area of Table 4. The river shown entering the Mekong is the Nam Theun/Kading (known as the latter in its lower reaches, the former in its upper); the tributary entering the Nam Kading within area A is the Nam Mouan.

A, Nam Kading NPA plus Nam Sanam PPA; B, Phou Hinpoun NPA; C, Nakai-Nam Theun NPA; D, Hin Namno NPA; E, Phong Nga-Ke Bang National Park; F, Phou Xang He NPA. 1, Nam Chouan proposed NPA; 2, Nam Theun Extension proposed NPA; 3, Nadi Limestone; 4, Sayphou Loyang; 5, Ban Lak-20; 6, Ban Na Sao/Ban Phontiou; 7, Pha Som; 8, Nakai plateau; 9, Thakhek; 10, Pha Lom; 11, Phou Padan; 12, Pha Kat and Pha Tadang.

specimens he received (for example, in the type locality of the jungle cat subspecies *Felis chaus fulvidina*; see Duckworth *et al.* 2005). Deuve and Deuve (1963) located Ban Na Sao as 12 km north of Thakhek (and beside the Mekong), giving Phontiou as 70 km to the north, but indicated that they based this on Thomas (1921), not on any independent re-evaluation.

A single *T. (f.) laotum* arrived at San Diego Zoo in 1947, but died after two days (Dolan 1994). The only other historical

references of *T. francoisi* (*sensu lato*) in Lao PDR seem to be those in Deuve and Deuve (1963) and Deuve (1972), who made essentially the same statements, that they had formally identified the species (whether they actually encountered it in the field themselves is unclear) at the limestone outcrops of “Phasom” (presumed to be the Pha Som on route 13 from Thakhek to Ban Pakkading, at 18°00'N, 104°19'E), and of “Phontiou” (presumed to be that listed above). They

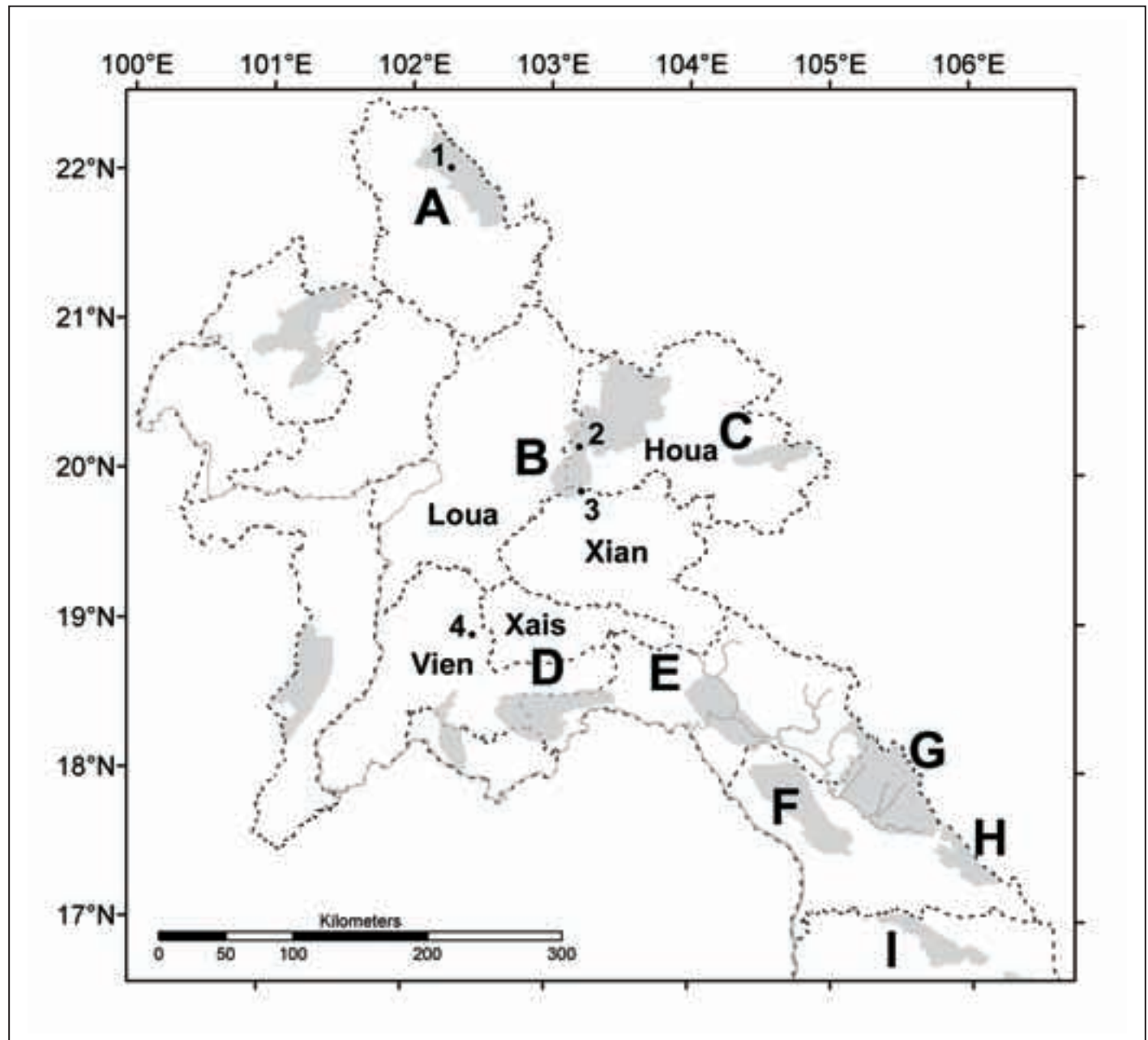


Figure 1b. Lao PDR, showing locations and features relevant to the possible occurrence of François'-group leaf monkey in the northern part of the country. Pale gray = national-level protected areas (not comprehensive for Vietnam); dashed lines separate provinces.

Provinces with extensive karst have abbreviated names: Loua = Louangphabang province; Houa = Houaphan province; Xais = the former Xaisomboun Special Zone, recently distributed among the neighbouring provinces; Xian = Xiangkhouang province; Vien = Vientiane province. A, Phou Dendin NPA; B, Phou Louey NPA; C, Nam Xam NPA; D, Phou Khaokhoay NPA; E, Nam Kading NPA plus Nam Sanam PPA; F, Phou Hinpoun NPA; G, Nakai–Nam Theun NPA; H, Hin Namno NPA; I, Phou Xang He NPA.

1, Ban Hathin; 2, Ban Sakok; 3, Ban Sopkhao; 4, Vangviang.

gave the Lao name “khang” for the species; while this cannot safely be assigned to François’-group leaf monkey (see “Local Names”), Ban Phontiou is in Phou Hinpoun NPA and within the complex’s recently validated range, and Pha Som is nearby; both are suitable karst habitat for these monkeys. Since the mid-1990s, Pha Som has been exploited for cement, and is so small, so isolated from other karsts by farmland, and so close to the country’s major road, that it seems unlikely to retain any leaf monkeys. Even if they inhabit this outcrop, numbers could not be significant compared with the nearby NPA populations.

Modern Records

Modern records of *T. (f.) laotum* come from much of Phou Hinpoun NPA, and, to its north, Nam Sanam Provincial Protected Area (PPA) of Khammouan province, southwestern Nam Kading NPA, and the unprotected land where a main road (route 8) runs between Phou Hinpoun NPA and Nam Sanam PPA (Nadler 2009; Steinmetz *et al.* in press). They are not detailed further here. Records of other taxa within the complex come from four areas in addition to Hin Namno NPA and its surrounds, as follows.

Nakai–Nam Theun NPA

Records come from two parts of the NPA (Table 1). The active sleeping site on Phou Vang was on a small non-limestone cliff, with old and fresh feces piled 20 cm deep at the base (Robichaud and Stuart 1999). The camera-trapped animals were sitting on large rocks in the bed of a short flat stretch of stream in steep terrain, with one apparently drinking. This camera trap was active over 4 March – 6 June 2008, and these were the only leaf monkeys photographed (WGR). At 3,500 km², Nakai–Nam Theun NPA is Lao PDR’s largest NPA, mostly covered in hill and montane (semi-)evergreen forest. This NPA has been relatively well surveyed using direct observation for large mammals, in 1994 (Evans *et al.* 2000), 1996 (Duckworth 1998), 1997 (WCS 1997), 1998–1999 (Boonratana 1998b; Robichaud and Stuart 1999), 2001 (Boonratana 2001) and 2006–2008 (WGR and the Nam Theun 2 Watershed Management and Protection Authority unpubl. data). Although in this very large NPA, a fair number

of areas of precipitous terrain remain unsurveyed, the high, geographically widespread, survey effort indicates that these monkeys are localized in the NPA, and their total population is certainly much smaller than in the karst-dominated NPAs of Phou Hinpoun and Hin Namno.

Phou Hinpoun NPA

As well as the large population of *T. (f.) laotum* (which has extensive white on the head) in the north and center of the NPA (Nadler 2009; Steinmetz *et al.* in press), animals fitting *T. (f.) ebenus* (lacking white on the head) occur in its south. Calls heard around Ban Lak-9 (=Ban Lak Kao; 17°27'N, 105°07'E) on 22 May 1994 were attributed by villagers to black-headed animals, and reports from nearby Ban Nakayak (17°28'N, 105°07'E) and Ban Nampik (17°29'N, 105°09'E) also were of black-headed animals (Timmins 1997). Further interviews in 1998 spread across the NPA received reports of black-headed animals around Ban Viang (17°36'N, 104°58'E), Ban Nakhu (17°39'N, 104°48'E) and Ban Phin (17°29'N, 105°00'E); in the last, southernmost site, only black-headed animals were reported, whereas at the other two, animals with white on the head were said to live in the immediate area as well (Steinmetz 1998). Two direct sightings of black-headed animals were made in early 1999, both south of 17°35'N (Table 2). Nadler (2009) observed three animals lacking any white on the head or ears (as far as could be told, with observation at 100 m range) in the southern part of the NPA, about 1 km from route 12 (T. Nadler pers. comm. 2009). All evidence therefore suggests only a narrow zone of overlap, if any, between animals typical of *T. (f.) laotum* and those with black heads.

Muang (administrative district of) Vilabouli, Savannakhet province

Records came from several outcrops (Table 3). Pha Kat is a small (*c.* 2.5 km²), narrow, karst which was surveyed only on its west face. All observations of monkeys were made from the plains below; JWD spent the day of 20 November 2008 and the morning of 22 November within tall semi-evergreen forest on the lower karst, without seeing, or, more surprisingly, hearing, the species. The animals on 16 November 2008 seemed to be heading towards a large cave, feeding now and

Table 1. Records of François’-group leaf monkey from Nakai–Nam Theun NPA.

Location	Co-ordinates	Date and time	Number of animals	Other notes	Observer / reference
West slope of Phou Vang	17°47'47"N, 105°32'15"E; 1,150 m	13 December 1998, evening; one evening within 31 December 1998 to 5 January 1999	15+	At cliff-ledge sleeping site; also seen once by day in nearby evergreen forest	Robichaud and Stuart 1999
Lower north slope of Phou Hua*	17°48'40"N, 105°34'04"E; <i>c.</i> 1,000 m	29 March 2008, 12:30 to 12:33	8+ (6 adults, 2 cling- ing, orange, infants)	Camera-trapped in evergreen forest	WGR
Lower north slope of Phou Hua	17°49'N, 105°34'E; <i>c.</i> 1,000 m	6 April 2008, 10:25	Group; no count possible	Flushed in evergreen forest canopy	WGR
Scarp slope of Phou Ak	17°38'40"N, 105°44'11"E; <i>c.</i> 850 m	27 May 2007, 17:00	3 adults with 1 baby	In SEF; photographed by observer	B. L. Stuart pers. comm. 2008

* Part of the Phou Vang massif.

SEF=semi-evergreen forest.

then on their slow journey. Based on calls heard earlier that afternoon, either two groups were involved, or these animals had moved a mile or more. The nearby karst of Pha Tadang is smaller (*c.* 0.6 km²); the leaf monkeys seen were foraging in tall semi-evergreen forest half-way up the karst, watched from the plain below. Phou Padan is a rugged *c.* 12 km² quartzite sandstone massif, disjunct from any karst. Most of this massif was not explored, but a cave high on the south face was visited specifically because local hunters reported that dark long-tailed monkeys used it as a sleeping site.

Muang Vilabouli is outside the NPA system and comprises a village- and road-studded landscape of heavily degraded semi-evergreen forest, secondary regrowth and agriculture, with various small rugged massifs. The intervening area north-west to Phou Hinpoun NPA holds a dispersed archipelago of small karst outcrops. Muang Vilabouli was surveyed using direct observation for large mammals only for a month (in late 2008), and time was insufficient to assess leaf monkey status in many of its rugged areas; village interviews suggested that *khung* (probably François'-group leaf monkey; see "Local Names") might be quite widespread in its various cliffs, mostly non-limestone. Nonetheless, although various isolated populations probably remain undocumented in the area, suitable habitats comprise blocks so tiny by comparison with those in Phou Hinpoun and Hin Namno NPAs that populations can only be relatively small.

Phou Xang He NPA (unconfirmed records)

During 8–10 May 1998, a group of three animals was seen by a village guide (RB himself only heard the crashing of foliage) in a narrow valley between two parts of the Phou Hinh massif at *c.* 16°49'N, 105°57'E (*c.* 400 m above sea level). The guide directly afterwards called the animals *thane* (invariably used for gibbons) but stated (in Lao), upon enquiry, that the animals were all black/dark, with long tails and crested heads; and the way he described their mode of locomotion through the canopy was consistent with leaf monkeys rather than gibbons, the only other black primates in the area. However, the possibility that these might have been silvered-type leaf monkeys *T. aff. T. cristatus* (a group also of unstable taxonomy in Indochina) cannot be ruled out. Villagers reported that some *khong* (probably François'-group leaf monkey; see "Local Names") regularly sleep at two caves or crevices in the precipice of Na Pha Daan, west of Ban Naphaling, at *c.* 16°51'N, 105°50'E (300–600 m above sea level), and fresh and old droppings and urine were observed on the trail just below the sleeping sites, with urine stains visible on the cliff face (Boonratana 1998a; Duckworth *et al.* 1999, plate 13; RB own data). These signs were perfectly consistent with those known for François'-group leaf monkeys, but it is uncertain whether such signs are left by other monkey species when living amid rock faces. Eudey (1991) suspected that red streaks on cliff faces in Huay Kha Khaeng Wildlife

Table 2. Records of black-headed François'-group leaf monkey in Phou Hinpoun NPA.

Location	Co-ordinates; altitude above sea level	Date and time	Number of animals	Other notes	Observer / reference
Ban Koktong-Noy	17°34'55"N, 104°49'45"E; 160 m	10 January 1998; <i>c.</i> 10:00	15–20	Base of karst near heavily degraded plains forest	M. F. Robinson
Tam Sompoy	17°33'05"N, 104°49'50"E; 160 m	14 January 1998; morning	1	Seen at 30–50 m range in open karst near scrub and bamboo	M. F. Robinson

See also Nadler (2009).

Table 3. Records of François'-group leaf monkey in Muang Vilabouli.

Location	Co-ordinates; altitude above sea level	Date and time	Number of animals	Other notes	Observer / reference
Pha Kat	17°03'N, 106°07'E; 450 m	15 November 2008, 15:30–15:45	2–3 adults and one black young	Towards the southern end of the west face	JWD
Pha Kat	17°03'N, 106°07'E; within 320–600 m	16 November 2008, 15:00–15:45	Calls heard intermittently	Central west face	JWD
Pha Kat	17°03'N, 106°07'E; 350–400 m	16 November 2008, 16:50–17:00	12+, including two black young	Low on the west face of the karst, south of center	JWD
Pha Kat	17°03'N, 106°07'E; within 320–600 m	20 November 2008, 11:30–12:15	2+ adults	Southern end of the west face	I. Woxvold pers. comm. 2008
Pha Kat	17°03'N, 106°07'E; within 320–600 m	21 November 2008, 11:05	Calls heard	Northern part of the west face	JWD
Pha Tadang	17°02'N, 106°09'E; within 320–500 m	7 December 2008, morning	Calls heard several times		JWD
Pha Tadang	17°02'N, 106°09'E; 400 m	8 December 2008, 16:00–16:20	5+ adults, 1 <i>c.</i> ½-adult-length young	North-west tip of the outcrop	JWD
Phou Padan	16°58'N, 106°02'E, 700 m	25 November 2008, 16:00–17:45	2 adults, one black young		JWD
Phou Padan	16°58'N, 106°02'E, 700 m	26 November 2008, 05:50	Calls heard at first light	Same animals, same site as previous evening	JWD
Phou Padan	16°58'N, 106°02'E, 700 m	30 November 2008, 10:30	Calls heard	Same site as previous animals	I. Woxvold pers. comm. 2008

Sanctuary, Thailand, came from urine and/or faeces of Assamese macaques *Macaca assamensis*.

Phou Xang He NPA consists of two semi-evergreen clad hill ranges separated by a narrow lowland plain, in which forest is heavily degraded and fragmented; the bigger, sandstone, Sayphou Xanghe and the smaller, more mesic, igneous Phou Hinho. Fairly brief and spatially-limited surveys were carried out in the NPA in 1993 and 1998 (Duckworth *et al.* 1994, Boonratana 1998a). It is possible that the François'-group leaf monkey population is much larger than can yet be inferred, not least because Sayphou Xanghe has a c.40 km-long, several hundred meter-high, precipitous scarp that has not been surveyed. This being a linear feature, however, it could not support numbers comparable to those in Hin Namno and Phou Hinpoun NPAs.

Other areas

Village interviews across Lao PDR during 1988–1993 included François'-group leaf monkey as a species for discussion, and of the 24 areas in which they were undertaken (which did not include Hin Namno NPA), positive responses were received in only four (Duckworth *et al.* 1999: Annex 5): Nakai–Nam Theun and Nam Kading NPAs, where later field records have confirmed their presence; Phou Xang He NPA, corroborated as above; and Phou Khaokhoay NPA, where occurrence remains highly uncertain. Only two of 16 interview villages in and around Phou Khaokhoay NPA reported animals that the interview team took to be François'-group leaf monkeys. The NPA contains much rugged terrain, and given the relatively light survey effort there to date (Timmins and Duckworth 2008) it is quite plausible that François'-group leaf monkeys might indeed live there. There are also reports from local people of dark leaf monkeys from just north of their confirmed occurrence in a poorly-surveyed area with many limestone outcrops extending from north/east of the Nam (=River) Theun around Ban Lak-20 (=Ban Lak Xao; 18°11'N, 104°58'E) north to the Nam (=River) Mouan and east to the Lao–Vietnam border (Duckworth *et al.* 1999; Timmins and Robichaud 2005), including the Nam Theun Extension proposed NPA (Berkmüller *et al.* 1995b). This area is north of the Nam Theun, a river forming a biogeographic barrier for, for example, *Callosciurus* squirrels (Timmins and Duckworth 2008). D[ao] Van Tien (1989, p.502) stated that “rivers seem to be frequent natural barriers” for this group of monkeys, but gave no basis for this; an anonymous referee of the present text stated that it “was the Vietnam museum specimens documented by Brandon-Jones (1995) ... a totally inadequate basis for such generalization”. The available information (Table 4) is inconsistent between interviewees, but suggests there might be a François'-group leaf monkey in the area north of the Nam Theun and south of the Nam Mouan, with a white/grey pattern on the head ranging from a greyish forehead area to perhaps a *laotum*-like white facial surround, with white to or perhaps even beyond the ears.

There are also several, rather weak, suggestions of occurrence in Lao PDR's northern highlands. Davidson (1998)

received local reports in Phou Louey NPA which he felt perhaps referred to François'-group leaf monkey, from Ban Sakok (20°11'N, 103°13'E) and Ban Sopkhao (19°53'N, 103°14'E); both these villages are close to substantial forested limestone outcrops; however “these discussions about langurs were somewhat confused, and the team left being uncertain as to the reliability of the villagers' identifications” [this might have been better phrased as “... the reliability of their interpretations of the villagers' views”]. Hansel *et al.* (1998) presented some highly uncertain village reports perhaps of François'-group leaf monkey from Nam Xam NPA. Unfortunately neither source seems to have provided the name(s) used by villagers to refer to the monkeys in question. Reports were again received, in 2006, of animals fitting François'-group leaf monkey from Ban Sakok by Hamada *et al.* (2007). In Phou Dendin NPA in 2004–2005, WGR received reports in Ban Hathin (22°03'N 102°16'E), from three informants in their late 40s to early 60s (questioned together) that two types of leaf monkey (*khang*) inhabit the area (no karst is known in or around it), a dark one (*khang dam*) and a pale one (*khang khao*). The types were said to be about equally common, and always to be found in separate groups. Phayre's leaf monkey *Trachypithecus phayrei* has already been confirmed from this NPA (Evans *et al.* 2000); if the two forms represent different species, then François'-group leaf monkey is the most likely other candidate. Hamada *et al.* (2007) received reports of François'-group leaf monkey in Nam Ha NPA, but dismissed them as unreliable, although without any discussion as to why they should be any more particularly unreliable than all the other mass of interview information they presented. Phou Louey and Nam Xam NPAs have had substantial direct observation surveys, and Phou Dendin NPA has been visited briefly several times; but the lack of records of François'-group leaf monkey is not a strong indication of genuine absence from these areas, given the highly localized occurrence of these monkeys apparent in other hill forest NPAs, such as Nam Kading and Nakai–Nam Theun, and the generally greater hunting pressure in northern than in southern Lao PDR (see “Conservation Considerations”). Reports of dark-coated long-tailed monkeys living on rugged karst cannot, however, be assumed to be François'-group leaf monkeys: a group of Phayre's leaf monkeys was seen in such habitat (near the border of Nam Kading NPA) in April 1995 (Evans *et al.* 2000). And around Vangviang (18°55'N, 102°27'E), detailed questioning by S. Chounnavanh (with oversight by JWD) in 2009 found that long-tailed, non-macaque, monkeys (always called *khang*) lived around (or were recently extirpated from) the karst of 14 of 17 villages, but on detailed discussion were invariably described as gray (*si mok* and *si khi thao*; “fog-colored” and “wood-ash-colored” respectively), not black, in pelage, and thus are likely be Phayre's leaf monkeys.

In April 2010, a resident of Ban Phonsavat, Muang Sanakham, Vientiane province (18°17'N, 101°44'E), evidently very knowledgeable of the area's wildlife, swore that two sorts of *khang* lived in the area, which contains extensive

forested karst. They differed in color, one being *si mok* (fog-colored) and the other *si dam* (black or dark), kept separate company, and were certainly different “types” (= *sanit*). This is as suggestive as any of the Lao northern highland reports for a François’-group leaf monkey. However, on detailed discussion, the only other difference was said to be that the dark one had a longer tail. It was specifically said to live in the same habitats as, to have calls identical to, and to have identical face-markings to, with white only around the eyes and mouth, the fog-colored *khang*. Both were said to have been seen during the previous week’s survey (of non-karst areas) when he was village counterpart (but observing separately, much of the time) to JWD, who saw only typical Phayre’s leaf monkeys. The balance of probabilities, given how adamant the informant was concerning head-markings, is that both types refer to Phayre’s leaf monkeys.

Local Names

Assessing François’-group leaf monkey distribution and status in Lao PDR through local information requires extreme care. First, the adjective *dam*, usually translated as “black”, is not conclusive of François’-group leaf monkey rather than any congener because it means simply “dark”: potentially gray. Thus, H. Wright (pers. comm. 2010), an ornithologist asking on our behalf in Lao-speaking northern Cambodia about the colobines present there, heard about an animal called “taloung”, described through translation from Lao as “considerably larger than a long-tailed macaque, mostly black with a very long tail”. It is inconceivable that François’ leaf monkey would occur in these lowland, predominantly deciduous plains habitats; in southern present-day Lao PDR, “taloung” shows some linkage with silvered

Table 4. Names and appearance of village-reported monkeys in and around the Nam Kading catchment.

Village	Monkeys reported (focus on colobines)
North of the Nam Kading	
Ban Hinggunn (NE of Nam Kading NPA, north of Nam Theun, south of Nam Mouan)	”Ling khang”, macaque; “khang” (long tail – two types) one sounds like François’-group LM (black; only on cliffs) the other like Phayre’s LM (“sii mok” [= fog-coloured] with white lips)
Ban Nadi (NE of Nam Kading NPA, north of Nam Theun, south of Nam Mouan)	1st interview: “cung” (all black, on rock mountains); “cadung” (black, white crown and chin (jaw) and white ventral midline, on rock mountains); “khang” (sii mok in good forest, not really on rock mountains). 2nd interview (different villagers): “cadak” (fog-coloured, with white “chin”, on rock mountains); these villagers did not mention “cung” saying the only other long-tailed “monkey” was “cadung”.
Ban Paka (along Lak-20 limestone)	“Cung”, also sometimes called “cadung” (all of head including the crown white, face also white; body black).
Ban Tampung (along Lak-20 limestone)	“Cung”, also called “talung” (black with white face; another man said white face with whitish coming down and around the nape).
Ban Phon(sat) (along Lak-20 limestone)	“Cung” = “talung” (black, with black face and white around forehead and temples and going back to the ears).
Ban Mai-sivilai (along Lak-20 limestone)	“Cung” (black including the face with white forehead).
Ban Phong (along Lak-20 limestone)	“Cung” (all black apart from a white crown not extending down face or past the top of the ears); “ling khang”, macaque.
Ban Kokton (on Nam Mouan - north)	“Kang” (long tail, grey pelage, no mention of white lips)
Ban Phoupiang (on Nam Mouan - south)	“Kang” (all grey pelage, long tail.)
Ban Vangmagk (NE of Nam Kading NPA, north of Nam Theun, south of Nam Mouan)	In 1979 the interviewee shot a black colobine; he’d not seen such an animal before, but a friend told him that it was a “cadung”. Another interviewee saw a “cadung” shot by a friend in limestone close to Ban Lak-20 (Ban Tasala). Both these animals were described as black, but with dark greyish heads and a paler ashen-grey spot on the forehead. There was a consensus that there was a “langur” called “cadung” in other areas to the south, but few people had ever seen them.
Ban Supsai (NE of Nam Kading NPA, north of Nam Theun, south of Nam Mouan)	“Khang” (long-tailed, fog-coloured, limestone)
Ban Chomthong (on Nam Mouan)	“Khang” (big, long tail, all palish grey, on limestone); “khang”, a sort of “ling”, evidently macaque (tail 20 cm).
In range of <i>T. (f.) laotum</i>	
Ban Nakua-nai (SW of Nam Kading NPA, south of Nam Theun)	“Cung”, evidently François’-group LM
Ban Konglor (in middle of Phou Hinpoun NPA)	“Cung”, François’-group LM (black, black face, head all white, but: tail short!!!); “khang”, seems to be macaque.
Hin Namno NPA	
Ban Tasang	“Cung”, evidently François’-group LM (all black); “khang”, evidently macaque (tail 20 cm)
Ban Vangngnow	“Cung”, evidently François’-group LM (all black); “talung” (black, as “cung”; but without the pointed crest, and with white lower jaw and chin; pale area across chest; on sandstone mountains and escarpments); “khang”, macaque (lives in karst).
Ban Katok	“Cung”, evidently François’-group LM (all black); “ling khang”

LM = leaf monkey.

All information from RJT.

The focus of the undertaking was to investigate if François’-group leaf monkey lived north of the Nam Theun. Other colobines and, particularly, macaques were only discussed to the extent necessary to exclude given names from possible reference to François’-group leaf monkey.

No sightings of living monkeys were possible to validate any of these usages. Black and gray were determined by the interviewee pointing at something comparable in color. Use of c, k, and kh is as transcribed and implies nothing about the actual Lao consonant.

leaf monkey (see p. 71), and this is evidently the species under discussion here, notwithstanding the stated pelage color in translation. This ambiguity can be minimized by asking informants to point to a visible object of color comparable to the animal under discussion. Second, names vary in use for a given species across Lao PDR (see below; discussions concerning Tables 4–6). Third, a set of words used in monkey names is so similar-sounding that many listeners not fluent in Lao find significant confusion. Fourth, Lao has a unique alphabet and lacks a universal system of transliteration into the Roman alphabet, thus consultation of half-a-dozen documents mentioning a place name like Xaignabouli may find as many different spellings (as different as “Sayabury”), and whether a Roman spelling is “correct” has meaning only according to a specified base (such as the 1:100,000 maps taken here as the datum for place-names). Fifth, Lao is tonal (hampering representation of vowel sounds in non-tonal languages) with consonants and vowels that do not all equate directly to Roman letters. These transliteration difficulties would be irrelevant were animal names in village use noted in the Lao alphabet, but many outside surveyors use only the Roman. Finally, even transcription in the Lao alphabet is insufficient to prevent later ambiguity with words from the many ethnic minority languages in Lao PDR: and in much of the Lao range of these monkeys, the first language of many people is not Lao.

Of particular relevance to monkeys, Lao has three discrete consonants that sound similar, to many western ears, to Roman “k”. One (seen by some Lao-speaking westerners as closer to a Roman “g” sound) is an unaspirated voiceless velar stop; the other two are voiceless aspirated velar stops. Confusingly, these two distinct phonemes are not contrastive in English (i.e. “k” is used for both, as in “sky” and “king” respectively), but in Lao (which lacks the voiced velar stop, as in the first “g” of “gang”) the first is fairly consistently transcribed in the Roman alphabet as a “k” not followed by an “h”, the latter two as linked “kh”. This convention is not, however, known (or, therefore, used in field transcriptions) by all foreigners active in Lao, even for many years (such as, until this manuscript, JWD).

Preparation of this account revealed difficulties on this topic far greater than initially suspected, sufficient to hinder communication between wildlife surveyors not fluent in Lao (often unaware of difficulties beyond those of tone) and those few who are (who often read too much into the way a word has been transcribed by someone in the former group). For example, in March 2009 during discussions in the Vangviang area it was clear to JWD that two distinct forms of monkey existed locally, one of which he transcribed as “ling khang” (clearly, from the hunter’s morphological description, macaque *Macaca*) and the other as “khang” (a colobine). Despite several minutes of focus on these names (to see if

Table 5. Use of *ling kang* for macaques.

Location, year	Identification	Validation	Source	Notes
Nam Pouy NPA, 1997, 1999	Pig-tailed	Direct sighting	RB	
Vangviang, 2009	Stump-tailed?	Villager description	JWD & S. Chounnavanh	Karst
Nakai–Nam Theun NPA, 1998–2004	Pig-tailed	Direct sighting	RB	
West of the Nakai plateau, 1998	Pig-tailed	Direct sighting	RB	Multiple local observers
Phou Hinpoun NPA, 1998	Assamese?	Villager description**	Steinmetz 1998	Karst?
Muang Vilabouli, 2008	Assamese	Direct sighting*	JWD	Two well-separated villages; karst

* Name was not known to be *ling kang* as distinct from *ling khang* (but no wildlife surveyor fluent in Lao has ever heard the latter combination, and it may well not exist).

**Source presents name as *kang* (not as *ling kang*); it was transcribed thus in over 50 separate interviews, and never as *ling kang* (R. Steinmetz pers. comm. 2009).

In no case was exclusive linkage (at village or even individual person level) between the name and the species of macaque established.

See also Table 4.

Table 6. Local names used for François’-group leaf monkey in Lao PDR.

Location	Name used	Validation	Source	Notes
Nam Kading NPA, 1995	<i>khung</i>	Villager description of animals	RJT	Transcribed in Lao
Phou Hinpoun NPA, 1995, 1996	<i>khung</i> (or <i>kung</i>)*	Direct sighting and hearing	RJT	<i>laotum</i> -type animals
Hin Namno NPA, 1996	<i>khung</i> (or <i>kung</i>)*	Direct sighting and hearing	RJT	<i>ebenus</i> -type animals
Phou Hinpoun NPA, 1998	<i>khong</i>	Direct sighting	R. Steinmetz pers. comm.	White-headed animals (only?)
Phou Hinpoun NPA, 1998	<i>taloung</i>	Villager description of animals	R. Steinmetz pers. comm.	Black-headed animals (only?)
Muang Vilabouli, 2008	<i>khung</i>	Direct sighting	JWD	Three sites, many people; transcribed in Lao at one
Nakai–Nam Theun, 2008	<i>khong</i>	Direct sighting	WGR	Sek guide speaking Lao

Transliterations following the k/kh convention for initial consonant (see text) are in italics. Those transliterated “as heard” (without reference to this convention) are not italicized.

* Not distinguishable to observer at time of survey.

See also Table 4.

the vowel tone was the same) it never occurred to JWD that the two words had, in Lao terms, entirely different leading consonants. Discussions in the same area by S. Chounnavanh (native Lao speaker) in May 2009 proved that the two names were in fact *ling kang* and *khang*. JWD had simply spelled both as “khang” because he knew of a monkey-meaning word in Lao spelled thus, whereas WGR and RB inferred, until corrected by JWD, that the latter’s rendering meant specifically *khang* and not *kang*. A similar confusion beset the presentation in Evans *et al.* (1997) of a common Lao name for White-winged Duck *Cairina scutulata* as “pet khaa”; in fact it is generally, quite probably universally, *pet kaa*. The upshot of this is that a monkey name transliterated in Roman by a person of limited or unknown linguistic bent cannot necessarily be interpreted meaningfully back into Lao.

A focus on the genuine difficulties for people of varying nationalities and fluencies in Lao to transcribe unambiguously Lao names for wildlife risks overshadowing an even more important issue: that detailed investigation (multiple precise questions to multiple people in the area) invariably shows that specific morphological and ecological characters attributed to a named animal are inconsistent between interviewees, and that a given name can be applied to multiple discrete biological entities. Table 4 shows the results of RJT’s discussions in 1995 and 2005 with villagers in Bolikhamxai province north of the Nam Kading (also with some examples from areas of known François’-group leaf monkey range), to exemplify how intractable is this problem. These interviews were all conducted through Lao counterparts speaking good English and mostly with significant wildlife survey experience, and RJT spoke enough basic Lao to follow the general nature of the discussion; neither RJT nor the counterpart took note of any conventions for transcription of Lao into the Roman alphabet, and the Lao names are written here as they were transcribed in the field. Adding to the bewildering variety in Table 4 of monkey names beginning with consonants similar to Roman “k”, Steinmetz (1998) listed a couple more (for macaques) in nearby Khammouan: *khama* and *khameut*. How many of these names come from Lao and how many from ethnic minority languages was not recorded; this oversight is widespread, and severely hinders attempts to understand vernacular animal names in Lao PDR. *Kang* / *ling kang* (treated here as the same name) provide the particularly significant confusion risk of a macaque with a colobine (*khang*) using Lao language. *Kang*, in most areas with the *ling* prefix, is in wide use for macaques in Lao PDR over a wide geographical area, including the entire known latitudinal range of François’-group leaf monkey; it is not tied to a single species (Table 5). There is no evidence of *kang* being used for a colobine or of *khang* being used for a macaque, but this does not mean such usage does not occur. Considerable further work is necessary before even provisional records of François’-group leaf monkey would be defensible solely through deduction from a Lao name.

Mindful of the previous minefield, some general patterns of Lao-language colobine nomenclature can be proposed,

using the k/kh convention as described above. Although the Lao word *ling* is often translated as “monkey”, in fact all evidence suggests it means specifically macaque (or, in the combination *ling lom*, loris), never colobine. The latter have a series of unique names: *khadeng* means red-shanked douc *Pygathrix nemaeus* and seems to be a very tight linkage (Deuve’s [1972] assignment of *ling kha deng* to stump-tailed macaque *Macaca arctoides* seems not to have been corroborated in more recent times and was presumably an error; *kha deng* means “red leg”, but the Deuves misidentified the doucs in Lao PDR as black-shanked doucs *Pygathrix nigripes*). The names *khang* and *taloung* have several times been validated for *Trachypithecus* spp. (Deuve’s [1972] assignment of *taloung* and *loung* to douc has never recently been found, and is surely in error). *Khang* is used for gray *Trachypithecus* species widely in Lao PDR; areas where this has been validated, by direct observation of live animals, include Nam Pouy NPA (North Lao PDR west of the Mekong; RB) and Vientiane province (east of Mekong; JWD). The possibility remains that *khang* may be used, somewhere in Lao PDR, for François’-group leaf monkey, although there is as yet no firm evidence of this. Specifically, Deuve’s (1972) assignment of *khang* to François’-group leaf monkey, in the light of his other errors, is meaningless; moreover, as he knew of no Lao silvered leaf monkey records, and declared that the Lao had no name for Phayre’s leaf monkey *T. phayrei* because they did not know it existed, François’-group leaf monkey was the only *Trachypithecus* to which he could apply the name *khang*!

Across Khammouan province and in neighboring parts of Savannakhet and Bolikhamxai supporting the species, one or more word(s) distinct from *khang* seem(s) to predominate in local usage for François’-group leaf monkey, although validations, by direct sighting of the species simultaneous with local speech, are few (Table 6). The name, transliterated as *khung* (rhyming with “[tuk]-tuk”) or *khong* (rhyming with “[tele]phone”), is apparently an onomatopoeia of a commonly given loud call. Because the words heard were almost always transcribed into English, not Lao, it is unclear whether the *khong* / *khung* transliterations reflect genuinely different forms, or simply idiosyncrasies in listeners’ hearing. Our only two direct transcriptions into Lao, from the northern extent of the known Lao range (by RJT and K. Khounboline, Nam Kading NPA, April 1995; not validated to species by direct sighting, but village description clearly indicated François’-group leaf monkey) and the southern (by Bounhaem Xaikhongham at Ban Houayhong in January 2010) have the same spelling, which is pronounced *khung*, without hesitation, by both Lao (S. Chounnavanh) and non-native Lao-speakers (WGR).

RJT’s detail in Bolikhamxai province (Table 4) suggests that “khang”/“kang” (= *khang*?) is used for Phayre’s leaf monkey and perhaps François’-group leaf monkey where sighting the latter is not a regular occurrence; “cadung” is used for François’-group leaf monkey and/or Phayre’s leaf monkey north of the Nam Theun; “cung” (= *khung*) is used for François’-group leaf monkey both north and south of the Nam Theun, and perhaps might be used for Phayre’s to the

north; “talung” is used for Phayre’s to the south of Nakai–Nam Theun NPA [and, further in the south of Lao PDR for silvered leaf monkey], but north of this NPA it might be being used for François’-group leaf monkeys; and that “khang”/ “ling khang” (= [*ling*] *kang*?) is an amalgam of macaque species.

A fresh and significant further source of confusion is that the recently published first color-illustrated comprehensive guide to large mammals of Lao PDR (Parr 2008), receiving wide circulation, gave the names *khung* and *khong* as alternatives for silvered leaf monkey, and gave for François’ -group leaf monkeys only the name *khang*. It cannot be ruled out that these names might be appropriate somewhere in Lao PDR, but these are about the least helpful associations that could have been given for these names, and were evidently made with no primary deference to common usage in rural areas. Given the way that pictures and Lao name are typically used in rural interviews in Lao PDR (see p. 75, right column), this situation is sure to lead to erroneous records of silvered leaf monkeys actually relating to François’ -group leaf monkeys, and to bogus claims of François’ -group leaf monkeys, probably predominantly in the northern half of the country, based on Phayre’s leaf monkey.

Morphology

The animals observed in Nam Kading NPA were typical of *T. (f.) laotum*. Those in southern Phou Hinpoun fitted typical *T. (f.) ebenus*. There is no information on morphology in Phou Xang He NPA. The animals in Nakai–Nam Theun NPA and in Muang Vilabouli were not typical of any named form as presented in available literature such as Brandon-Jones (1995) and Francis (2008). The two named forms living closest by are *hatinhensis* and *ebenus* (see Timmins and Khounbolin 1996; Walston and Vinton 1999; Nadler *et al.* 2003). The former is conventionally seen as having a bold white facial stripe including moustache and white marks on the nape, the latter an all-black head (see, for example, Brandon-Jones 1995; Francis 2008). Moreover, Nadler *et al.* (2003) stated that *T. (f.) hatinhensis* shows a white moustache but *T. (f.) francoisi*, otherwise similar in head pattern, lacks one.

The camera-trapped Nakai–Nam Theun NPA animals show a facial pelage pattern consistent with *T. (f.) hatinhensis*, a neat white stripe across each cheek to over the ear; but all animals showing the back of the head lack extensive white on the nape (Fig. 2a), although some images show significant white extension behind the ear (Fig. 2b). Most animals on which the face can be seen seem to have a trace of a pale moustache (Fig. 2d), but a few seem not to (Fig. 2e); the feature is difficult to interpret from these photographs. T. Nadler (pers. comm. 2009) found, through observation of over 60 captive animals, all from Phong Nha–Ke Bang NP, and a number of close observations in that protected area, that *hatinhensis* is much more variable in head color and pattern than published information states. In sum, the white beards vary from thin and light gray, to wide and clear white; young to “nearly subadult” individuals (about three years old) can show a nearly white

forehead up to the crest, although most lose their pale forehead after one year; the white line behind the ear is variable in length (but in all examined so far extended well beyond the ears) and sometimes clear, bright, white but sometimes duller, gray-tinged; and the white moustache is very variable, sometimes there being only about a dozen white hairs amid the black ones. Superficially, these photographs also need careful distinction from *T. (f.) francoisi*, even though its occurrence at this locality is highly unlikely, given its documented range (northern Vietnam and adjacent China). Stevens *et al.* (2008) documented how *T. (f.) hatinhensis* habitually carries its tail differently from *T. (f.) delacouri* and stated that on casual observations *T. (f.) francoisi* resembled the latter in this feature. Two photographs of the same animal from Nakai–Nam Theun NPA (Figs 2a, 2c) show the tail in the “back concave up” position of *T. (f.) hatinhensis* and three other photographs strongly suggest this, although viewing angle is not optimal for assessment. The camera-trapped animals are clearly, therefore, not *T. (f.) francoisi*. The photographs of the Phou Ak animals show white on the sides of the face, but no napes or tail postures are visible, and no relevant information is available for the 1998–1999 or 6 April 2008 sightings. Nothing suggests that these animals differed in pelage or postural characters from the camera-trapped animals.

Animals in Vilabouli were different from conventional *T. (f.) hatinhensis*, *T. (f.) ebenus* and the Nakai–Nam Theun NPA animals. All three animals (two of adult size and one a youngster, about half adult length) observed at Phou Padan had the head (pelage and exposed skin) black except for a bright, well-demarcated, white line along the top of the pinna (the rest of the ear being black). Poorer views at Pha Tadang confirmed the bright white ear-top stripe on the only animal where the feature could be assessed. Similarly at Pha Kat, although the animals were at an even greater distance, some pale around the top of the ear and/or on the adjacent part of the head was visible. An animal seen in Hin Namno NPA in 1998 had a head pattern at least somewhat similar to these Vilabouli animals, although it was described as a “short, indistinct, narrow, horizontal white line on the tip of each ear, or on the sides of the head just above the ear” (Walston and Vinton 1999, p.25).

As well as white head stripes connecting the face stripes to the white nape pelage, *T. (f.) hatinhensis* typically has a white line also along the top of the pinna (T. Nadler pers. comm. 2008). In various forms of François’-group leaf monkeys, including the holotype (and then sole known specimen) of *T. (f.) ebenus*, Brandon-Jones (1995) documented on some specimens the presence of inconspicuous white or pale hair tracts on various parts of the head, although these would not be visible in the field (even during the close observation on Phou Padan). This indicates intra-taxon variability, and given the few specimens reported on in detail so far, the extent of such variation in each taxon is unclear. Age-related variation is a further complication: the *ebenus* at the Endangered Primate Rescue Center (born most probably in 1996) had a completely black head for its first decade, but in the last two years



2a



2b



2c



2d



2e

Figure 2. François'-group leaf monkeys camera-trapped in Nakai–Nam Theun National Protected Area, 29 March 2008. Note the absence of white on the nape in at least some animals (2a), but, on others, the presence of some white pelage behind the ear (2b); the way the tail is held (2a, 2c; the same animal, taken only seconds apart); the apparent white moustache (Fig. 2d), although this may be lacking on some (Fig. 2e); and the pale buttocks and pubic patch (Fig. 2e). Photographs by Nam Theun 2 Watershed Management & Protection Authority.

has shown an increasingly light grey color where *hatinhensis* has its pale beard (Nadler 2009; T. Nadler pers. comm. 2009). A *hatinhensis* at Korat Zoo, Thailand, fully grown but of otherwise unknown age, shows a similar feature (Nadler 2009).

The single animal with white ear-stripes seen in 1998 in Hin Namno NPA was responsible for the statement of animals in that NPA “tending towards [*T. (f.)*] *hatinhensis*, but most appeared black-headed” (Duckworth *et al.* 1999, p.177). In fact, all animals seen well enough to assess in the estimated six groups observed in two parts of the NPA by Timmins and Khounboline (1996) were entirely black-headed, as were all animals viewed similarly well in the eight other groups observed in several parts of the NPA by Walston and Vinton (1999). These, thus, fitted the holotype of *T. (f.) ebenus*. Various external sources (Nadler *et al.* 2003; Nadler 2009; Roos *et al.* 2007) have stated that *T. (f.) ebenus* overlaps with *T. (f.) hatinhensis* in Lao PDR, citing Ruggeri and Timmins (1997), which contains no statement to that effect, and Duckworth *et al.* (1999), which made the unfortunately vague, although explicitly non-conclusive, statement quoted above. The present review of evidence from Lao PDR provides no support to the suggestion that *T. (f.) ebenus* and *T. (f.) hatinhensis* overlap in range within the country, although survey effort has been inadequate to state that they do not. Nadler *et al.* (2003) traced only one explicit record of *ebenus* from Vietnam (they cautioned that many given as *T. (f.) hatinhensis* might better be considered unidentified): two observations of a one animal in Phong Nha–Ke Bang National Park. They made no explicit statement that *T. (f.) hatinhensis* was recorded in the same area. Another population of *T. (f.) ebenus* has subsequently been found in Vietnam, but there were no records of *T. (f.) hatinhensis* from the area (Le Khac Quyet 2004). It therefore seems questionable whether *T. (f.) hatinhensis* and *T. (f.) ebenus* really do overlap to any significant extent in Vietnam, either (Groves 2004).

Nadler *et al.* (2003) and the IUCN Red List (Le Xuan Canh *et al.* 2008) both subsumed *ebenus* within *hatinhensis*, seeing the former as a melanistic variant of the latter. Such a course leaves open how to name the black-headed animals in southern Phou Hinpoun NPA, which are remote from any animals resembling *T. (f.) hatinhensis*. There is no information on the geographic origin of the *T. (f.) ebenus* holotype and, therefore, at this stage, no objective reason to associate it more with populations close to those of *T. (f.) hatinhensis* (e.g. Hin Namno NPA) than with those close to *T. (f.) laotum*. That it has been done so reflects nothing more than that the first wild *T. (f.) ebenus* population found, in Hin Namno NPA, was geographically closer to *T. (f.) hatinhensis* than to *T. (f.) laotum*, and that the analyzed parts of the mitochondrial DNA of two specimens (themselves of unknown provenance) do not differ strongly from those of *T. (f.) hatinhensis* (Roos *et al.* 2007; Nadler 2009).

However these names will eventually be found to relate to real biological entities, the spatial separation of forms in Lao PDR indicates a pattern that cannot be dismissed as simple individual variation: in sum, in Nakai–Nam Theun NPA, all

animals documented had white face stripes, which are not known (except in *T. (f.) laotum*) from any other populations in Lao PDR; at least most animals in the surveyed parts of Hin Namno NPA and southern Phou Hinpoun NPA have all-black heads (including ears); and animals in Muang Vilabouli are black-headed except for a white pinna-stripe, with no evidence to suggest it is ever lacking there.

Another pelage feature noted on Lao animals in several areas is a neat white or whitish patch across the buttocks. This is shown by the only animal in the Nakai–Nam Theun NPA photographs (Fig. 2e) with a clean rump view, although the harsh lighting prevents determination of exactly how pale it is. All three animals observed at Phou Padan (Muang Vilabouli) had a bold, well-demarcated, bright white patch in this position, extending right to the insertion of the tail. Because it was usually hidden by the animals’ posture, it was a deal more difficult to see in the field than was the white ear-stripe. This same feature has been noted on animals elsewhere in Lao PDR. During a sighting of a group of 10–11 *T. (f.) ebenus* in Hin Namno NPA (1996), the anal area of two animals was seen clearly and was whitish (RJT). In two sightings of *T. (f.) laotum* in Phou Hinpoun NPA in 1996, two from one group (the other animals of which were not seen well) and several in the other group were noted to have “white patches in anal area”; in a third well-observed group (in this NPA in 1995), of at least eight, one animal showed “a white round patch in anal region” as it walked away in a view similar to that of the animal in Fig. 2b, but at least some others in the group did not show such a patch (RJT). RJT also observed two *T. (f.) hatinhensis* in the field in Phong Nha–Ke Bang National Park, Vietnam, in 1998, and noted that one had a “large white bare anogenital patch”. The buttock patch is clearly distinguishable in Fig. 2e from the adjoining pale pubic patch. These pale patches occur, variably in extent and brightness, in females of all known forms of François’-group leaf monkeys; they have no taxonomic value (e.g., Groves 2001; T. Nadler pers. comm. 2009).

Distribution and Habitat Use

These field records confirm the presence of François’-group leaf monkeys in a rather small portion of Lao PDR. North of this area, there are extensive karsts scattered across Vientiane, Xiangkhouang, Louangphabang and Houaphan provinces; these (including the former unit of the Xaisomboun Special Zone, now reabsorbed by neighboring provinces) have barely been surveyed (see Timmins and Duckworth 1999, Fig. 1 for survey areas). François’-group leaf monkeys may thus have a more extensive Lao range to the north than is yet known, and the interview-derived suggestions from Phou Dendin, Phou Louey and Nam Xam NPAs might be corroborated. Earlier, Deuve (1972) also speculated that François’-group leaf monkey (specifying *T. (f.) delacouri*) might be found to inhabit the northern highlands, in the karsts of Xiangkhouang and Sam-Nua (=Houaphan) provinces; these remain almost unsurveyed. East of Lao PDR, the

various forms of François'-group leaf monkey extend from a known southern limit in Vietnam rather similar to that known in Lao PDR, north right through Vietnam into China (Nadler *et al.* 2003; Nguyen Manh Ha 2006). It is thus entirely plausible that they inhabit Lao PDR's northern highlands. Groves (2004, p.20) wrote that "the distribution of [François'-group leaf monkey] does not reach south of 17°N." These records push it slightly below, to 16°58'N (probably to *c.*16°49'N), and this may be the real limit in Lao PDR: south of the known Lao range, large blocks of karst do not exist and other forms of rugged terrain are more limited. Surveying has been more intense in this southern area than in the northern highlands and there has been no suspected occurrence of François'-group leaf monkeys. A claim in Vietnam from well to the south (14°33'N, 108°35'E), from Kon Cha Rang (Lippold and Vu Ngoc Thanh 1995), was published without any indication of what was actually seen, and was rejected by Nadler *et al.* (2003).

Clarifying the Lao range of each taxon requires understanding taxonomic variation within the complex. This will be complicated: it requires detailed observation of pelage supported by, preferably, genetic analysis of animals in as many areas as possible. Information from areas where two forms occur in close proximity or even overlap is particularly valuable.

These monkeys are often believed to be strongly associated with karst limestone. For example, Groves (2004, p.18), remarking on the lack of a handy, non-cumbersome, name for François'-group leaf monkeys, urged use of the term "limestone langurs" for them, but this does not seem to be particularly apt for Lao PDR: all records in and around Nam Kading and Nakai-Nam Theun NPAs are from non-calcareous formations, which they also inhabit in Muang Vilabouli. There are, however, no records known from any Lao site which is remote (more than 25 km) from a massive karst landscape.

Nadler *et al.* (2003) speculated that the association with karst reflected the thermal benefits of sleeping within caves, and that in warmer areas the animals would not need these benefits, and so might be less tied to karst areas. The present set of records, coming from the southern part of the global distribution of François'-group leaf monkeys, and at generally fairly low altitudes, are consistent with this suggestion. However, non-karst rugged terrain is not bereft of caves, and on at least Phou Padan the monkeys sleep in a non-calcareous cave. Furthermore, other monkeys occur in northern Indochina without needing caves to sleep in, and there is no obvious reason why François'-group leaf monkey would be more thermally challenged than the other species. Even in the far north of the complex's range, Li and Rogers (2005) questioned that limestone karst was an obligate habitat of these monkeys, rather than just overwhelmingly the most likely place for them to survive heavy hunting in a landscape of widespread forest conversion. This latter suggestion could not, however, apply in Central Lao PDR, where forest is much more extensive: here, there were many dozens of direct field encounters with monkeys during wildlife surveys in the

1990s (Timmins and Duckworth 1999, for red-shanked douc; not published in detail for the other species), spread across gentle and steep terrain; but François'-group leaf monkey was found only in areas with cliffs. This comparison with the other monkeys, which were often found far from such landforms, suggests strongly that the association of François'-group leaf monkey with precipitous landforms occurs irrespective of human activity and is not a facultative result of heavy habitat conversion and hunting.

All these records come from areas with extensive forest on or adjacent to the rugged terrain on which the monkeys were seen. On and around Phou Padan, the forest has been very heavily logged, with only a few groves of mature trees remaining. Several of the karst sightings were of monkeys foraging and resting on bare rock with scattered, often pachycaulous and/or deciduous, woody shrubs and small trees, while on thin-soiled non-calcareous slopes they were seen amid well-developed grass and herb swards. While it is clear that tall forests are much used, the extent of reliance upon such forest, if any, in Lao PDR is unclear. Because both timber and primates are harvested when people enter areas, the ease of human access is a major determinant of the status of both, and an absence of leaf monkeys from areas where forest has been cleared or degraded does not imply they could not persist in such habitat in the absence of hunting.

Conservation Considerations

Karst areas are difficult of access and the large ones are unlikely to be subject to wholesale habitat conversion, although small outcrops may be demolished as raw material for cement. Several low-level flights over much of the karst in Central Lao PDR (including Phou Hinpoun, but not Hin Namno, NPA) between 10 November 2008 and 8 July 2009 showed that many and large areas of reasonably tall forest remain in the karst landscapes. Much such forest has been lost around karst-bases, and species composition and structure has probably changed significantly even in many internal areas, particularly pockets where soil is suitable for agriculture. The sort of rugged non-calcareous areas used by the species are also ill-suited to agriculture on any but the smallest scale.

Hunting is therefore likely to determine the mid-term, and probably long-term, future of François'-group leaf monkey in Lao PDR. In Muang Vilabouli in 2008, individuals were readily observed on karst cliffs from the adjacent plains, where they seemed oblivious to noisy people moving around below (as did Assamese macaques *Macaca assamensis*). Those at Phou Padan were observed at a sleeping cave, known to local hunters. The observer intended to conceal himself in a bush; but the monkeys' arrival betimes (at 16:00) meant that they saw him, and responded with alarm calls (well-spaced, very loud, growling, wet-lip-smacking *hEEYY-hOOOORGHN* notes, sometimes with an extra terminal half-syllable sounding like *schll*) and by hiding in a rock fold, but only for 20 minutes. They then emerged, sat around and occasionally ate leaves of various unidentified species (and the flower

heads of the exotic composite *Chromolaena odorata*) for over 90 minutes, viewed from a distance of only *c.* 50–60 m. That they did not flee corroborates village reports that hunting at these caves is very rare. At nightfall they were still outside the cave and it is unclear if they entered it. It is typical for François'-group leaf monkeys to rest in the vicinity of the cave mouth for a protracted period before entering (Huang Chengming *et al.* 2004; Nguyen Manh Ha 2006). Similarly, the progress towards a presumed sleeping cave an hour before dusk at Pha Kat, and its location low down (and quite plausibly accessible from the plains) contrasts with François'-group leaf monkey behavior in Phong Nha-Ke Bang National Park, Vietnam, where heavy hunting has forced them to arrive at and leave the caves under cover of darkness (Timmins *et al.* 1999); Nadler (1997) reported the same for heavily hunted Delacour's leaf monkeys *T. (f.) delacouri*.

Villagers in November–December 2008 reported that *khung* used to be common on Pha Lom, Muang Vilabouli (16°58'N, 105°48'E) and adjacent karst outcrops, which lie fairly close to, but west of, the sites in Phou Xang He NPA and in Muang Vilabouli; one informant said that it had been hunted out about a decade previously, while the others (as a group) believed that a few *khung* held on. The several days spent on Pha Lom (mainly for bird survey) by observers familiar with these monkeys' calls suggests that at most only a very few leaf monkeys remain (by contrast, Assamese macaques were seen and heard there near-daily). Reports apparently of François'-group leaf monkey were also received around here by Duckworth *et al.* (1994) in 1993, when two-person days on Pha Lom also failed to find any. Pha Lom is likely to typify small karsts in heavily settled areas, with François'-group leaf monkeys extirpated or nearly so. The larger and more remote karsts retain larger numbers of François'-group leaf monkeys, which at least sometimes are readily observed: villagers in eastern Vilabouli reported that they did not hunt them because it was difficult to retrieve the shot bodies from within the rugged terrain. However, this situation cannot be assumed to last, because some taxa in Vietnam (particularly *T. (f.) poliocephalus* and *T. (f.) delacouri*) have been devastated by directed hunting for the Vietnamese and Chinese markets (see, for example, Timmins *et al.* 1999; Nadler and Ha Thang Long 2000; Nadler *et al.* 2003; Nadler 2004; Nadler and Streicher 2004; Stenke and Chu Xuan Canh 2004; Nguyen Manh Ha 2006), as they have in China (Li *et al.* 2007). Lao PDR is already a major source country for wildlife markets in these two countries (for example, Nooren and Claridge 2001), and *T. (f.) laotum*, endemic to Lao PDR, has been confiscated in trade in Vietnam (Nadler 1996; Dang Huy Huynh 2004). Recent major expansion and upgrading of roads within these monkeys' known Lao range, especially in Muang Vilabouli and in Khammouan province, and across to Vietnam, and the massive rise in the number of vehicles in these areas, as in Lao PDR as a whole, has made many places much more accessible, and wildlife trade an add-on economic possibility to many more people, than in previous years. Animals and plants that were formerly not economically worth bulk

collection may now, or soon, be so (see, for example, Wilkie *et al.* 2000). These leaf monkeys are at high risk of mid-term hunting-driven local extirpation, pending effective controls on trade-driven hunting.

The global significance of Lao populations of the various forms is very high. *Trachypithecus (f.) laotum* is endemic to the country, while *T. (f.) hatinhensis* and *T. (f.) ebenus* are severely imperiled in Vietnam, being known from few locations, perhaps only one of which, Phong Nha-Ke Bang National Park (Nguyen Manh Ha 2006), is a protected area.

The declaration of Lao PDR's impressive system of national protected areas is not yet matched by effective systems and sufficient resources to manage them, and currently the best protection for quarry animals in the country is that afforded by inhabiting remote, rugged, areas (Timmins and Duckworth 1999). Mindful of this, the huge karst-dominated NPAs of Phou Hinpoun and Hin Namno are surely the areas of overwhelming conservation importance to *T. (f.) laotum* and *T. (f.) ebenus* respectively, and the former also supports *T. (f.) ebenus* in its southernmost part (Timmins and Khounboline 1996; Walston and Vinton 1999; Nadler 2009; Steinmetz *et al.* in press). Nakai-Nam Theun NPA and Muang Vilabouli support smaller populations but are also important (precisely how much so remains unclear, pending taxonomic clarification) because their animals differ morphologically from those of the two main areas.

As yet undescribed taxa, if they exist at all, are most likely to inhabit the un- and poorly surveyed areas north of Nam Kading and Nakai-Nam Theun NPAs, and perhaps the northern highlands of Lao PDR. Compared with the South and Center of the country, in the North generally forest is more disrupted and hunting levels are higher, so many hunted species are more heavily depleted there (Duckworth *et al.* 1999; Timmins and Duckworth 2008). Of specific relevance to these monkeys, in the North agricultural conversion within karst is more prevalent, and karsts are generally smaller and less well connected. Therefore, localized extinctions, if these monkeys occur at all, are likely to be much advanced over the situation in the known Lao range, and reconnaissance surveys for these monkeys in these areas are of urgent priority. The strongly suggestive results from fairly extensive interviewing for these monkeys north of the Nam Theun in Bolikhamxai province in the mid-1990s by RJT and colleagues means that the priority there is field surveys of the larger, most rugged, karsts (especially the Sayphou Loyang and Nadi Limestone areas), in particular using local knowledge to find sleeping sites.

The general congruence of areas where well-executed village interviews and subsequent field surveys found these monkeys in Central Lao PDR, coupled with the monkeys' often localized distribution, suggests that surveys in poorly known regions should start with extensive interviews around areas topographically most likely to support them. Given the complexities of similar-sounding words in use for various monkeys, such surveys cannot take a "dictionary" approach to names heard from villagers, but must assign identifications based only upon how the animals are described, irrespective

of what they are called locally. Pictures of animals should not be shown until late in an interview (if at all), that is, once the number of named forms in the basic group under discussion has been established together with the particular local name, morphology, distinguishing characters, local distribution and abundance, and the interviewer's hypothesized zoological identification, of each. If pictures are introduced early on, firstly, it is difficult to determine, within what is said by the informants, what was previously known or believed by them, versus what is being drawn subconsciously or deliberately from the picture; and secondly, the range of pictures used defines unintentionally to the interviewees the animals of interest to discussion. Such circumscription is highly undesirable when novel forms may be present (as here): the most dramatic example of this is that numerous picture-based interviews in the Lao range of saola *Pseudoryx nghetinhensis* failed to reveal the presence of this animal in the years immediately before it was discovered in Vietnam in 1992 (Vu Van Dung *et al.* 1993), whereas verbal discussions using such topics as "please name and describe each species of large animal living round here" would certainly stimulated mention of this remarkably distinctive animal. It is quite possible that, if there are François'-group leaf monkeys in Lao PDR's northern highlands, they will be known by one or more Lao or minority-language names different from any yet recorded, so they cannot predictably be picked up by interviews asking whether each of a list of named (Lao name) species lives in the area.

It is generally impossible to determine the precise morphology of François'-group leaf monkeys from village reports (Table 4), and thus in each discrete area where such monkeys are convincingly reported, it will be necessary to see them directly, well enough to determine the exact distribution of white or grey pelage, if any, on them. Priority areas for these interview surveys include the massifs of Louangphabang province and karst in eastern Houaphan province; massifs of the Vangviang–Kasi area (Vientiane province) are a lower priority given the strong suggestion that karst-living leaf monkeys there, at least in the southern part, are not a form of François'-group leaf monkey.

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Status and Conservation of Golden Langur in Chakrashila Wildlife Sanctuary, Assam, India

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Abstract: The golden langur, *Trachypithecus geei*, is an endangered species endemic to India and Bhutan. Its distribution is limited to a small forest belt in western Assam in Northeast India and Bhutan, between the River Manas in the east, River Sankosh in the west and the Brahmaputra in the south. Chakrashila Wildlife Sanctuary straddling Kokrajhar and Dhubri districts of Assam is the only protected habitat for the golden langur in India. From December 2006 to January 2007, we carried out the first survey of the golden langur in the sanctuary. Data were collected using line transects and total counts. We counted 474 individuals in 64 troops in and around the sanctuary through direct sightings. Group size ranged from 3 to 15 individuals, with a mean size of 7.4. The adult sex ratio was 1:1.53, and the ratio of adult females to infants was 1:0.617. The age structure of the population counted comprised 49.8% adults, 33.5% juveniles and 16.7% infants. Domestic dogs (*Canis familiaris*) and illegal felling were found to be the major threats for golden langur in this protected habitat. We hope that this report will help guide future conservation efforts for the golden langur and for the management of the Chakrashila Wildlife Sanctuary.

Key words: Golden langur, endangered species, conservation status, Chakrashila Wildlife Sanctuary, India

Introduction

The golden langur (*Trachypithecus geei*) is endemic to a limited area of western Assam in India and a neighboring part of Bhutan. The distribution of this endangered species lies north of the Brahmaputra River, bounded on the east by Manas River, and on the west by the Sankosh River. The range in south-central Bhutan is between the Sankosh River and a high mountain ridge (running across Pele-la) in the west, and Manas River, Mangde Chu and the high mountain ridge west of Chamkhar Chu in the east (Choudhury 2008). There have been a number of studies that have examined the distributional limits and the population status of the species in India and Bhutan (Gee 1961; Khajuria 1956, 1961; Wayne 1968; Mukherjee and Saha 1974; Mukherjee 1978, 1994, 1995; Mukherjee *et al.* 1992, 1997; Mukherjee and Southwick 1997; Subba 1989; Choudhury 1992, 2008; Wangchuk 1995; Mohnot 1995–2001; Mohnot 2002). Srivastava *et al.* (2001b) estimated a population of 1,500 in India. There are reports on population dynamics of the species from different forest fragments (Srivastava *et al.* 2001a; Choudhury 2002; Medhi *et al.* 2004; Biswas 2004).

The golden langur occurs in three protected areas in Bhutan: the Jigme Singye Wangchuk (Black Mountains) National Park (173,000 ha), Royal Manas National Park (103,300 ha) and the Phibsoo National Wildlife Sanctuary (26,600 ha). In India, the golden langur receives the highest legal protection as a Schedule-I species in the Indian Wildlife Protection Act (1972), yet nearly all of the areas where it is still found lie outside the protected area network. Chakrashila Wildlife Sanctuary in the districts of Kokrajhar and Dhubri is the only protected habitat for golden langur in the country. Datta (1998) it was who first reported the occurrence of golden langur in Chakrashila Wildlife Sanctuary, and a few studies on the ecology and behavior of the species have already been conducted there (Mukherjee 1996; Chetry 2002a; Chetry *et al.* 2002a). Chetry *et al.* (2005) also carried out an education and awareness program for the conservation of the golden langur in the vicinity of the sanctuary. There was no systematic attempt, however, to examine the population status of the species in the sanctuary even after 11 years of its declaration as a protected area specifically for the golden langur.

Rapid loss of habitat and habitat fragmentation are the major threats for the golden langur in India (Srivastava

2001b; Choudhury 2002). Chetry (2002b; Chetry *et al.* 2002b) reported substantial anthropogenic pressure in and around Chakrashila and, with this in mind, we decided to carry out a study to assess the status of the golden langur population in this protected habitat. Here we provide an estimate of the size (number of individuals and groups, and average group size) and composition of the golden langur population in the Chakrashila Wildlife Sanctuary.

Methods

Chakrashila Wildlife Sanctuary

Chakrashila Wildlife Sanctuary (26°15'–26°26'N, 90°15'–90°20'E; 4,500 ha) is in the districts of Kokrajhar and Dhubri in Assam. The sanctuary, in the southernmost part of the range of the species, is the only protected area for the golden langur in India. The hilly terrain is covered with dense forest which is mostly semi-evergreen and moist deciduous, with patches of grassland and scattered bushes (scrubland). The forest type falls in the category 3C/C.1.a(ii) following Champion and Seth (1968). The communities living around the sanctuary belong to various ethnic groups, including Bodo, Rabha, Garo, Rajbanshi, Nepali and Muslims.

Survey

The survey was carried out from December 2006 to January 2007, and data were collected using both direct and indirect methods. A modification of the line transect method (Burnham *et al.* 1980; NRC 1981; Struhsaker 1997) was used, depending upon the habitat and the forest condition. Twelve transects totaling 120 km were set up in a stratified random

manner to cover all representative areas of the wildlife sanctuary (Mueller-Dombois *et al.* 1974; Kent *et al.* 1994). Three people walked the existing forest trails (and occasionally off the trails), covering an average of 10 km per day. Transects were initiated at 06:00 and terminated in the evening (16:30). The observers walked slowly through the transect pausing regularly, at least every 500 m. On sighting the golden langur, the global positioning system (GPS) co-ordinates, altitude, group structure and, when possible, age, sex and number of individuals were recorded.

At 500-m intervals and at each location where golden langur were encountered, the observers estimated the tree height, canopy cover, ground cover, dominant tree species, and shrub and herb species in a 10-m radius. Observers also took notes *ad libitum* on any evidence for, and degree of, grazing and logging in the study area.

We recorded indirect evidence for the presence of primates, such as grunts, branch shaking, and sounds associated with locomotion and feeding. All such indications were used to trace the animals and we stopped for about 10 minutes to collect the details. Secondary information was also gathered by talking with the local people in the vicinity of the sanctuary.

Results

Population of golden langurs

In all, direct sightings during the survey resulted in an estimate 474 individuals in 64 groups. The average group size ranged from 3 to 15 individuals, with a mean of 7.40. These 64 troops were recorded from both peripheral and

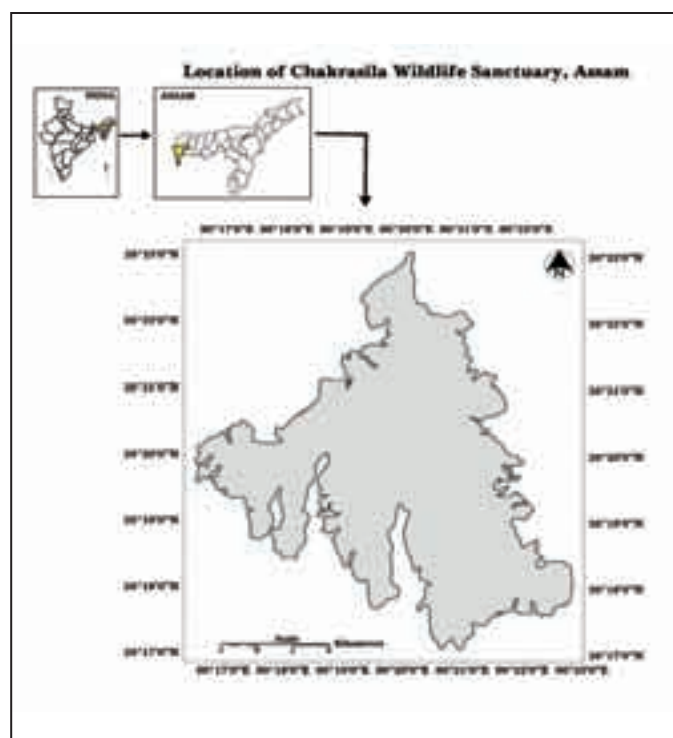


Figure 1. The Chakrashila Wildlife Sanctuary, Assam.

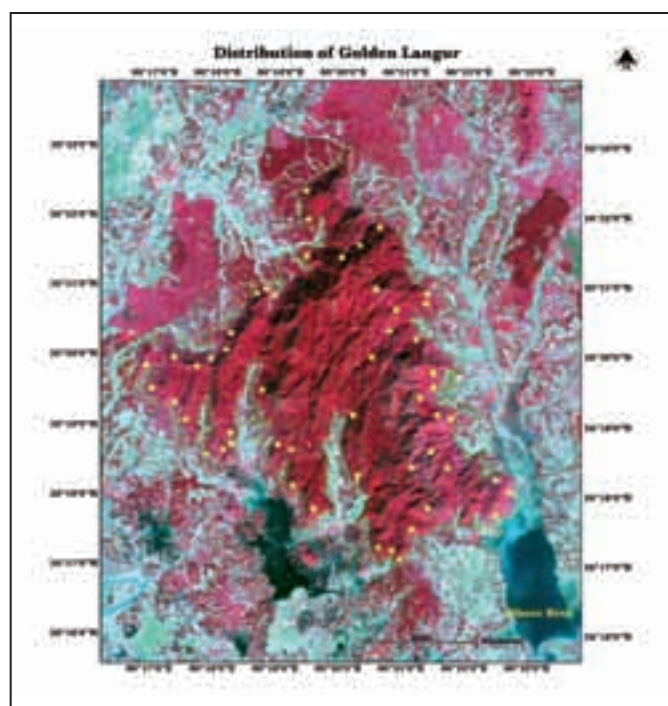


Figure 2. The Chakrashila Wildlife Sanctuary, Assam, showing the locations of the 64 golden langur groups recorded in this survey.

core areas of the sanctuary. Groups were located at altitudes of 34 m to 417 m above sea level. Table 1 gives the locations of the golden langur troops in the Chakrashila Wildlife Sanctuary.

Population structure and group composition

We counted the numbers of all troops and individuals we saw, and also analyzed the age–sex composition of the groups. Of the 474 individuals, 236 were adults, 159 were juveniles and the rest (79) were infants (Table 2). Thus, 49.78% were adults, 33.54% were juveniles and 16.66% were infants. The demographic records further revealed that the adult sex ratio was 1:1.53 (Table 3). Of the 64 groups, most (43) were single male/multi-female, while 19 groups had two-male/multi-female social structures. Only two all male groups were seen during the survey period. The population density in the sanctuary was estimated at 65.83/km².

Sympatric primates and other mammals

Two other primates were recorded in the Chakrashila Wildlife Sanctuary: rhesus macaque (*Macaca mulatta*) and slow loris (*Nycticebus bengalensis*). Other mammal species include tiger (*Panthera tigris*), leopard (*Panthera pardus*), clouded leopard (*Neofelis nebulosa*), wild pig (*Sus scrofa*), barking deer (*Muntiacus muntjak*), sambar (*Cervus unicolor*), and pangolin (*Manis pentadactyla*).

Threats

Dogs kill the langurs particularly in the fringe areas of the sanctuary. We recorded seven incidences during one year (2005–2006) of golden langurs being killed by dogs in the nearby villages; of these, two of the victims were adult females and five were juveniles. General forms of exploitation and disturbance of the forest were also found to be a threat to the langurs in the sanctuary. They included illegal logging, the collection of firewood and non-timber forest products, and grazing. Although not evaluated systematically, interviews and qualitative observations during the study indicated that the golden langurs were not hunted.

Discussion

Our results indicate that the Chakrashila Wildlife Sanctuary is an important stronghold for the endangered golden langur in the western-southernmost part of its range in India. The Chakrashila population is one of the largest in the country, and the current age structure indicates that it is a healthy and growing population. The population density is high when compared to other localities (Srivastava *et al.* 2001b), and the single-male/multi-female group which is predominant in Chakrashila is the most stable social system for golden langur (Biswas 2004). Ghosh (2009) also counted 501 individuals in 66 groups in Chakrashila Wildlife Sanctuary and its adjacent areas.

An important measure for its conservation in the sanctuary will be to stop the ongoing illegal felling of trees and

the encroachment. The golden langurs in the forest at Nayakgaon were evidently part of a single population with those in Chakrashila (Srivastava *et al.* 2001a; Medhi *et al.* 2004), but the connection has been lost. The current high density of golden langur in the sanctuary may result from lack of opportunities for dispersal, a threat over the mid-term (Choudhury 2002; Biswas 2004). In this context, we recommend that efforts should be made to restore the lost continuity between the sanctuary and other isolated forest pockets, planting natural corridors using bamboo species along with other preferred food plant species of golden langur. Bamboo is recommended not only because it grows fast, but golden langurs also eat the stem cortex of growing bamboo shoots and it provides the thick canopy which the langur uses to hide from predators. There are a number of native bamboos which are intricately associated with the traditional life styles of local people, so local communities can benefit not only from being involved in planting the corridor, but also in promoting the availability of non-timber products of interest to them.

The absence of hunting pressure is positive and probably one of the reasons that the area still has a high density of the species, despite habitat degradation and other human pressures. The concentration of langurs mostly in the periphery of the sanctuary however, may be an indication of potentially high predator pressure in the core area. All the incidences of killing of golden langur by domestic dogs recorded during the study need special attention. Chetry *et al.* (2005) also identified dogs as a threat to the golden langur. Illegal felling still continues in the area, with a significant ongoing loss of canopy cover as a result. Overall the conservation of the golden langur in and around the Chakrashila Wildlife Sanctuary requires a landscape approach. An integrated management program of forest fragments taking golden langur as a flagship species will also ensure the conservation of other wildlife in this part of Assam.

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Table 1. Sightings of golden langur, *Trachypithecus geei*, in the Chakrashila Wildlife Sanctuary, Assam, India.

	GPS locations	Locality	Alt. m	No. Indiv.
1	26°16'975"N 90°20'820"E	Jornagra L.P.School	44	10
2	26°17'927"N 90°21'820"E	Bada Manush kata	169	8
3	26°18'153"N 90°21'267"E	Bada Manush kata	273	7
4	26°18'208"N 90°21'106"E	Bada Manush kata	262	3
5	26°18'327"N 90°20'905"E	Bada Manush kata	172	6
6	26°17'429"N 90°20'622"E	Bada Manush kata	105	5
7	26°17'377"N 90°20'510"E	Bada Manush kata	99	5
8	26°17'511"N 90°20'506"E	Bada Manush kata	95	5
9	26°17'779"N 90°20'491"E	Bada Manush kata	102	6
10	26°17'761"N 90°20'451"E	Bada Manush kata	84	3
11	26°18'039"N 90°20'435"E	Bada Manush kata	34	7
12	26°18'137"N 90°20'482"E	Bada Manush kata	37	15
13	26°17'883"N 90°20'851"E	Bada Manush kata	173	3
14	26°17'741"N 90°20'836"E	Bada Manush kata	176	8
15	26°17'330"N 90°20'842"E	Bada Manush kata	72	9
16	26°16'921"N 90°20'693"E	Bada Manush kata	46	7
17	26°18'397"N 90°21'857"E	Chakrashila village	144	9
18	26°18'053"N 90°21'340"E	Chakrashila village	290	5
19	26°17'869"N 90°21'298"E	Chakrashila village	200	10
20	26°17'645"N 90°21'381"E	Chakrashila village	88	7
21	26°18'267"N 90°20'416"E	Salbari Naribhuri	116	9
22	26°18'482"N 90°20'453"E	Salbari Naribhuri	105	11
23	26°18'770"N 90°20'483"E	Salbari Naribhuri	98	4
24	26°18'596"N 90°20'319"E	Salbari Naribhuri	203	11
25	26°18'300"N 90°20'352"E	Salbari Naribhuri	114	8
26	26°18'319"N 90°20'149"E	Abhaykuti PHE	62	6
27	26°18'809"N 90°20'092"E	Abhaykuti PHE	114	7
28	26°19'299"N 90°20'216"E	Abhaykuti PHE	75	9
29	26°19'293"N 90°20'137"E	Abhaykuti PHE	93	9
30	26°18'935"N 90°19'949"E	Abhaykuti PHE	53	12
31	26°18'976"N 90°19'627"E	Jainpur	129	12
32	26°19'258"N 90°19'671"E	Jainpur	143	9

	GPS locations	Locality	Alt. m	No. Indiv.
33	26°19'567"N 90°19'752"E	Jainpur	162	8
34	26°19'682"N 90°19'870"E	Jainpur	218	10
35	26°19'440"N 90°19'923"E	Jainpur	206	3
36	26°18'061"N 90°19'586"E	Bor Bamuni	93	11
37	26°18'431"N 90°19'532"E	Bor Bamuni	51	7
38	26°18'811"N 90°19'492"E	Bor Bamuni	80	3
39	26°18'623"N 90°19'394"E	Bor Bamuni	128	5
40	26°18'412"N 90°19'229"E	Bor Bamuni	129	13
41	26°20'883"N 90°18'680"E	Korwari	105	7
42	26°21'742"N 90°18'935"E	Nalbari	50	7
43	26°21'493"N 90°19'543"E	Goyjora	100	6
44	26°21'373"N 90°19'717"E	Goyjora	211	4
45	26°21'188"N 90°19'784"E	Goyjora	254	11°
46	26°20'913"N 90°19'764"E	Goyjora	417	7
47	26°20'857"N 90°19'606"E	Goyjora	356	6
48	26°20'834"N 90°19'468"E	Goyjora	324	9
49	26°20'792"N 90°19'332"E	Kumertol	299	9
50	26°20'420"N 90°19'274"E	Rajapahar	316	5
51	26°20'515"N 90°19'225"E	Rajapahar	320	15
52	26°21'920"N 90°19'640"E	Nalbari	56	4
53	26°22'109"N 90°19'812"E	Nalbari	90	7
54	26°23'131"N 90°19'602"E	Kowari	98	12
55	26°20'414"N 90°18'659"E	Kowari	90	6
56	26°20'204"N 90°18'585"E	Kowari	89	6
57	26°20'140"N 90°18'450"E	Kowari	105	5
58	26°20'100"N 90°18'235"E	Kowari	187	7
59	26°20'020"N 90°18'117"E	Kowari	191	7
60	26°21'859"N 90°18'211"E	Belguri	49	7
61	26°21'805"N 90°18'208"E	Belguri	57	3
62	26°21'877"N 90°18'273"E	Belguri	53	5
63	26°22'526"N 90°20'039"E	Kakrikhola	61	5
64	26°22'808"N 90°19'974"E	Kakrikhola	51	9

Table 2. Age and sex composition of 64 golden langur groups, *Trachypithecus geei*, in the Chakrashila Wildlife Sanctuary, Assam, India.

Adult male	Adult female	Adult unidentified	Total adults	Juvenile male	Juvenile female	Juvenile unidentified	Total juveniles	Infant male	Infant female	Infant unidentified	Total infants	Total
85	127	24	236	7	25	127	159	0	1	78	79	474

Table 3. Age category and sex ratios in golden langur, *Trachypithecus geei*, in the Chakrashila Wildlife Sanctuary, Assam, India.

No. of groups	Adult Male:Adult Female	Adult Female: Immature	Adult: Immature	Adult Female: Infant
64	85:127(1:1.53)	127: 159(1:1.86)	236:238(1:1.017)	127:79(1:0.617)

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Status and Distribution of the Eastern Hoolock Gibbon (*Hoolock leuconedys*) in Mehao Wildlife Sanctuary, Arunachal Pradesh, India

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Abstract: A field survey was conducted in 2008–2009 in the Mehao Wildlife Sanctuary in Arunachal Pradesh, India, to investigate the status and distribution of the eastern hoolock gibbon there. The data were collected using line transects (trails covering all representative areas of the sanctuary) and by registering calling groups. We recorded 157 groups of gibbon in the sanctuary, of which 28 were directly sighted and 129 groups were registered by their calling. Of the 88 individuals seen, 61.4% were adults, 22.7% juveniles and 15.9% infants. Average group size was 3.14, with an adult sex ratio of 1:1. The survey also confirmed the presence of capped langur (*Trachypithecus pileatus*), Assamese macaque (*Macaca assamensis*), rhesus macaque (*Macaca mulatta*) and slow loris (*Nycticebus bengalensis*) in the sanctuary. We identified encroachment, *jhum* cultivation, horticulture, selective logging and inadequate infrastructure as being the major threats for the hoolock gibbon and other wildlife in the sanctuary. Although the gibbons were not hunted, hunting was evidently a threat to other wildlife in the sanctuary.

Key words: Eastern hoolock gibbon, status, Mehao Wildlife Sanctuary, threats, conservation, Arunachal Pradesh, India.

Introduction

In India, gibbons are restricted to tropical and subtropical forests of the southern bank of the Dibang-Brahmaputra river system in the seven states of the Northeast. Western hoolock gibbons (*Hoolock hoolock*) occur in all of the states: Assam, Arunachal Pradesh, Meghalaya, Mizoram, Tripura, Nagaland and Manipur. The eastern hoolock gibbon (*Hoolock leuconedys*) occurs in two: Arunachal Pradesh and a small part of Assam (Chetry and Chetry 2010).

Seven other primates occur in Arunachal Pradesh besides the two hoolock gibbons (Borang *et al.* 1993; Singh 2001). Chetry (2002) and Chetry *et al.* (2003) reported on the primates in Namdapha National Park and Pakke National Park, respectively, and Chetry (2004) described the diversity and status of the primates in the Eagle Nest and Sessa Orchid wildlife sanctuaries. Sinha *et al.* (2005) described a new macaque from the Tawang district in the eastern part of the state, the Arunachal macaque (*Macaca munzala*), and Kumar *et al.* (2005) indicated the presence of the Tibetan macaque (*Macaca thibetana*), although this has yet to be confirmed. There are also reports on the status of primates in Dibang

Valley Wildlife Sanctuary (Chetry and Medhi 2006; Chetry and Chetry 2009). There have been studies on the distribution of the western Hoolock gibbon in the districts of Tirap, Changlang and Lohit (Mukherjee *et al.* 1988, 1991, 1992; Choudhury 1991; Biswas *et al.* 2007). Das (2002) studied the behavior of *H. hoolock* in Namdapha, and Das *et al.* (2006) it was who reported finding the eastern hoolock (*H. leuconedys*) in Arunachal Pradesh, the first record for India (see also Chetry *et al.* 2007, 2008). Here we present our findings on the status and distribution of the eastern hoolock gibbon in the Mehao Wildlife Sanctuary in the Lower Dibang Valley district of Arunachal Pradesh. We also report on the anthropogenic pressures that the hoolock gibbon and its habitats in the sanctuary are facing.

Study Area

The Mehao Wildlife Sanctuary (281.5 km²) is in the Lower Dibang Valley district of Arunachal Pradesh (93°30'–95°45'E, 28°05'–8°15'N) (Fig. 1). The topography is undulating and hilly, and altitude ranges from 400 to 3,568 m above sea level. The forest types change with altitude: tropical

evergreen forest, tropical semi-evergreen forest, subtropical evergreen forest, temperate broad leaf forest and temperate conifer forest. The human population living around the sanctuary is primarily of the local Idu and Padam tribes of Arunachal Pradesh. Mehao is a sanctuary for numerous threatened species of the Indian flora and fauna, and much has yet to be explored and properly documented.

Methods

Line transect survey

A population survey was carried out in the Mehao Wildlife Sanctuary from October, 2008 to April, 2009. The trails were set up to cover all representative areas of the park (Muel-ler-Dombois *et al.* 1974; Kent *et al.* 1994). The total length of the trails was 800 km. Three observers walked the trails, covering 10–12 km per day from 06:00 to 15:00 h, during 80 days of field surveys. Observers walked slowly along the transects, pausing at intervals of 500 m. When gibbons were seen, the observers recorded the location using a Global Positioning System (GPS), and noted the group size and composition. At 500-m intervals, and at every location where gibbons were encountered, the observers estimated the tree height and

canopy cover in a circle of radius 10 m, and also took note of the evidence and degree of grazing and logging in the study area.

Recording calls

Whenever we heard the gibbons calling but did not see them, we noted the time, direction, duration and GPS co-ordinates. All the transects were more than 1 km apart. As a rule of thumb, calls heard from locations 500 m to 1,000 m apart were considered to be different groups. We also co-related the time of calling and direction of the call. Accordingly, during the survey we recorded 210 calls, from which we identified 129 groups.

We also recorded secondary information relevant to the study, such as on hunting and traditional beliefs, through our informal interaction with forest field staff, local guides, hunters and elderly people.

Results

Population size

We saw 88 individuals in 28 groups in the sanctuary at altitudes of 300 m to 1,713 m above sea level (Table 1). Locating calling gibbons, we estimated a further 129 groups at altitudes ranging from 142 m to 1,865 m above sea level (Table 2, Fig. 2).

Seventy-five percent of the 28 groups seen were at altitudes below 1,000 m; 25% above 1000 m. Of the 21 groups seen below 1,000 m, most (16 groups) were at or below 500 m. For the call counts, 69% of the calls were recorded at

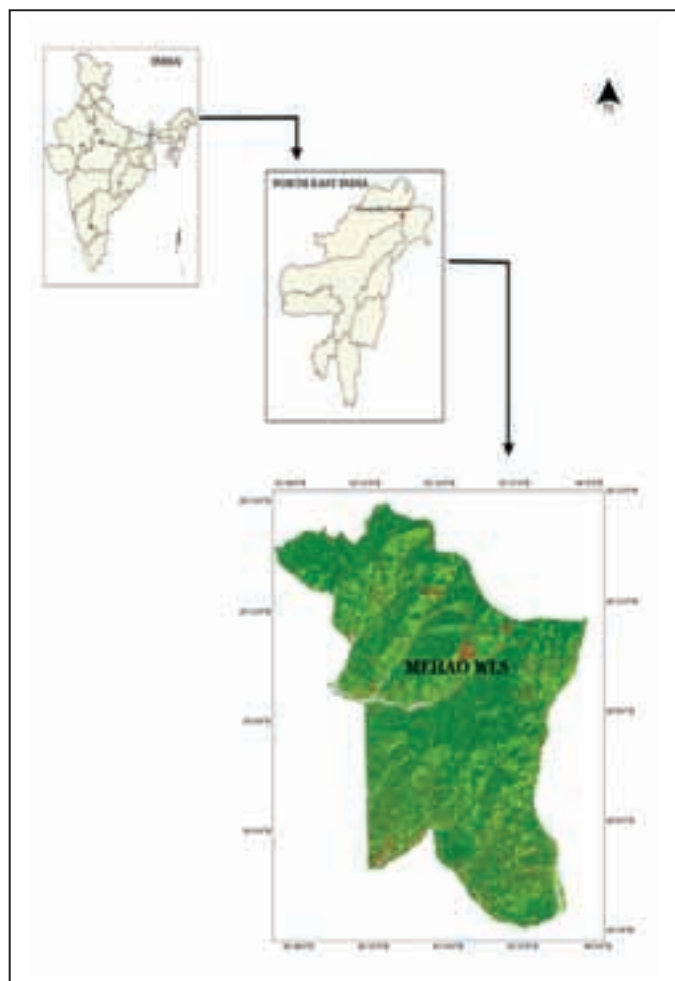


Figure 1. Location of the Mehao Wildlife Sanctuary, Arunachal Pradesh, Northeast India.

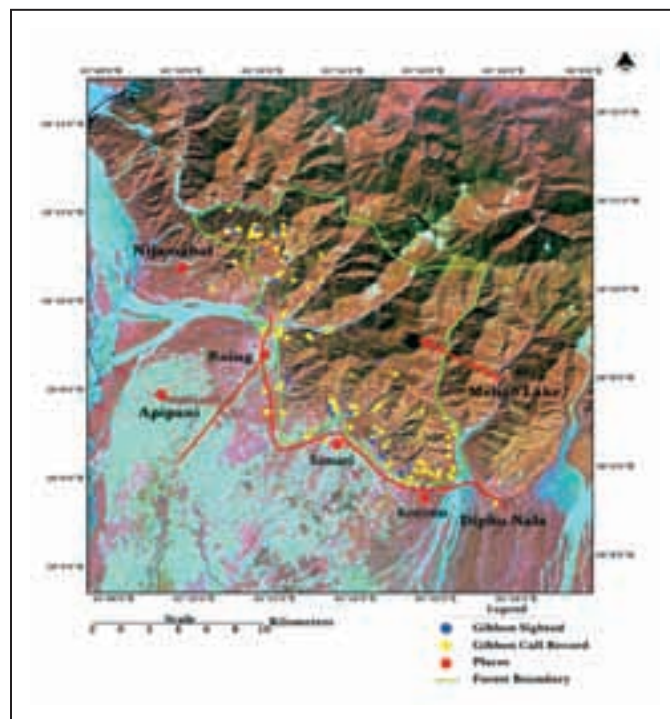


Figure 2. Location of eastern hoolock gibbon (*Hoolock leuconedys*) groups seen and recorded by their calls in the Mehao Wildlife Sanctuary, Arunachal Pradesh, October, 2008 to April, 2009.

altitudes below 1,000 m, while 31% were above 1,000 m. Of the calls recorded from below 1,000m, 60% were at altitudes of 500 m or lower, and 40% were at altitudes of 500 m to 1,000 m (Tables 1 and 2).

Group size and composition

The structure and composition of the 28 groups we were able to watch are shown in Table 1. The average group size was 3.14, ranging from 1 to 5. Most of the groups were observed with either four (10 groups) or three (11 groups) individuals. The adult sex ratio is 1:1. Age classification showed that, of the population seen, adults constituted 61.4%, juveniles 22.7%, and infants 15.9% of the population.

Sighting time and calling times

We saw 25 of the 28 groups before 12:00, and only three groups after mid-day. Sightings were evenly distributed through the morning—52% of them between 06:00 and 09:00 and 48% between from 09:00 and 12:00.

Of the 129 groups registered from calling bouts during the survey, 92.2% called before 12:00, and only 7.8% of the

calls were heard after 12:00. Of the morning calls, 42.4% were between 07:00 and 09:00, and 57.6% between 09:00 and 12:00. The average duration of the calls was 18.26 minutes, with a range of 5 to 35 minutes.

Threats

During the survey, we also tried to identify the threats to the hoolock gibbon population and other wildlife of the sanctuary. The conversion of forest for the commercial cultivation of orange, ginger and cardamom is increasingly widespread in the area and is undoubtedly a serious threat to the gibbons, reducing habitat and fragmenting the remaining forest. All the primates there are hunted for their meat and skins and as agricultural pests, except for the hoolock gibbons (the Idu people of the area do not hunt gibbons although, elsewhere, other communities do). The local communities at Mesao have a long tradition of hunting, which is a major threat to wildlife in the sanctuary. The survey team recorded several incidences of hunting of such as takin, serow, musk deer, sambar and barking deer, and bears by the different local communities.

Table 1. Sightings of eastern hoolock gibbons (*Hoolock leuconedys*) in the Mehao Wildlife Sanctuary, Arunachal Pradesh, October, 2008 to April, 2009.

No.	Location		Altitude	Locality	Time	AM	AF	J	I	Total
1	N28°03.319	E95°56.482	309 m	Koronu	07:20	1	1	1	1	4
2	N28°03.25.9	E95°57.07.9	382 m	Koronu	08:00	1	1	1	1	4
3	N28°03.46.4	E95°56.14.2	332 m	Koronu	12:05	1	1	1	1	4
4	N28°04.00.6	E95°56.51.8	990 m	Korunu	09:45	1	1	1	1	4
5	N28°04.408	E95°55.445	378 m	Injunu	06:45	1	1		1	3
6	N28°04.037	E95°57.802	418 m	Injunu	08:10	1				1
7	N28°04.981	E95°55.049	367 m	Injunu	10:32	1	1	1	1	4
8	N28°08.07.3	E95°55.40.2	1,713 m	Mehao Lake	10:00	1	1	2	1	5
9	N28°03.12.2	E95°57.15.5	300 m	Dipu nala	07:00	1	1	1		3
10	N28°03.12.2	E95°57.15.5	300 m	Dipu nala	06:30	1	1	1	1	4
11	N28°06.13.2	E95°57.16.5	310 m	Dipu nala	06:00	1	1		1	3
12	N28°03.611	E95°56.254	335 m	Balani	09:30	1	1	1	1	4
13	N28°03.07	E95°57.4.6	298 m	Balani	07:45	1	1	1	1	4
14	N28°05.32.5	E95°55.11.0	491 m	Balani	08:00	1	1	1		3
15	N28°06.38.9	E95°53.20.7	474 m	Balani	09:38	1	1			2
16	N28°06.15.6	E95°53.26.1	430 m	Balani	07:15	1	1		1	3
17	N28°06.20.8	E95°53.21.2	484 m	Chimari	06:30	1	1	1	1	4
18	N28°06.12.7	E95°54.11.7	489 m	Chimari	07:56	1	1	1		3
19	N28°07.40.7	E95°51.41.0	716 m	Roing	09:25	1	1	1		3
20	N28°07.40.8	E95°51.41.1	716 m	Roing	09:30		1			1
21	N28°07.46.8	E95°51.45.0	760 m	Roing	10:40	1	1			2
22	N28°13.14.4	E95°49.33.9	1,575 m	Tiwarigaon	13:22	1	1	1		3
23	N28°11.27.8	E95°53.02.9	1,110 m	Tiwarigaon	11:30	1	1			2
24	N28°13.34.8	E95°50.18.0	1,260 m	Tiwarigaon	08:25	1	1			2
25	N28°13.19.3	E95°51.10.9	1,537 m	Tiwarigaon	09:25	1	1	1	1	4
26	N28°13.43.3	E95°49.11.5	1,128 m	Tiwarigaon	10:16	1	1	1		3
27	N28°11.29.0	E95°51.08.6	1,865 m	Epipani	09:05	1	1	1		3
28	N28°12.12.6	E95°51.51.3	759 m	Epipani	01:05	1	1	1		3
Total						27	27	20	14	88

AM = Adult male; AF = Adult female; J = Juvenile; I = infant

Table 2. Eastern hoolock gibbon groups located by their calls in the Mehao Wildlife Sanctuary, Arunachal Pradesh, October, 2008 to April, 2009.

No	Location		Altitude	Locality	Time and duration
1	N28°03.117	E 95°57.140	306 m	Koronu	08:10 to 08:24 = 14 min
2	N28°03.615	E95°57.768	370 m	Koronu	09:22 to 09:38 = 16 min
3	N28°03.789	E95°58.462	350 m	Koronu	09:50 to 10:15 = 25 min
4	N28°03.891	E95°58.447	315 m	Koronu	10:37 to 10:51 = 14 min
5	28°03.894	E95°58.452	318 m	Koronu	10:47 to 11:05 = 18 min
6	N28°04.021	E95°55.609	290 m	Koronu	07:40 to 08:00 = 20 min
7	N28°04.117	E95°55.764	381 m	Koronu	08:55 to 09:13 = 18 min
8	N28°03.537	E95°56.66.8	347 m	Koronu	09:05 to 09:33 = 28 min
9	N28°03.626	E95°56.301	329 m	Koronu	11:27 to 11:36 = 9 min
10	N28°03.599	E95°56.189	335 m	Koronu	09:52 to 10:12 = 20 min
11	N28°03.21.7	E95°57.16.9	361 m	Balani	07:42 to 07:52 = 10 min
12	N28°03.34.7	E95°57.12.5	371 m	Balani	09:46 to 09:54 = 8 min
13	N28°05.34.9	E95°55.11.5	513 m	Balani	08:32 to 08:50 = 18 min
14	N28°05.40.9	E95°55.09.6	533 m	Balani	09:03 to 09:32 = 29 min
15	N28°06.36.6	E95°55.28.4	533 m	Balani	12:18 to 12:39 = 21 min
17	N28°04.070	E95°57.130	366 m	19kilo	07:37 to 07:48 = 11 min
18	N28°04.352	E95°58.280	384 m	19kilo	08:07 to 08:12 = 5 min
19	N28°05.469	E95°58.463	423 m	19kilo	09:07 to 09:17 = 10 min
20	N28°05.817	E95°58.104	441 m	19kilo	09:40 to 09:49 = 9 min
21	N28°03.59.9	E95°58.28.9	350 m	Dipu nala	07:15 to 07:22 = 7 min
22	N28°05.07.6	E95°58.26.8	397 m	Dipu nala	08:35 to 08:52 = 13 min
23	N28°04.979	E95°55.697	500 m	Dipu nala	10:52 to 11:20 = 28 min
24	N28°03.51.5	E95°58.34.1	335 m	Dipu nala	10:00 to 10:20 = 20 min
25	N28°05.550	E95°54.121	142 m	Dipu nala	08:00 to 08:15 = 15 min
26	N28°06.062	E95°54.380	166 m	Dipu nala	08:30 to 08:40 = 10 min
27	N28°06.232	E95°55.156	219 m	Dipu nala	09:30 to 09:40 = 10 min
28	N28°06.389	E95°55.381	249 m	Dipu nala	10:15 to 10:30 = 15 min
29	N28°02.48.5	E96°00.19.2	347 m	Dipu nala	12:45 to 13:00 = 15 min
30	N28°03.800	E95°57.852	375 m	Sakole	08:20 to 08:34 = 14 min
31	N28°04.050	E95°57.749	437 m	Sakole	10:25 to 10:50 = 25 min
32	N28°05.030	E95°53.040	376 m	Injunu	10:20 to 10:37 = 17 min
33	N28°05.193	E95°55.073	388 m	Injunu	11:20 to 11:40 = 20 min
34	N28°03.820	E95°56.897	346 m	Purana basti	08:23 to 08:45 = 22 min
35	N28°04.159	E95°57.008	463 m	Purana basti	09:50 to 10:02 = 12 min
36	N28°03.805	E95°57.212	449 m	Purana basti	08:40 to 08:53 = 13 min
37	N28°03.684	E95°57.490	329 m	Purana basti	10:35 to 10:42 = 7 min
38	N28°05.50.2	E95°55.16.0	592 m	Abango	08:18 to 08:47 = 29 min
39	N28°05.30.6	E95°55.27.1	515 m	Abango	10:20 to 10:49 = 29 min
40	N28°05.35.7	E95°55.43.5	551 m	Abango	11:17 to 11:56 = 39 min
41	N28°06.13.9	E95°53.51.3	583 m	Abaily nala	09:42 to 09:59 = 17 min
42	N28°06.32.0	E95°53.49.5	586 m	Abaily nala	10:15 to 10:30 = 15 min
43	N28°06.33.2	E95°53.48.6	624 m	Abaily nala	10:30 to 10:46 = 16 min
44	N28°06.35.6	E95°53.45.8	671 m	Abaily nala	11:37 to 11:50 = 13 min
45	N28°06.04.3	E95°53.34.5	260 m	Chimari	12:30 to 12:45 = 15 min
46	N28°06.13.0	E95°53.33.4	407 m	Chimari	08:00 to 08:20 = 20 min
47	N28°06.52.7	E95°53.27.8.4	580 m	Chimari	09:30 to 09:45 = 15 min
48	N28°06.52.3	E95°53.32.1	612m	Chimari	09:50 to 10:02 = 12 min
49	N28°06.52.1	E95°53.33.8	640 m	Chimari	10:19 to 10:32 = 13 min
50	N28°06.53.2	E95°53.35.4	630 m	Chimari	10:47 to 10:54 = 7 min
51	N28°07.577	E95°56.093	1,519 m	Chimari	10:48 to 11:00 = 12 min
52	N28°06.06.4	E95°53.25.9	398 m	Chimari	07:26 to 07:37 = 11 min
53	N28°06.06.4	E95°53.25.9	405 m	Chimari	10:00 to 10:35 = 35 min
54	N28°06.36.0	E95°53.21.8	466 m	Chimari	09:02 to 09:27 = 25 min

table continued on next page

Table 2. continued

No	Location		Altitude	Locality	Time and duration
55	N28°05.53.1	E95°52.42.8	466 m	Chimari	08:42 to 08:59 = 17 min
56	N28°05.19.7	E95°52.24.5	298 m	Chimari	11:15 to 11:40 = 25 min
57	N28°06.34.8	E95°54.40.2	623 m	Chimari	09:19 to 09:46 = 27 min
58	N28°06.15.9	E95°54.13.7	564 m	Chimari	08:47 to 09:17 = 30 min
59	N28°06.36.4	E95°54.18.5	191 m	Chimari	12:06 to 12:19 = 13 min
60	N28°06.20.9	E95°50.52.6	323 m	Chimari	09:47 to 10:13 = 26 min
61	N28°09.17.8	E95°51.23.7	529 m	Roing	08:15 to 08:20 = 5 min
62	N28°09.09.8	E95°51.52.4	631 m	Roing	09:15 to 09:33 = 18 min
63	N28°07.14.0	E95°51.02.7	330 m	Roing	07:02 to 07:09 = 7 min
64	N28°07.19.8	E95°51.18.1	488 m	Roing	07:41 to 07:52 = 11 min
65	N28°07.28.7	E95°51.26.4	510 m	Roing	08:15 to 08:30 = 15 min
66	N28°07.35.8	E95°51.31.7	529 m	Roing	08:51 to 09:10 = 19 min
67	N28°09.09.5	E95°50.54.9	399 m	Roing	08:00 to 08:30 = 30 min
68	N28°09.16.7	E95°51.03.3	462 m	Roing	08:10 to 08:35 = 25 min
69	N28°06.19.1	E95°51.24.9	372 m	Roing	11:30 to 12:06 = 36 min
70	N28°09.40.3	E95°51.16.3	452 m	Roing	07:45 to 08:20 = 35 min
71	N28°09.50.1	E95°51.22.5	477 m	Roing	08:32 to 08:52 = 20 min
72	N28°10.07.7	E95°51.42.3	507 m	Roing	09:26 to 09:57 = 31 min
73	N28°10.34.4	E95°52.19.4	574 m	Roing	10:47 to 11:10 = 23 min
74	N28°11.00.1	E95°52.46.6	658 m	Roing	12:02 to 12:31 = 29 min
75	N28°09.9.28.8	E95°51.31.3	491 m	Deopani	07:55 to 07:58 = 3 min
76	N28°09.15.7	E95°52.40.6	555 m	Deopani	09:01 to 09:21 = 20 min
77	N28°09.03.8	E95°52.50.3	711 m	Deopani	10:12 to 10:38 = 26 min
78	N28°09.44.4	E95°50.45.5	475 m	Deopani	08:00 to 08:20 = 20 min
79	N28°09.29.0	E95°50.50.3	454 m	Deopani	09:02 to 09:19 = 17 min
80	N28°09.33.8	E95°51.25.5	482 m	Deopani	09:52 to 10:06 = 14 min
81	N28°11.03.2	E95°48.39.7	587 m	Epipani	08:36 to 08:42 = 6 min
82	N28°09.28.2	E95°53.18.8	626 m	Tewari gaon	10:05 to 10:41 = 36 min
83	N28°09.32.2	E95°53.41.0	657 m	Tewari gaon	11:28 to 11:59 = 31 min
84	N28°13.26.8	E95°49.57.6	1,420 m	Tewari gaon	07:30 to 07:45 = 15 min
85	N28°13.16.4	E95°51.08.5	1,564 m	Tewari gaon	08:30 to 08:50 = 20 min
86	N28°13.08.4	E95°51.04.1	1,586 m	Tewari gaon	09:40 to 09:55 = 15 min
87	N28°12.52.6	E95°51.15.3	1,285 m	Tewari gaon	10:50 to 11:07 = 17 min
88	N28°13.11.2	E95°50.15.6	1,495 m	Tewari gaon	08:47 to 09:05 = 18 min
89	N28°13.11.3	E95°50.15.6	1,495 m	Tewari gaon	09:04 to 09:12 = 8 min
90	N28°13.10.0	E95°50.19.2	1,477 m	Tewari gaon	09:20 to 09:48 = 28 min
91	N28°13.17.7	E95°50.12.7	1,520 m	Tewari gaon	10:17 to 10:46 = 29 min
92	N28°13.15.9	E95°50.09.5	1,527 m	Tewari gaon	10:57 to 11:11 = 15 min
93	N28°13.10.3	E95°50.19.5	1,569 m	Tewari gaon	11:51 to 11:57 = 6 min
94	N28°13.02.6	E95°50.02.0	1,578 m	Tewari gaon	12:17 to 12:33 = 16 min
95	N28°13.28.2	E95°49.47.7	1,374 m	Tewari gaon	07:50 to 08:00 = 10 min
96	N28°13.10.7	E95°50.19.9	1,465 m	Tewari gaon	08:01 to 08:19 = 18 min
97	N28°12.38.3	E95°51.52.4	1,235 m	Tewari gaon	08:49 to 09:09 = 20 min
98	N28°12.32.9	E95°51.55.8	1,186 m	Tewari gaon	09:18 to 09:30 = 12 min
99	N28°13.15.3	E95°51.21.91	1,592 m	Tewari gaon	09:50 to 10:03 = 13 min
100	N28°13.42.8	E95°51.46.9	1,708 m	Tewari gaon	10:45 to 11:00 = 15 min
101	N28°12.06.5	E95°49.36.6	1,535 m	Tewari gaon	08:38 to 08:49 = 11 min
102	N28°13.05.4	E95°50.27.6	1,508 m	Tewari gaon	08:20 to 08:34 = 14 min
103	N28°13.06.4	E95°50.28.7	1,285 m	Tewari gaon	08:00 to 08:15 = 15 min
104	N28°13.31.6	E95°49.53.8	1,353 m	Tewari gaon	08:01 to 08:20 = 19 min
105	N28°13.32.9	E95°49.53.7	1,301 m	Tewari gaon	08:31 to 08:39 = 8 min
106	N28°13.26	E95°49.17.1	1,317 m	Tewari gaon	12:23 to 12:35 = 12 min
107	N28°13.29.2	E95°50.14.7	1,360 m	Tewari gaon	07:56 to 08:10 = 14 min

table continued on next page

Table 2. *continued*

No	Location		Altitude	Locality	Time and duration
108	N28°13.45.66	E95°50.23.66	1,186 m	Tewari gaon	09:11 to 09:36 = 15 min
109	N28°13.44.3	E95°50.28.20	1,080 m	Tewari gaon	10:03 to 10:34 = 31 min
110	N28°13.47.8	E95°50.28.7	955 m	Tewari gaon	11:33 to 11:45 = 12 min
111	N28°13.08.9	E95°50.41.4	1,513 m	Tewari gaon	07:46 to 07:58 = 12 min
112	N28°13.09.8	E95°50.48.4	1,541 m	Tewari gaon	08:50 to 09:10 = 20 min
113	N28°13.09.4	E95°51.50.0	1,555 m	Tewari gaon	10:33 to 10:56 = 23 min
114	N28°13.05.8	E95°51.51.2	1,530 m	Tewari gaon	11:10 to 11:21 = 11 min
115	N28°12.33.9	E95°51.54.4	1,204 m	Tewari gaon	13:09 to 13:39 = 30 min
116	N28°13.25.7	E95°49.05.1	1,325 m	Tewari gaon	07:33 to 07:59 = 26 min
117	N28°13.34.7	E95°49.05.5	1,296 m	Tewari gaon	08:17 to 08:39 = 22 min
118	N28°13.39.4	E95°49.08.1	1,191 m	Tewari gaon	09:40 to 09:59 = 19 min
119	N28°13.47.6	E95°49.12.3	1,080 m	Tewari gaon	10:50 to 11:13 = 23 min
120	N28°14.06.3	E95°49.16.8	954 m	Tewari gaon	12:10 to 12:23 = 13 min
121	N28°11.43.00	E95°51.15.4	624 m	Tewari gaon	08:47 to 09:14 = 27 min
122	N28°11.49.9	E95°51.19.4	649 m	Tewari gaon	09:32 to 09:59 = 27 min
123	N28°11.59.5	E95°51.32.5	707 m	Tewari gaon	10:48 to 11:19 = 31 min
124	N28°12.07.0	E95°51.43.10	738 m	Tewari gaon	11:52 to 12:05 = 13 min
125	N28°12.13.3	E95°51.57.6	789 m	Tewari gaon	13:35 to 13:52 = 17 min
126	N28°12.59.4	E95°50.34.0	1,555 m	Tewari gaon	08:10 to 08:36 = 26 min
127	N28°12.59.	E95°50.34.0	1,555 m	Tewari gaon	08:26 to 08:59 = 33 min
128	N28°12.55.4	E95°50.36.2	1,544 m	Tewari gaon	09:17 to 09:42 = 25 min
129	N28°12.48.3	E95°50.36.0	1,495 m	Tewari gaon	10:20 to 10:48 = 28 min

A newly constructed, high-tension, electric power line along the southern boundary of the sanctuary, running parallel to the Roing-Koronu-Bhisma Nagar road, is emerging as a potential threat to the wildlife of the sanctuary, especially the arboreal species. A male gibbon was killed due to electrocution during the survey.

There is widespread encroachment of the forest for human settlements and for small-scale agriculture (horticulture, tea plantations, ginger cultivation, *jhum* cultivation), along with illegal felling of select trees, and the extraction of non-timber products such cane, bamboo, and medicinal plants. Cane and bamboo are also extracted commercially from the sanctuary.

In practice, the sanctuary does not have a well-marked boundary. Other than declaring the sanctuary, the forest department seems to have not taken any initiatives to convey the message to the local people. Most of the local people have no clear understanding of the existence of the sanctuary or its boundaries, and still think that the land belongs to their forefathers and they have the right as such to hunt and to carry out their day-to-day activities as they always have.

Discussion

This is the first assessment of the eastern hoolock gibbon population in the Mehao Wildlife Sanctuary. Das *et al.* (2006) had first reported the species from the district of Lohit, Arunachal Pradesh, and Chetry *et al.* (2008), discovered it also in the district of the lower Dibang Valley. With

an estimated 157 groups, the Mehao Wildlife Sanctuary is clearly an important stronghold for this species.

Das *et al.* (2006) estimated an average group size of 3.37 for the eastern hoolock gibbon. The average size of the 28 groups we observed was slightly smaller at 3.14. Groves (1971) reported that eastern hoolock gibbons can be found between 1,067 m and 1,219 m above sea level in Myanmar and China. The Indian populations, however, also occupy the lowlands. Das *et al.*, (2006) found them occurring at altitudes of 122 m to 1,075 m, and in the Mehao Wildlife Sanctuary they range from 142 m to 1,865 m; higher and lower elevations than had been recorded previously, although in Mehao the majority of the groups we saw were below 500 m. The gibbons were found to occupy primarily the subtropical evergreen and semi-evergreen forests that are predominant in the lower elevations of the sanctuary.

During the surveys, we recorded four other primates besides the eastern hoolock gibbon. We saw rhesus macaque (*Macaca mulatta*), Assamese macaque (*Macaca assamensis*), and the capped langur (*Trachypithecus pileatus*), and the slow loris (*Nycticebus bengalensis*) was reported to occur there by the local people and rangers. It is possible that stump-tailed macaques (*Macaca arctoides*) and pigtail macaques (*Macaca leonina*) may also occur the sanctuary, but they may have been extirpated or reduced to extremely low numbers by hunting. This assemblage of five, possibly seven, species of non-human primate establishes the sanctuary as one of the most primate-rich areas in Arunachal Pradesh (and the entire



Figure 3. Adult female (left) and male (right) eastern hoolock gibbons (*Hoolock leuconedys*). Photo by Dilip Chetry.

country), but only the hoolock gibbons can be seen and heard regularly. The other primates were very scarce. Biswas *et al.* (2007) also found stump-tailed and pigtailed macaques to be very rare in the Lohit and Changlang districts of Arunachal Pradesh. The low numbers of primates other than Hoolock gibbon in the Mehao sanctuary indicates regular hunting. Only the centuries-old traditional belief of the local “Idu Mishimi” tribe is protecting the hoolock gibbons there. Elsewhere in Northeast India, the gibbon populations are declining severely due to hunting (Das *et al.* 2005), habitat loss and habitat fragmentation (Chetry *et al.* 2007). Habitat loss and fragmentation resulting from encroachment, *jhum* cultivation (traditional slash and burn cultivation) and other horticultural and agricultural practices (especially ginger, cardamom, orange and tea cultivation) are major threats to the eastern hoolock gibbons and to other wildlife of the sanctuary.

Effective conservation measures involving the local community and with a long-term vision are needed, along with regular population monitoring and ecological studies, if the eastern hoolock gibbon is to continue to thrive in this sanctuary. Infrastructure and facilities, and strict vigilance on the part of forest department is also vital for protecting and conserving all the rich wildlife there.

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First Record of Eastern Hoolock Gibbon in Assam, India

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Abstract: The western hoolock gibbon (*Hoolock hoolock*) and eastern hoolock gibbon (*Hoolock leuconedys*) are the two representatives of gibbons in India. Their distribution is restricted to the south bank of the Dibang-Brahmaputra river system in the northeast. The western hoolock gibbon has the wider distribution of the two, occurring in all of the seven states of the Northeast region, namely Assam, Arunachal Pradesh, Meghalaya, Mizoram, Tripura, Nagaland and Manipur. It was thought that, in India, the eastern hoolock gibbon was restricted to the state of Arunachal Pradesh. Here, we report the occurrence of this species in three reserve forests of the Sadiya sub-division of the Tinsukia District of the state of Assam, extending the previously known range of the species in the country.

Key words: *Hoolock leuconedys*, *Hoolock hoolock*, distribution, Sadiya, Assam

Gibbons are found only in the tropical and subtropical forests of South and Southeast Asia. There are 17 species in four genera. The genus *Hoolock* is represented by two species: the western hoolock gibbon (*Hoolock hoolock*) and the eastern hoolock gibbon (*Hoolock leuconedys*). The eastern form was earlier considered to be a subspecies of *hoolock* (see Groves 1967). Formerly, they were placed in the genus *Hylobates* along with all the other gibbons, except for the siamang (*Symphalangus*), but a different karyotype and distinctive morphological features resulted in them being placed in a separate genus, *Bunopithecus*, by Prouty *et al.* (1983a, 1983b). *Bunopithecus*, however, proved not to be applicable to the hoolock gibbons, and the generic *nomen* was changed by Mootnick and Groves (2005) to *Hoolock*.

Both the western hoolock (*Hoolock hoolock*) and eastern hoolock gibbons (*Hoolock leuconedys*) are found in India. The western hoolock gibbon is also found in neighboring Bangladesh (Anderson 1878; Gittins 1980; Gittins and Akonda 1982; Khan 1984, 1985) and Myanmar (Tickell 1864; Groves 1967, 1972). The eastern hoolock gibbon extends into Myanmar and China (Groves 1971).

In India, the distributions of the two species are limited to the south of the Dibang-Brahmaputra river system in the Northeast region. The western hoolock gibbon has the wider range in India. It occurs in all of the seven states of

the Northeast: Assam, Arunachal Pradesh, Meghalaya, Tripura, Manipur, Mizoram, and Nagaland. A number of reports have detailed its range in this region (Mukherjee *et al.* 1982, 1988, 1991–1992; Choudhury 1991, 2006, 2009; Das *et al.* 2003; Gupta and Sharma 2005; Chetry *et al.* 2007; Kakati *et al.* 2009).

The eastern hoolock gibbon was discovered in India only recently. Das *et al.* (2006) reported on its occurrence between the River Lohit in the north and the high mountains of the Dafa Bum in the south, in the state of Arunachal Pradesh. Subsequently, Chetry *et al.* (2007, 2008) and Chetry (2009) reported the species from the Lower Dibang Valley district, also in Arunachal Pradesh. Here we report the occurrence of the species in Assam.

From March to May, 2010, we carried out a survey of the hoolock gibbon in the reserve forests of the Sadiya sub-division in the Tinsukia district of Assam. The first time we saw the eastern hoolock gibbon was in the Hallowgaon Reserve Forest (371 ha, 27°50'54.9"N, 95°45'52.9"E; altitude 120 m above sea level). We found two groups and heard calls from two other groups nearby. Using binoculars, we were able to confirm the lighter coat color of the adult female when compared to the western species—one of the most reliable identifying characters. For confirmation, however, we took photographs of both the male and female. For further verification,

we consulted the recent literature (Groves 1972, 2001; Das *et al.* 2003, 2005, 2006; Mootnick and Groves 2005; Chetry *et al.* 2008) and compared them with photographs of gibbons from the Lower Dibang Valley in Arunachal Pradesh. We also sent the photographs to Colin P. Groves, Warren Brockelman and Thomas Geissmann. On the basis of our observations, the photographs and experts' comments, we concluded that the hoolock gibbons in Sadiya are indeed the eastern form, *Hoolock leuconedys*.

Previous surveys of primates in Sadiya (Mohnot 1995; Sharma and Sinha 2007) had reported the gibbons as belonging to the western form, *Hoolock hoolock*. Our findings have not only extended the range of the eastern Hoolock gibbon in India but have also given a new direction to Hoolock gibbon conservation in Assam.

The gibbon survey covered six reserve forests in the Sadiya Range, *H. leuconedys* was found in only three of them—Kukuramara (365 ha) and Kundil Kolia (7,284 ha), besides Hallowgaon. The survey confirmed that the gibbon had already been extirpated from three other reserve forests, Deopani Reserve Forest, Sadiya station North Block, and Sadiya Station West Block. The survey was able to confirm 23 groups of eastern hoolock gibbons in the Sadiya region, north of the River Lohit.

With the inclusion of eastern Hoolock gibbon, Assam has now 10 species of primate, the highest diversity of any part of India. Forest loss and fragmentation due to the expansion of agricultural activities (for example, ginger and mustard), encroachment by human settlements, selective illegal felling,

the collection of firewood, and grazing are the major threats to this species. The Assam State Forest Department should take immediate steps for the conservation of this rare gibbon. The Kundil Kolia Reserve Forest is an important potential conservation site for this species, and would benefit from being upgraded in status to a wildlife sanctuary.

Acknowledgments

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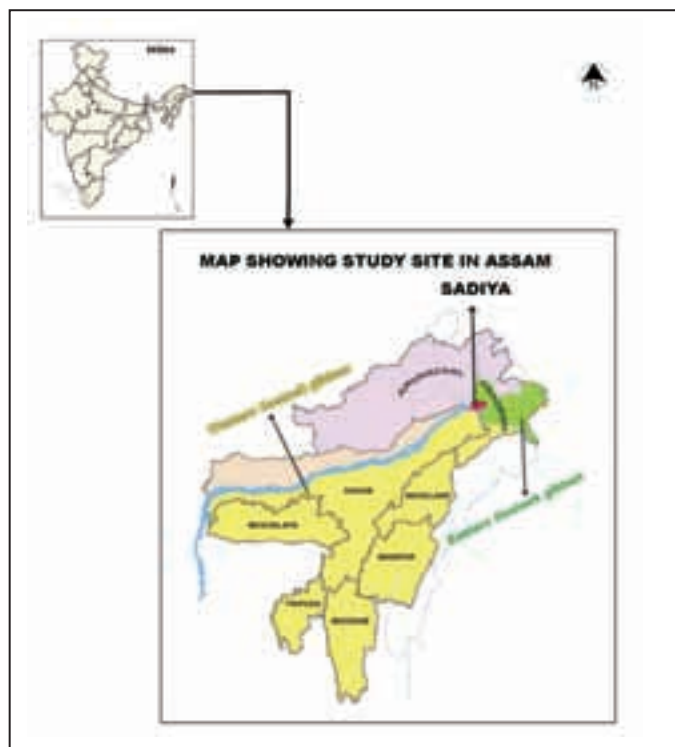


Figure 1. The ranges of the western hoolock gibbon, *Hoolock hoolock* (yellow) and the eastern hoolock gibbon, *H. leuconedys* (green) in Northeast India. In red is the range extension for the eastern hoolock in far northeastern Assam.



Figure 2. Adult female eastern hoolock gibbon, *Hoolock leuconedys*. Photograph by Dilip Chetry.

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Tourist Behavior and Decibel Levels Correlate with Threat Frequency in Tibetan Macaques (*Macaca thibetana*) at Mt. Huangshan, China

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Abstract: Tourism is a common component of management practices directed toward endangered species and habitats, but few studies have explored the potential stressors that may occur to nonhumans as objects of tourism. We examined the impact that tourists have on provisioned, habituated Tibetan macaques (*Macaca thibetana*). Data were collected during August 2005 at the Valley of the Wild Monkeys (VWM), Mt. Huangshan, China. From a tourist viewing platform, we measured tourist densities, behaviors (for example, foot, hand, and mouth noises; mimicking monkeys; throwing objects or food), and decibel levels. Frequencies of monkey threats in the provisioning area of their range were recorded. The tourists' collective behaviors correlated with monkey threats (Pearson's correlations; $r=0.391$, $p=0.014$), as did decibel levels on the viewing platform ($r=0.334$, $p=0.038$). No relationship between tourist density and monkey threats, or between particular tourist behaviors and monkey threats, was significant. Based on these results, we recommend park staff be trained on how to discourage noise often associated with tourists and regulate prohibited tourist behaviors, such as feeding the monkeys. Enforcement of park rules will decrease chances that tourist-monkey interactions at VWM will escalate into situations where injuries occur, as has happened at some other macaque tourism sites. Finally, we suggest the development of tourist education materials.

Key words: ecotourism, macaques, aggressive behavior, stress

Introduction

During the late 1990s, China's economy was the fastest growing in the world, a trend that has continued into the new millennium (Harkness 1998). Emergence of large numbers of Chinese people in middle and upper economic classes coincides with a rapidly growing domestic tourism industry (Sofield and Li 1998). The rise in tourism has stimulated changes in policies that protect China's wildlife, and nature-based tourism is increasingly popular (Ji and Jiang 2004).

The attraction of tourists to an area demonstrates to local, provincial, and national governments the economic value of the region, but tourism is often accompanied by increased noise and pollution, unchecked development, and the potential for increased human/wildlife contact. This contact can be stressful and detrimental, particularly when there is a potential

for interspecies aggression and disease transmission. Left unmanaged, nature-based tourism can prove harmful to the very area that is being sought out for its natural beauty, unique wildlife, or cultural significance.

Perhaps in part because of their adaptability and inquisitive, bold natures, species in the genus *Macaca* are sometimes the focus of "macaque tourism" (Fuentes *et al.* 2007, p.1144) in Asian countries, within the natural range of the genus. In China, there are two locations where tourists can see Tibetan macaques (*Macaca thibetana*): Mt. Emei in Sichuan Province (Zhao 2005) and the Valley of the Wild Monkeys (VWM), near Mt. Huangshan in Anhui Province (Matheson *et al.* 2006). Both sites are popular destinations for domestic and international tourists.

At Mt. Emei, tourists follow trails from the base of the mountain to its summit. Monkeys approach tourists on trails

and inspect them or their baggage for food (Zhao 1999). Zhao and Deng (1988a) call this behavior “beg-robbing”, which they vividly describe as the monkey “approaching the visitor, often standing bipedally, the animal reached for food in the hand or carrying bag of the visitor, sometimes stealing the bag (Zhao and Deng 1992, p.25).” As a result, trailside tourist-monkey interactions have changed from tourists feeding monkeys as a form of entertainment, to tourists throwing food in self-defense against aggressive monkeys (Zhao 1994).

Mt. Huangshan is located in Anhui Province and is a United Nations World Heritage site (see Figure 1). VWM is south of the main park and receives fewer visitors than does Mt. Huangshan. Visitors to VWM enjoy the beauty of the area, stroll along paved walkways, and climb a series of stairs to viewing platforms from which they can see Tibetan macaques during regularly scheduled feeding sessions by park staff.

We explored the potential impacts of tourism on the behavior of one group of habituated macaques at VWM. We examined whether: 1) the rate of monkey threats (directed toward humans, monkeys, or both) was related to tourist numbers on the viewing platform; 2) the rate of monkey threats was correlated with decibel levels measured on the viewing platform; and 3) specific behaviors engaged in by tourists were associated with increased frequencies of monkey threats. This study has direct implications for management practices at VWM to help reduce negative interactions between humans and Tibetan macaques.

Methods

Data were collected from 11–26 August 2005 at VWM, Mt. Huangshan, China (30°07'09"N, 118°09'41"E; 1,841 m above sea level). Mt. Huangshan is a popular tourist destination famous for an endemic pine species (*Pinus huangshanensis*) found at higher elevations. Lower elevations, where

Tibetan macaques are found, have mixed evergreen and deciduous forests (McCarthy *et al.* 2009).

The group called Yulingkeng A1 (YA1) was habituated for research in 1986 and for tourism in 1992 (Berman *et al.* 2007). A viewing platform from which tourists could observe the monkeys was constructed in 1994 (Berman *et al.* 2007). Since 1992, park rangers have provisioned monkeys with corn four times each day. This attracts them to areas where they are more easily viewed by tourists and researchers. In 2005, YA1 consisted of 25 individuals: five adult males, five adult females, two subadult males, nine juveniles, and four infants.

In order to record pre- and post-feeding monkey and tourists behaviors, we collected data during intervals corresponding to the four scheduled provisioning times: 09:30–10:30, 13:00–14:00, 15:00–16:00, and 17:00–18:00 h. Each hour constituted a session.

Three researchers collected data during each session. One researcher recorded data on decibel levels and tourist numbers at two-minute instantaneous scans. She continuously recorded tourist behavior between instantaneous records using the tourist ethogram in Table 1. Decibel levels were recorded from the same location on the tourist platform using a Sper Scientific Mini Digital Sound Meter (model number 840014; Sper Scientific Ltd., Scottsdale, AZ). We recorded baseline decibel levels before morning data collection sessions from 2–8 August 2005 ($n=8$ baseline sessions). During these baseline sessions, monkeys, observers, and park staff may have been present, but tourists were not.

During each session, two researchers continuously recorded monkey threat behaviors during two-minute intervals, with each observer focusing on different provisioning areas to rule out overlapping data. They recorded all occurrences of *bite*, *chase*, *lunge*, *slap*, and *threat* (including *ground slap*) using Berman *et al.*'s (2004) behavioral ethogram.

The three data collectors achieved interobserver reliability for monkey identities (for adults) or age/sex class (for immatures) (100%) and monkey threat behaviors (92%) from 3–10 August 2005, prior to formal data collection. The first author (LAR) collected all tourist behavioral data and made *ad libitum* notes on tourist, monkey, and park staff behaviors during each session. Our research methods were approved by the Human Subjects Research and Institutional Animal Care and Use Committees of Central Washington University before the study began.

Results and Discussion

Results yielded a total of 1,046 scans (used for tourist counts and decibel levels) and 1,046 intervals (used for monkey and tourist behaviors). We recorded an average of 1.72 threats per monkey per interval (S.D.=0.96 threats), and an average of 22 tourists on the platform per scan (S.D.=17.12 tourists).

There was no correlation between tourist density and the occurrence of monkey threats ($r=0.153$, $p=0.351$). Average decibel levels were significantly higher on the tourist platform when tourists were present (Student's *t* test, $M_1=58.09$ dB,

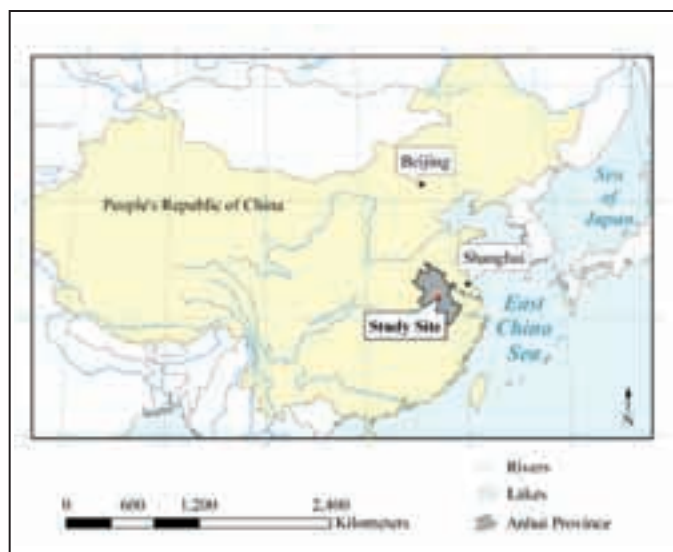


Figure 1. The location of the study site in Anhui Province, China (ESRI 2000, Website: <<http://www.esri.com>>).

$n_1=88$, $M_2=60.13$ dB, $n_2=1,040$, $df=1$, $t=-2.96$, $p=0.003$). Positive correlations occurred between decibel level and the occurrence of monkey threats ($r=0.334$, $p=0.038$; see Figure 2), and the total frequency of tourist behaviors and the occurrence of monkey threats ($r=0.391$, $p=0.014$; see Figure 3). However, correlations between the frequency of particular tourist behaviors (Table 2) and monkey threats were not significant.

Four situations occurred regularly in *ad libitum* notes taken during each session: 1) monkeys on the tourist platform with tourists and park staff ($n=108$ times); 2) tourists feed monkeys with corn provided by park staff ($n=102$ times); 3) tourists feed monkeys with food brought to the viewing platform ($n=39$ times); and 4) park staff reprimand tourists for feeding monkeys ($n=9$ times).

We found no correlation between tourist density and the occurrence of monkey threats. Perhaps the freedom to forage and the routine of scheduled feeding times mitigates negative aspects of large tourist groups on the platforms. Also, park staff spread corn widely around the provisioning area, so monkeys could forage some distance from tourists. Park

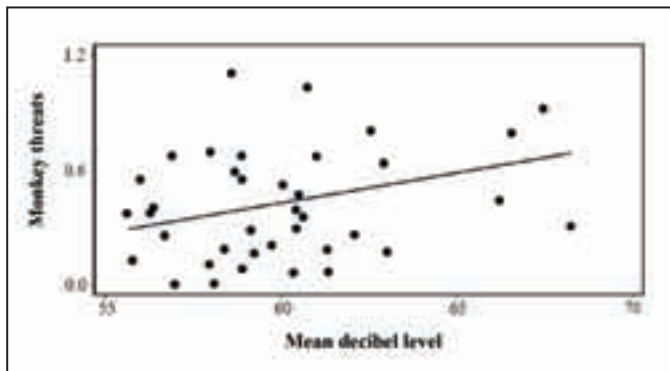


Figure 2. Decibel level on tourist platform and frequency of monkey threats ($r=0.334$, $p=0.038$).

Table 1. Tourist behavioral ethogram.

Behavior	Description
Foot noise	Tourist stamps feet or kicks wall in tourist platform.
Hand noise	Tourist makes noises with one or both hands (clap, snap, smack own body, smack a book).
Mimic ^a	Tourist mimics facial expressions and/or body movements of a monkey threat (eyebrow raise, stare).
Mouth noise	Tourist makes noise (whistle, kissing noises, shouts) with mouth directed toward monkey.
Point	Tourist points at monkeys; arm extends out of tourist platform.
Rock ^b	Tourist pretends to throw rock at monkeys.
Slap rail	Tourist slaps rail or post on tourist platform using hands and/or objects.
Throw food	Tourist drops or throws food item into the monkey area, or directly to a monkey.
Throw object	Tourist drops or throws nonfood item (tissue, wrapper, rock) into monkey area.
Wave	Using hands or objects, tourist waves at monkey

^a If mimicry included slap, it was coded as *Mimic*, not *Slap rail*.

^b If rock was thrown, it was coded as *Throw object* not *Rock*.

staff monitored where monkeys were and used their voices to encourage monkeys to come closer to the tourist platform to eat corn. However, monkeys could and did avoid the tourist platform altogether. In the past, park staff used more restrictive “herding” methods (Berman *et al.* 2007), essentially forcing monkeys into the provisioning area, but from 2005 through 2009 (our most recent research at the site), staff primarily monitored the monkeys’ locations and allowed them to approach the platform at will. This management technique may help to reduce the potential stress posed by large numbers of people.

Overall, behaviors exhibited by tourists were positively correlated with the occurrence of monkey threats (Figure 3). Tourist behaviors were often of an attention-seeking nature, such as waving, throwing food, making noises, or mimicking the monkeys’ behaviors, and tourists seemed to continue any behavior that elicited a response from the monkeys. Indeed, in another study conducted at VWM, McCarthy *et al.* (2009) found that tourists tended to initiate interactions with monkeys and repeated a behavior until a monkey responded; the monkey’s most common response was to threaten the tourist.

Although all tourist behaviors taken together had a significant impact on the occurrence of monkey threats, individual tourist behaviors did not (Table 2). This may be due to the varied types of behavior tourists engaged in and the resulting small sample size for each behavior. *Throw object* appears to be a candidate for additional research ($r=0.927$, $p=0.073$,

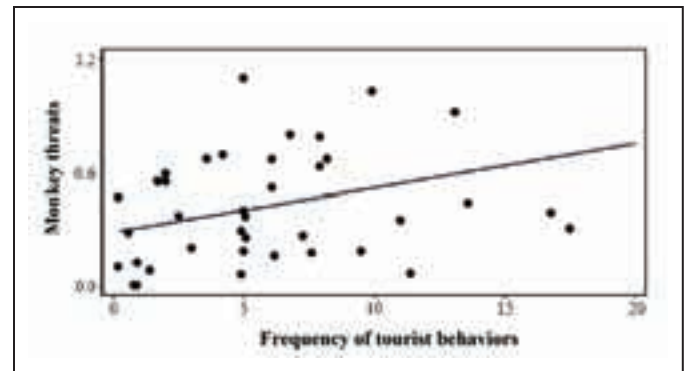


Figure 3. Frequency of all tourist behaviors and frequency of monkey threats ($r=0.391$, $p=0.014$).

Table 2. Occurrence of tourist behaviors.

Behavior	N	Percent	<i>r</i>	<i>p</i> (n. s.)
Point	676	45	-0.0362	0.5981
Mouth noise	252	17	-0.0858	0.4352
Wave	241	16	0.0628	0.5874
Throw food	153	10	-0.1417	0.2565
Hand noise	57	4	-0.1669	0.5521
Mimic	40	3	-0.0110	0.9634
Throw object	17	1	0.9272	0.0728
Rock	9	<1	0.5452	0.2632
Slap Rail	2	<1	0.0215	0.9349

Note. Percentage of individual behaviors derived from total of all behaviors ($N=1,503$); some behaviors occurred that were not on the tourist ethogram.

which is suggestive considering its small representation in the data set: $n=17$, or 1.13% of all intervals). Of note, rock throwing is the primary means used by park staff to discourage monkeys from climbing on the platform and being aggressive toward tourists; in the recent past but to a lesser extent now, it was used to herd monkeys when they strayed too far from the provisioning area (Berman *et al.* 2007). The monkeys showed a pattern of fleeing from, but directing threats towards, park staff (Jones *et al.* 2008), so it is not surprising that having tourists show or throw rocks would be perceived as particularly alarming to them. Similarly, McCarthy *et al.* (2009) found that monkeys responded with threats to the tourist behaviors *point* and *slap rail*. The latter mimics a macaque threat behavior, *ground slap* (Berman *et al.* 2004), and thus may be perceived by the monkeys as a threat towards them.

Average decibel levels on the tourist platform were correlated with the occurrence of monkey threats (Fig. 2). Noise emitted by tourists is unpredictable and uncontrollable, and thus meets two criteria for what constitutes a stressor to animals (Wingfield and Kitaysky 2002). Noise is a component of many of the tourist behaviors described in this study: *mouth*, *foot*, and *hand noise* and *slap rail*. These tourist behaviors were directed towards monkeys as they approached the platform and tourists attempted to engage the monkeys or instigate a reaction from them.

VWM park staff instituted provisioning in 1992 to facilitate tourism and research (Berman and Li 2002). During this study through 2009, VWM monkeys were fed dried corn four times each day. The corn was scattered widely throughout the area of the monkeys' home range that is adjacent to the viewing platforms. Boccia *et al.* (1988) found that use of low-quality, widely distributed foods for provisioning reduced feeding competition among nonhuman primates, and that appeared to be the case at VWM: although monkeys did threaten one another over corn, it was too widely dispersed, and perhaps of too low a nutritional value, for one or a few animals to dominate access to it. Foods provided by tourists, by contrast, tended to be high quality (calorie- and fat-dense) and clumped in distribution and included energy drinks, soda, sugary rolls, fruit, and nuts tossed whole into the provisioning area. Such foods created quite a stir among the monkeys, and high ranking animals dominated access to them. Hapless tourists often attempted to toss food to juveniles and infants, unaware that this made the young monkeys the target of aggression from more dominant adult animals.

While not explicitly examined in our formal data collection, it seemed likely that some of the monkey threats we observed were related to the tourists bringing these highly prized foods onto the tourist platform, apparently intending to feed the monkeys. Our *ad libitum* notes indicated that monkeys received food in addition to provisioned corn from park staff or from tourists during approximately 15% of data collection time. Sometimes park staff let tourists feed corn to the monkeys from a small can (for free or in exchange for a small fee) as a photo opportunity. Monkeys, usually one or two particular adult males well-known to park staff, were sometimes

urged by staff to sit on the platform rail next to tourists, again as a photo opportunity. Both practices, however, have apparently stopped, and since 2005, we have not observed staff-encouraged feeding by tourists. Indeed, our *ad libitum* data showed that park staff reprimanded tourists for offering treats 23% of the times they occurred, but tourists often resumed when staff were not looking. Through 2009, we have seen local villagers within the park selling foods to tourists to give to the monkeys, so a mixed message is sent to tourists about whether or not feeding is allowed.

At VWM, the combination of tourists, food, and monkeys on the platform typically ended in threats from the monkeys and their eventual retreat when park staff approached, but occasionally escalated into more serious problems. In 2005, an adult male macaque sat on the railing of the tourist platform and was hand fed by tourists while they posed for photographs with him. Suddenly, the monkey hit a male tourist on the side of his head, knocking off his glasses. In 2008, an adult male monkey was aggressively approaching a little girl with a pear in her hand; the ranger moved between the two and received deep puncture wounds on his back from the monkey's canine teeth.

Tourist-provided food is associated with negative monkey-human interactions at other sites too. Zhao and Deng (1988b) characterized several behaviors that tourists were engaged in that preceded aggressive encounters with one or more Tibetan macaques, including enticing monkeys with food, posing for pictures with monkeys, and trying to touch monkeys. Fuentes (2006) found that when tourists fed long-tailed macaques (*M. fascicularis*) at Sangeh Monkey Forest in Bali, it increased the occurrence of their aggressive behaviors. Tourists at Sangeh often received bites or scratches when holding food, and of those injured by monkeys almost 95% of them were holding food (Engel *et al.* 2002). Hsu *et al.* (2009) found that illegally provided food increased the frequency and duration of aggressive interactions between humans and Formosan macaques (*M. cyclopis*) at Shou Shan Nature Park in Taiwan. Fuentes and colleagues (2007, p.1155) noted: "... the food tourists bring appears to be the primary stimulus for macaque-human interactions." Limiting monkeys' access to food will likely reduce opportunities for tourists to be bitten, scratched, or threatened.

Fuentes and Gamerl (2005) noted that because tourists stay only a short time at sites such as VWM, they do not learn how to safely interact with monkeys, but the monkeys have repeated opportunities to learn how to manipulate human behavior to obtain food. An effective form of manipulation is to threaten or be aggressive towards the tourists. Close contact and injury associated with tourist food handouts to monkeys are related to the possibility for bidirectional disease transmission (Jones-Engel *et al.* 2006). Tourists should be warned of the risks of feeding monkeys and should be dissuaded from doing so. At VWM, park staff practices of encouraging tourists to hand-feed monkeys and allowing tourists to pose for pictures with monkeys on the platform have not been seen since 2005, but it is still the case that tourists often arrive with

food and the apparent intent of feeding monkeys, and tourists disregard the staff's admonitions against doing so. Signs were posted throughout VWM stating that monkeys should not be fed, but as was true at the sites studied by Fuentes *et al.* (2007), we found that tourists ignored signage.

Throughout its time as a macaque tourism site, VWM has been characterized by relatively low levels of negative monkey-human interactions. Tourists stayed on the viewing platform, and monkeys infrequently approached them on cement pathways leading to the viewing area. However, without continued careful management of tourist-monkey interactions, VWM could become more similar to Mt. Emei or other sites where higher rates of monkey-human aggression have been reported (Zhao and Deng 1992; Fuentes and Gamerl, 2005; Zhao 2005; Sabbatini *et al.* 2006; Fuentes *et al.* 2007). It is also possible that tourism poses a stressor to VWM monkeys, thereby undermining the conservation and research goals established for the site (Berman and Li 2002).

Recommendations

Our data show that it is not merely the presence or total number of tourists on the platform that precipitates macaque threats, but rather what the tourists are doing and the amount of noise they make. To reduce the stress of tourism on the VWM monkeys and to ensure a more pleasurable visit for tourists, we recommend that:

1. Staff continue with the less restrictive "herding" methods that have been in place at this site since 2002. These allow monkeys more control over whether they will come near the viewing platform and may reduce the potential stress of forced interactions with humans;
2. tourists continue to be confined to the platform when viewing monkeys to reduce the chance of negative encounters with monkeys on pathways (as occurs at Mt. Emei, for example);
3. staff continue provisioning only with corn rather than more highly desired and easily monopolized foods, and staff enforce rules against the general public feeding monkeys;
4. only staff provide foods, so that monkeys do not associate food with tourists;
5. there be a higher ratio of staff to tourists, which would make it possible for staff to keep better watch over tourists and reduce opportunities for surreptitious feeding; and
6. tourists be better informed and educated about monkey behavior. Tourists may not realize that their behavior mimics macaque threats, or that the behaviors shown by the monkeys are indicative of fear, stress, or annoyance. Tibetan macaques appear to find the noise associated with tourists stressful. Tourists should be educated on the need to speak softly when on the viewing platform. Quiet tourists would reduce the need for park staff's use of a microphone. Abrupt human vocalizations such as shouting seem to startle the monkeys, and tourists should be

told to avoid making such noises when near the monkeys. Tourists should also be encouraged or required to wear disposable face masks while on the viewing platform. This would greatly reduce the risk of disease transmission and would provide opportunities to educate the public about the close biological and evolutionary relationship among primates. A better understanding of the monkeys, and of the effects of the tourists' own actions, may lead to a more positive tourism experience.

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Population Survey of the Bengal Slow Loris, *Nycticebus bengalensis*, in Meghalaya, Northeast India

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Abstract: The Bengal slow loris *Nycticebus bengalensis* is a nocturnal prosimian that inhabits the forests of northeastern India. As with many nocturnal prosimian species, little is known about its behavior or ecology; even less information is available on its distribution and population status in northeastern India. We conducted a survey of forest patches in the state of Meghalaya, in northeast India, in order to assess its distribution. A secondary aim of our study was to estimate the severity of threats that may affect the long-term survival of the slow loris in Meghalaya. We surveyed sixteen sites in six districts. Slow lorises were seen in only two sites; however, information obtained through secondary sources indicated that they were present in a number of other forest patches across the state. Many of the forests surveyed were severely affected by logging, poaching and forest fires; it is imperative that conservation measures, aimed at protecting existing forest patches, be implemented in order to ensure the long-term survival of the slow loris and other mammals in the state.

Key words: Bengal slow loris, distribution, survival threats, conservation, Meghalaya, India

Introduction

The Bengal slow loris (*Nycticebus bengalensis*) is one of two nocturnal primates found in India. It is poorly known, even when compared to the relatively little-studied nocturnal prosimians (Nekaris and Bearder 2006). Until 2007, the IUCN Red List had listed the species as Data Deficient, pointing out the lack of “adequate information [...] on its distribution and/or population status”. The IUCN Red List assessment carried out in 2008 classified the species as Vulnerable, and noted that “the species is predicted to decline by more than 30% in the next three generations over its entire range due to continuing hunting pressures and loss of habitat” (IUCN 2009).

Until a few years ago, information on the distribution and behavior of the slow loris in India was almost entirely lacking. Preliminary population surveys had reported the presence of the species in the northeastern states of Assam, Arunachal Pradesh, Mizoram, Nagaland, Meghalaya, Manipur, and Tripura (Choudhury 1992, 1996; Srivastava 1999). These studies also indicated that the species was seriously threatened by hunting and deforestation, and that it had already been extirpated in a number of forests in the region (Srivastava 1999; Choudhury 2001). However, the lack of information

on habitat variables and population densities for the species in these areas impedes the development of any conservation strategies to protect the Bengal slow loris.

Following these initial surveys, efforts were begun to map the current distributional status of the species in northeastern India. Slow lorises were seen in less than 20% of the sites surveyed in the states of Assam, Meghalaya and Tripura (Radhakrishna *et al.* 2006; Swapna *et al.* 2008). Mortality from road kill, disturbance caused by tree felling, trapping and hunting were identified as the main threats to the species (Radhakrishna *et al.* 2006). A study on the feeding ecology of the species in Tripura indicated that Bengal slow lorises feed largely on tree exudates, thereby making them vulnerable to habitat loss and disturbance (Swapna *et al.* 2009). These findings underline the need for surveys in the other states of northeastern India in order to understand better the limits of their range and the threats to their survival.

The main aim of this study was to conduct a rapid preliminary assessment of the distribution and relative abundance of *Nycticebus bengalensis* in the forested areas of the state of Meghalaya in northeastern India. An important secondary objective was to assess the nature and extent of potential threats that may affect the long-term survival of slow loris populations in the state.

Methods

The survey was conducted in six districts of the state of Meghalaya. Meghalaya (24°58'N to 26°03'N and 89°51'E to 92°49'E) is a small state in the southern part of northeastern India, bounded by the state of Assam on the north and east and Bangladesh on the south. The terrain is largely hilly, and nearly 70% of the state is forested. Temperatures range from about 38°C in June to about 2°C in January—the western part of the state is warmer, while the central uplands remain cool throughout the year (FSI 2005). The major forest types found in the state have been identified as Tropical Wet Evergreen, Tropical Moist Deciduous, Tropical Semi-Evergreen Forest, and Assam Sub Tropical Pine Forests (FSI 2005). The West Khasi Hills and West Garo Hills districts have the largest forest cover, amounting to almost 4,029 and 2,974 km², respectively (FSI 2005). More than 90% of the total forest area of the state is either private or clan/community owned, and falls under the control and management of the Autonomous District Councils. Notified forest land that is administered by the State Forest Department comprises two National Parks, three Wildlife Sanctuaries and more than 24 Reserved Forest patches scattered across six of the seven districts in the state.

We obtained information on the presence of Bengal slow loris (*Nycticebus bengalensis*) through field surveys and secondary sources of information. Night transects were conducted along established human and animal trails, roads, streams, and rivers. In the case of paved roads passing through the forest, we used four-wheel-drive vehicles driven slowly (<5 km/hr), most especially in areas with high numbers of rogue elephant incidents. Once, we used a boat to survey forests along the river, as it provided the best access in that terrain.



Figure 1. Bengal slow loris, *Nycticebus bengalensis*, in the state of Meghalaya, northeast India. Photograph by Anirban Datta-Roy.

Line transects were not feasible in most of the survey sites due to limited time, lack of existing transects and steep terrain. Hence we employed an encounter rate survey, using reconnaissance sampling (Walsh and White 1999), based on direct sightings of the animals. This was done to maximize coverage of forest areas and because of the methodological constraints of the traditional line transect method used for distance sampling (Burnham *et al.* 1980.). Slow loris encounter rates were calculated based on the total number of sightings and the distance surveyed as an Index of Relative Abundance of the species.

Nocturnal surveys were conducted between 19:00 and 23:00 hours. Two to four observers walked slowly (1 km/hr) and silently, flashing torches and headlamps to detect the characteristic orange eye-shine of *Nycticebus*. Whenever an eye-shine was detected, a high powered spotting light was used in conjunction with binoculars to confirm the identity of the species. We recorded details of all animal sightings, including species, numbers and age, and sex. Calls and sounds were also registered.

We also recorded disturbance levels and habitat types of the survey locations. We traversed nightly survey routes during the day to record information on habitat and disturbance parameters. We evaluated disturbance levels with particular reference to certain factors that may prove to be significant threats to the long-term survival of the slow lorises. These factors were hunting pressure, habitat destruction through logging or conversion to agricultural land, habitat disturbance through people/cattle movement, collection of firewood and non-timber forest products (NTFP), and forest fires. We also collected information on more direct survival threats to the slow loris such as electrocution, road kills, and instances of capture for pets.

Secondary information on the presence of slow loris was obtained from forest department personnel and local experts. We investigated State Forest Department records wherever maintained, for details of confiscation or rescues of captured slow lorises. When available, this provided us with the origin of the animals as well as their number, age and sex. Additional information on slow loris presence was obtained through informal, semi-structured interviews with local experts, hunters and knowledgeable elders living in the vicinity of forests. Locals were shown photographs of the slow loris to identify, and questioned to provide information on slow loris sightings over the last five years in that area.

Results

The survey was conducted from February 2009 to April 2009, and we surveyed 16 locations in six districts of Meghalaya (Table 1). The survey sites included 11 forest areas under the control of the State Forest Department (National Park, Wildlife Sanctuary, Reserve Forest) and five areas that were community-controlled forest lands. We covered 144.45 km during the course of the survey, of which 96.45 km were on foot, 39 km in four-wheel-drive vehicles, and 9 km in a non-motorised boat.

Distribution of the Bengal slow loris in Meghalaya

We saw slow loris individuals on two occasions in two different field sites. Both were adult males. One was seen in Nongkhylllem Wildlife Sanctuary (WLS) in Khasi Hills district, and the other was in the Narpuh Reserve Forest (RF) of Jaintia Hills district (Table 1). The relative abundance based on sightings in the two field sites was calculated to be 0.04 (Narpuh RF) and 0.1 (Nongkhylllem WLS). Apart from slow lorises, we also saw two species of flying squirrels, four species of viverrids and many bat species during our night transects in the different field sites. Apart from direct sightings, information collected from secondary sources such as forest department personnel and local people living near the forest areas indicated the presence of slow lorises in eight forest patches across the districts of South Garo and Jaintia Hills (Table 1).

Data gathered during the study attests that slow loris populations are present in fragmented forest patches at the southern end of South Garo Hills district, in the northern parts of Ri-Bhoi district around the Nongkhylllem Wildlife Sanctuary, and in the southern parts of Jaintia Hills district (Fig. 2). Slow loris populations may also be present in the forest patches of central East Garo Hills. However, repeated enquiries did not elicit any information on the presence of slow lorises in the southern parts of East Khasi Hills district. Indigenous people living in these areas also appeared quite unfamiliar with the species, which argues that slow lorises, if present earlier, may have become locally extinct from these parts.

Threats affecting Bengal slow loris in Meghalaya

We investigated the presence of some potential threats—hunting, capture for pets, electrocution, road kill, and man-made forest fires—on the long-term survival of the slow loris in Meghalaya (Table 2).

Hunting. Interviews with local people indicated that slow lorises were hunted for food. However, because of their small size, hunters were not interested in the species specifically

as a regular source of meat. Instead, hunting appeared to be opportunistic, and individuals were killed only when encountered accidentally, or during hunts for other mammals. There also did not appear to be a commercial trade of loris body parts, and people did not report hunting slow lorises for reasons other than for its meat.

Capture for pets. Capture of slow lorises and other primates to be kept as pets is a widespread custom in many parts of the state. This was especially evident in the Garo Hills, which has retained much of the original fauna when compared to the Khasi and Jaintia Hills. Hunters and local people said that the slow loris was a preferred pet and was captured whenever found for that reason. Sometimes, loris pets were confiscated by the forest department and released in adjacent forest patches, while in the large majority of the cases they would remain and die in captivity.

Electrocution and road kills. We did not encounter any evidence of slow loris road kills during our study; there was one report of a slow loris being electrocuted on overhead power lines near Siju WLS in Garo Hills.

Man-made fires. This is distinguished from the *jhum* (slash-and-burn cultivation) fires that are typical of the hill community-controlled forest areas. Low lying areas in Meghalaya, such as parts of Garo Hills, are extremely susceptible to fires in the dry season. These Reserve Forest areas are predominantly teak (*Tectona grandis*) or sal (*Shorea robusta*) plantations, and during the summer the forest floor is covered with dry leaves. Fires are common during this season and are almost entirely deliberate and man-made. Forest patches are usually surrounded by human habitation or fields and there is nowhere safe for the animals to flee. These fires usually prove fatal for the wildlife in these areas.

Habitat disturbance. Mining and conversion to agricultural land pose two significant habitat disturbance threats to the slow loris in Meghalaya. In large parts of the state, community-controlled forests are rapidly being converted to monoculture stands of cashew, rubber and areca nut. We did

Table 1. The presence of Bengal slow loris, *Nycticebus bengalensis*, in the state of Meghalaya, northeastern India.

	Year	Location	Secondary Information	Direct Sighting	Age/Sex	Secondary source
1	2009	Nongkhylllem WLS, Ri Bhoi District	-	×	1 adult	-
2	2009	Narpuh RF, Jaintia Hills District	-	×	1 adult	-
3	1996	Angratoli RF, South Garo Hills District	×	-	2 adults	Reported by forest beat officer
4	2002	Darugiri RF, East Garo Hills District	×	-	1 adult male	Reported by forest beat officer
5	2008	Angratoli RF, South Garo Hills District	×	-	3 adults	Reported by forest guards
6	2007-08	Sibbari-Jacksongram CRF, South Garo Hills District	×	-	2 adults 2 infants	Reported by local villager
7	2008	Dambuk adingre CRF, South Garo Hills District	×	-	1 individual	Reported by local villager
8	2004	Siju Dobakol caves, South Garo Hills District	×	-	1 adult	Reported by forest guard
9	2008	Siju Forest complex, South Garo Hills District	×	-	1 adult	Reported by forest guard, animal electrocuted on overhead wires
10	2005	Matcha nokpante CRF, South Garo Hills District	×	-	1 juvenile	Reported by local villager
11	2007	Jowai vicinity, Jaintia Hills District	×	-	1 adult	Forest department seizure
12	2008	Baghmara, South Garo Hills District	×	-	1 adult	Crossing road near the Baghmara town

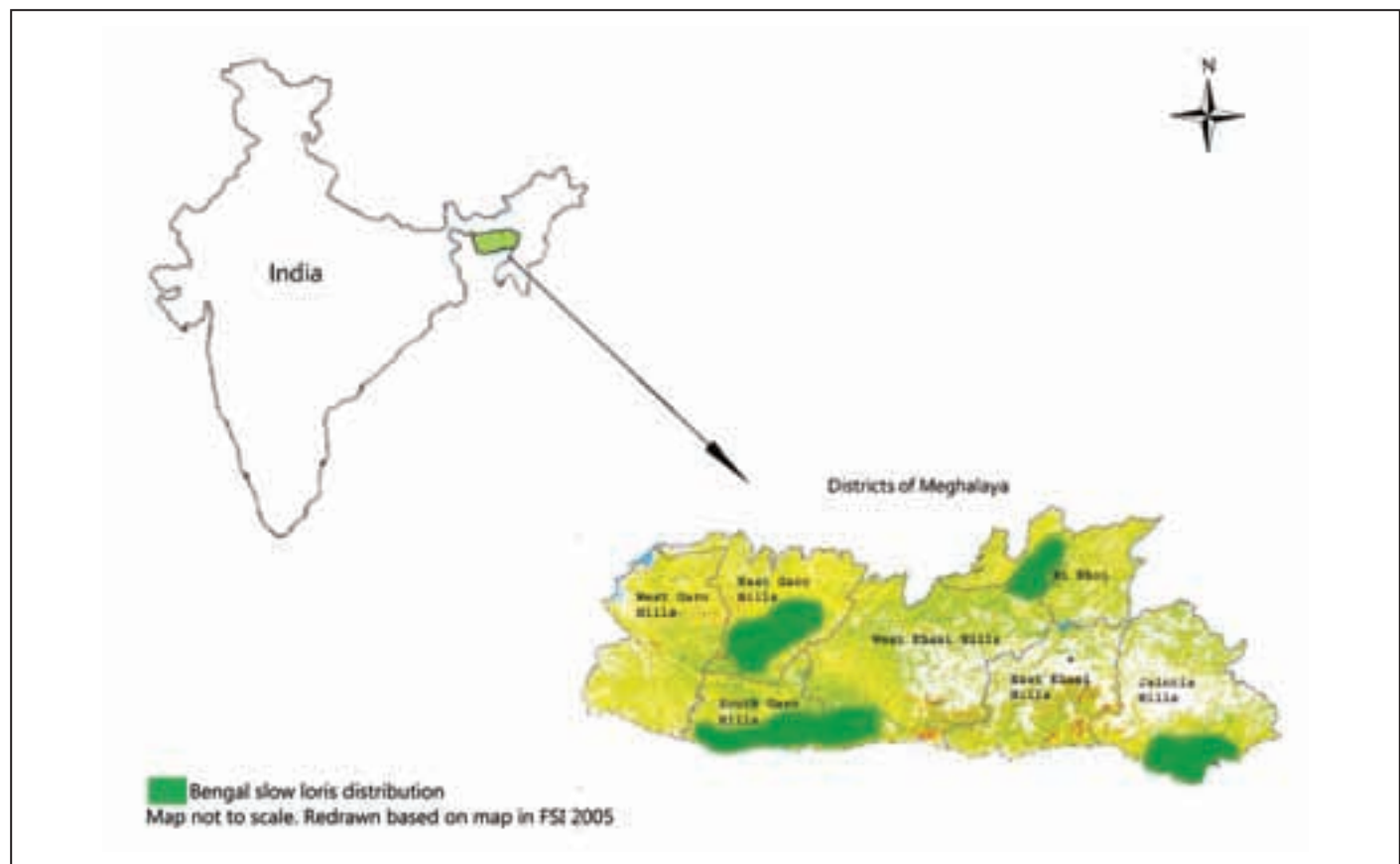
WLS=Wildlife Sanctuary, RF=Reserve Forest, CRF=Community Reserve Forest

Table 2. Threat levels and severity of fires in survey locations in the state of Meghalaya, northeast India.

	Location	Disturbance ranking*	Fire ranking*	Primary threats
1	Ringsangre/Selbalgre CRF, West Garo Hills District	+++	0	Small size, NTFP and bamboo extraction, <i>jhum</i> cultivation in the vicinity
2	Dariwokgre (Nokrek NP), West Garo Hills District	++	0	<i>Jhum</i> cultivation, firewood
3	Rongrengiri RF, East Garo Hills District	++	++++	Illegal logging, poaching, fire
4	Darugiri RF, East Garo Hills District	+++	+++	Surrounded by houses and crop fields, extensive firewood and NTFP extraction, highway, fire
5	Dambu RF, East Garo Hills District	+++	++	Incursion of cultivation and coffee plantation, highway, fire
6	Baghmara RF, South Garo Hills District	++	++	Illegal logging, poaching, highway, electric lines, fire
7	Angratoli RF, South Garo Hills District	+++	+++	Highway, electric lines, illegal logging and poaching, fire
8	Chambilgiri CRF, West Garo Hills District	++++	0	Small size, orchards and <i>jhum</i> cultivation, highway
9	Siju WLS, South Garo Hills District	+	++++	Small size, fire, coal mining
10	Rewak RF, South Garo Hills District	+++	+++	Highway, illegal logging, fire
11	Balpakram NP, South Garo Hills District	+	++	Fire, <i>jhum</i> cultivation, encroachment, coal mining
12	Matcha nokpante CRF	+++	+	<i>Jhum</i> cultivation, plantations, highway, small size, illegal logging
13	Dalengittim CRF, South Garo Hills District	+++	++	Poaching, illegal logging, firewood extraction, fire
14	Umblai, East Khasi Hills District	+++	++	<i>Jhum</i> cultivation, NTFP and firewood extraction, poaching, trapping, fire
15	Nongkhylllem WLS, Ri Bhoi District	+	+	Fire, encroachment of plantations
16	Narpuh RF, Jaintia Hills District	+++	++	Highway, encroachment, fire, water pollution

*Evaluated on arbitrary subjective scale; 0: nil; +: low; ++: medium; +++: high; ++++: very high.

CRF=Community Reserve Forest, NP=National Park, RF=Reserve Forest, WLS=Wildlife Sanctuary

**Figure 2.** Distribution of the Bengal slow loris, *Nycticebus bengalensis*, in the state of Meghalaya, northeast India.

not detect slow lorises in patches of such monocultures; our findings conformed with those of local people, who said that they had never seen slow lorises in these plantations. Habitat destruction through *jhum* is another serious threat that has increased in magnitude due to the paucity of land and increase in human population. Clear felling and the eventual burning of patches of forests is seriously detrimental to slow lorises—local people reported that lorises are sometimes found moving towards human habitation for protection during the *jhum* fires. Clear felling precedes mining, not just in the area to be mined but also in the construction of access roads. Mining has also destroyed the forests in numerous sites due to the open dumping of coal on the roadsides and river banks; a practice that causes pollution of the water and soils.

Discussion

Despite the low encounter rates of *Nycticebus bengalensis* during this study (seen in only two of 16 sites), secondary information collected during the course of the survey does indicate the presence of Bengal slow lorises in many of the forest patches in Meghalaya. It would appear, however, that the species is generally present in very low densities. That this is not an artefact of the sampling methodology is borne out by the finding that surveys for slow lorises, in the north-eastern states of Tripura and Assam, using similar methodology, have resulted in low/nil encounter rates in many sites but high encounter rates in others (Radhakrishna *et al.* 2006; Swapna *et al.* 2008; Das *et al.* 2009). Nekaris and Nijman (2007) reported that encounter rates for *Nycticebus bengalensis* are 5–15 times lower than for *Nycticebus coucang*; the results of this survey underline the need to investigate in more detail the factors affecting slow loris abundance in different parts of northeastern India.

Indigenous people living in settlements near forest areas reported many instances of slow lorises wandering out of the forest and into the villages and houses. To some extent, these statements may be attributed to the fact that the slow loris is a popular pet and an excuse for the presence of lorises in their homes (rather than having captured them from the forest). Higher encounter rates of slow lorises at forest edges have, however, been reported in previous studies (Johns 1986; Radhakrishna *et al.* 2006; N. Swapna unpubl. obs.). A more detailed investigation into this aspect of slow loris behavior will provide a deeper insight into factors affecting the long-term survival of the species.

Severe habitat disturbance, affecting most of the forest patches in Meghalaya, is clearly an important factor that affects the distribution and abundance of *Nycticebus bengalensis* in the state. Apart from age-old threats such as logging and hunting, newer threats such as man-made fires and mining has virtually decimated forest cover across the state. Man-made forest fires of different levels of severity were found in more than 80% (13 out of 16) of the survey sites. Forest fires are especially fatal for slow-moving animals such as slow lorises, and were undoubtedly a major reason for

the low encounter rate of slow lorises (and flying squirrels) during this survey.

Widespread and illegal coal and limestone mining in many parts of Meghalaya in the past has led to widespread destruction of forest cover in the Khasi Hills and Jaintia Hills, and irreversible damage to the environment in the form of polluted water bodies. This threat is now rapidly spreading in the Garo Hills district, which still has large stretches of community-controlled as well as protected areas. The lack of a mining policy in the state has resulted in wanton destruction of community forests for mining and the construction of numerous access roads. Unless conservation measures that focus on ending such destructive activities and practices are implemented urgently, it may well mean the end of the road for the few remaining populations of slow lorises and other mammals that are still found there.

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Behavioral Observations and Notes on the Vertical Ranging Pattern of the Critically Endangered Cat Ba Langur (*Trachypithecus poliocephalus poliocephalus*) in Vietnam

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Abstract: The golden-headed or Cat Ba langur (*Trachypithecus poliocephalus poliocephalus*) is endemic to Cat Ba Island in northern Vietnam. Two free-ranging groups were studied for 22 days of data collection. Behavioral data were collected via instantaneous scan sampling for determining the time budget, activity pattern and vertical ranging pattern of these groups. The langurs spent two thirds of their time resting, 15% foraging, 11% moving and 8% in social activities. Time budgets differed between age classes, with infants and juveniles spending more time being social. The activity pattern of the groups revealed that the langurs rested mostly during the morning and at midday when most of the social behavior was also observed. Foraging and moving occurred more often in the morning and afternoon, with foraging being more pronounced later in the day. With respect to their ranging, the langurs spent most of their time in the higher elevations, but foraged more in the lower elevations of the hills where they live. In this study, we show that the best time to census this Critically Endangered species is from sunrise till 12:00 am.

Key words: Cat Ba langur, golden-headed langur, *Trachypithecus poliocephalus poliocephalus*, time budget, activity pattern, vertical ranging pattern

Introduction

Vietnam has a high diversity of primates; 25 species and subspecies of primates are known to occur there (Fooden 1996; Roos *et al.* 2007; Van Ngoc Thinh *et al.* 2010). However, a fast developing economy combined with illegal wildlife trade, habitat degradation and hunting has led to population declines in all species (Lippold and Vu Ngoc Thanh 1998). Currently, five of the world's 25 most endangered primates are found in Vietnam (Mittermeier *et al.* 2009).

One of these five species, arguably the most endangered in Vietnam (Schrudde *et al.* 2009), is the golden-headed or Cat Ba langur, *Trachypithecus poliocephalus poliocephalus* (Trouessart, 1911), which occurs only on Cat Ba Island in northern Vietnam (Schrudde *et al.* 2009). It belongs to the subfamily of the leaf eating monkeys (Colobinae) and has the smallest distribution of any of the langur species (Nadler *et al.* 2007). Cat Ba langurs are classified as Critically Endangered on the IUCN Red List (IUCN 2009) as a result of illegal hunting, which has led to small, isolated subpopulations and low population numbers. Poaching has resulted in a serious population decline from an estimated 2,400–2,700 individuals in

the 1960's (Nadler and Long 2000) to only 52–54 individuals in 2000 (Stenke 2003). Concerned about the declining numbers, in 2000, Münster Zoo and the Zoological Society for the Conservation of Species and Populations (ZGAP) founded the Cat Ba Langur Conservation Project (CBLCP). The project's implementation of strict protection measures, such as the Langur Guarding Program, and the establishment of a langur sanctuary, has led to an increase in population numbers to 60–70 Cat Ba langurs at present (Schrudde *et al.* 2009). The remaining individuals at the time of writing are fragmented into six subpopulations of which some are all-female groups while others are isolated on small offshore islands.

Little information is available concerning the ecology and biology of the Cat Ba langur. Research on daily behavior patterns especially can provide crucial data for the conservation management of the Cat Ba langur with respect to population monitoring. The Cat Ba langur shows strict behavioral adaptations to its preferred limestone karst hill habitat. Throughout the year, for example, it sleeps in caves (Nadler and Long 2000). The Cat Ba langur is one of a number of karst-dwelling leaf monkeys that includes another five or six taxa of the *T. francoisi* group (Groves 2001, 2004; Schrudde

et al. 2009) of which the white-headed langur (*Trachypithecus p. leucocephalus*) in China is its closest relative. Little is known about the ecology and behavior of the *T. francoisi* group, which makes reference material scarce. Investigating the behavioral adaptation of this species to its habitat could help to understand the species' biology and conservation requirements. Furthermore, data about the vertical ranging behavior of a species can provide important information for conservation and management programs (Clemmons and Buchholz 1997; Caro 1998). This paper describes the daily time allocation to different activities and the vertical ranging behavior of two wild groups of Cat Ba langurs.

Methods

Study area

Fieldwork was conducted on Cat Ba Island in Hai Phong Province, northern Vietnam (20°42'–20°54'N and 106°54'–107°09'E). Cat Ba Island (140 km²) is part of the Cat Ba Archipelago which consists of 366 offshore islands (Viet and Lin 2001). The climate is humid, subtropical monsoon, with wet and dry seasons (Nadler and Long 2000). The wet season lasts from May to September and the dry season from November to March. The mean annual rainfall is 1,900 to 2,100 mm, and annual temperatures range from 23°C to 28°C (Viet and Lin 2001). More than half of the main island is covered by the Cat Ba National Park, including the study area. The study site covered an area of about 0.6 km², and is directly connected to human settlements and frequently used boat routes in the

west. The area consists largely of vertical limestone cliffs, up to 300 m above sea level, with the slopes mostly covered with dense bushy vegetation (Nadler and Long 2000). Moist tropical limestone forest is found at the lower elevations.

Data collection and analysis

Two family groups of Cat Ba langurs (GR6 and GR10, Table 1) were observed on 22 observation days (52.6 h total observation time) during April and May 2009. GR6 and GR10 were observed on 17 (34.2 h) and 8 days (18.4 h) respectively. The duration of the observations ranged from 10 minutes to 6 hours (continuous). Observation days started at 06:00 and ended usually at 18:00 when the langurs moved to their sleeping caves. We were unable to follow the groups because they were not habituated and because of the difficult terrain. Several fixed hilltop positions, providing a good overview of the area, were used to observe the langurs (with binoculars 7 × 50). On six days, observations were made by boat/kayak along the coastline to catch the langurs emerging from or returning to their sleeping caves, which faced the open water and were not visible from the fixed observation points.

Behavioral data was collected using instantaneous scan sampling (Martin and Bateson 1993). Individual langurs could not be identified because they were generally too far away; up to 300 m from the observers. The scan interval was set at two minutes, and individuals were observed cyclically, scanning the entire group from left to right. The following behavior categories were recorded: moving, resting, foraging and social behavior. Foraging was defined as the active intake

Table 1. Age and sex composition of the two free-ranging study groups of Cat Ba langurs, *Trachypithecus p. poliocephalus*.

Group	No. of adult males	No. of adult females	No. of adults of unknown sex	No. of Juveniles	No. of Infants	Total
GR6	2	2	2	0	0	6
GR10	1	2	3	2	2	10



Figure 1. *Trachypithecus p. poliocephalus* adults, juveniles and infant of group GR10 at the study site. At the time the photograph was taken GR10 comprised six adults, two juveniles and two infants. The pelage gradually changes from all orange in infants to black with golden-yellow heads in adults. Photo by Johanna Rode, 2009.



Figure 2. Floating village adjacent to the study site and the home ranges of GR6 and GR10. Human settlements close to the Cat Ba langur's habitat still pose a threat. Photo by Isabell Schneider, 2009.

of food and searching for food items (examining vegetation). Social behavior included grooming activities and playing (running, jumping or play-fighting with one another or alone). Individuals that could not be seen during the scans were marked as 'out of sight'. When the langur groups went out of sight during the observation, the observers waited for them to reappear. The langurs were classified into three age groups according to size and fur color: infants (completely orange), juveniles (golden-yellow head, shoulders and extremities) and adults (golden-yellow to creamy-white heads).

Their use of the different elevations on the cliffs and hills was recorded at each scan. Four levels were distinguished. At each scan we noted where the majority of the langurs were to be found: top (upper third of the hill or cliff), middle (middle third), bottom (lowest third) or valley (lowland).

For the data analysis, we calculated total counts of each behavior. For the analysis of the activity pattern, we pooled behavior records into six time-intervals, each of two hours, starting at 06:00 and ending at 18:00. The time the langurs spent in each behavior was then calculated as a percentage of the total count of all behaviors a) per age class (time budget), b) per time interval (activity pattern), and c) per elevation level (ranging pattern). The time the langur groups were observed in each time interval (time seen) was calculated as a percentage of the total observation time (52.6 h). The Friedman Test (SPSS 15.0) was used to examine differences between the means for each behavior category based on 22 (time budget) and 21 (activity pattern) sample days.

Results

Time budget

One or more individuals were out of sight for the majority of observations (55% of the time). The Cat Ba langurs spent

on average 66% of their time resting. Considerably less time was spent moving (11%) and foraging (15%), and in social behavior, which accounted for 8% of their daily activities.

The time budgets of adult and juvenile langurs were similar (Fig. 3), but infants spent one-third (33%) of their daily activities in social behavior, which included playing. Adult Cat Ba langurs, on the other hand, spent the least time of all age classes in social behavior (6%) and the most time resting (69%).

Activity patterns

The daily activity pattern of the adult langurs was described using six time intervals of two hours each. Analysis showed that their behavior was significantly related to time of day (Friedman Test: $\chi^2 = 39.970$, $df = 23$, $p < 0.05$) (Fig. 4). They rested more in the morning to the early afternoon, between 08:00 and 14:00. Generally, the time the langurs spent resting decreased towards the end of the day. Foraging, on the contrary, showed a bimodal distribution during the day. Inversely to the pattern in resting behavior, foraging increased towards the end of the day (14:00–18:00). Social behavior was observed most around midday (10:00–14:00), while the time spent moving did not vary notably during the day.

Our data showed that the groups were more visible between 06:00 and 10:00 (17.1% and 24.0%) and especially between 14:00 and 16:00 (18.4%). 'Out of sight' rates were lowest between 08:00 and 12:00 (48.1% and 48.0% respectively).

Vertical ranging pattern

The langurs spent more than half of their time in the top section of the hills (58%). The middle section was used for 29.5% of the time and the lowest part of the hill for 10.3%.

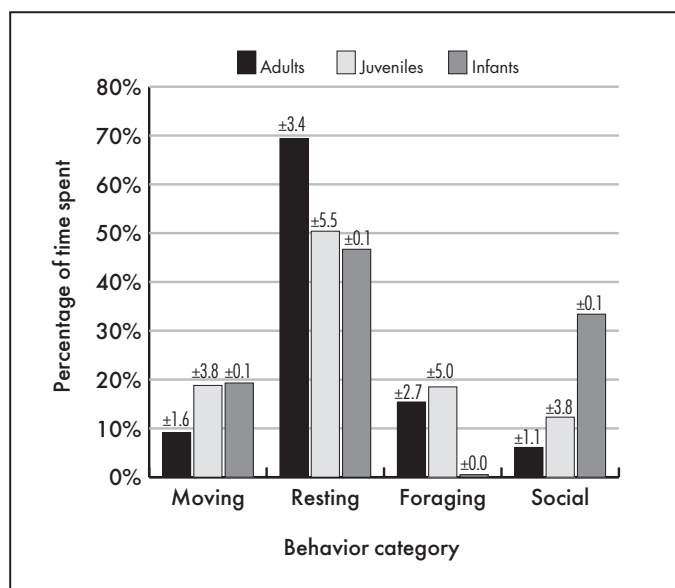


Figure 3. Comparison of time budgets (mean \pm SE) between age classes for GR6 and GR10 combined (Adults: out of sight 53%; Juveniles: out of sight 66%; Infants: out of sight 65%).

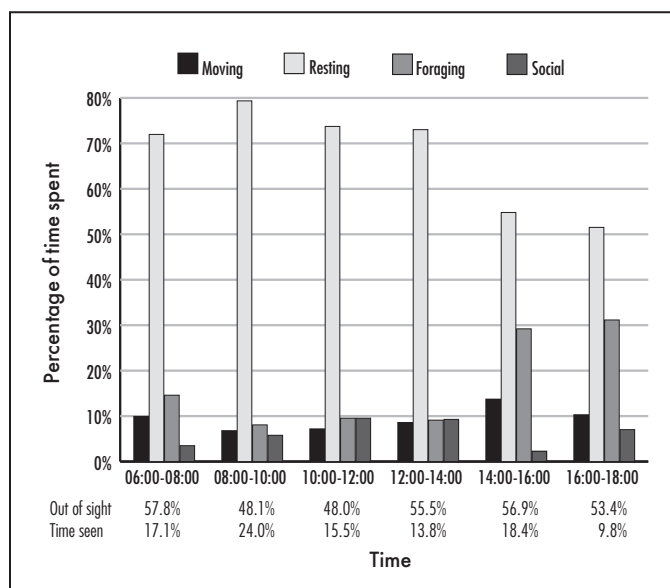


Figure 4. Daily activity pattern of adult langurs of groups GR6 and GR10 for six time intervals between 06:00 and 18:00. Percentages of 'Out of sight' and 'Time seen' of the langurs are given for each interval.

They only spent 2.2% of the time in the valley. Generally, the langurs moved from one elevation to another 1.5 times per hour. The langurs spent more time resting on the hill slopes and cliffs, and especially near the top, than elsewhere. The time spent in social behavior decreased as they descended, and social behavior was not observed at all in the valley. Foraging activity increased considerably in the lower elevations and was predominant in the valleys (Fig. 5).

Discussion

In this study the langurs were often difficult to see when in the dense vegetation which, as pointed out by Plowman (2006), can lead to underestimation of the frequency of certain behaviors. The fact that we observed the langurs only

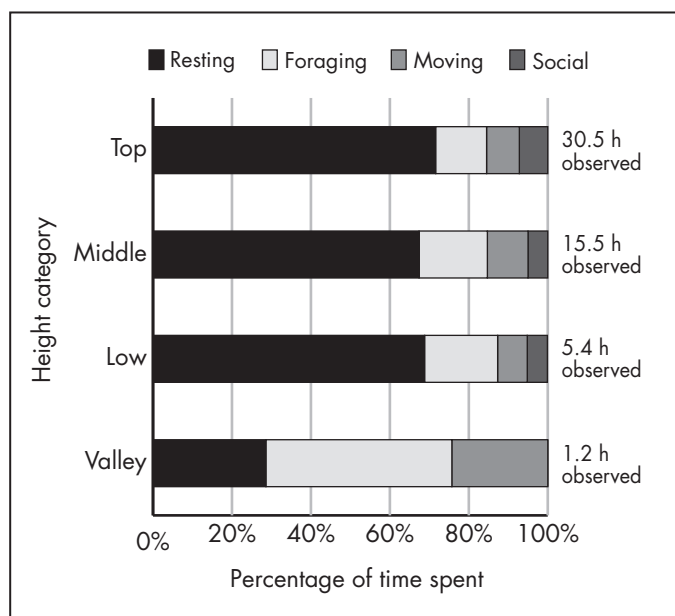


Figure 5. Behaviors displayed in different elevations (GR6 and GR10 combined) and the number of hours that the langurs were recorded in each.



Figure 6. Limestone karst hills on Cat Ba Island are the prime habitat for *Trachypithecus p. poliocephalus*. The densely vegetated lower slopes of the hills offer abundant food for the Cat Ba langurs. Photo by Pieter Levelink, 2010.

from some distance away might likewise have led to the frequency of some behaviors being underestimated and others overestimated. Resting and foraging were at times difficult to distinguish and small movements of the hands were difficult to see with the result that foraging as a behavior category may have been underestimated.

The results of this study show similarities as well as differences in the behavior patterns and spatial distribution of Cat Ba langurs compared to other species of the *Trachypithecus francoisi* group of karst langurs. The time budget of the folivorous colobines is largely influenced by their diet. They spend the majority of their time resting and considerably less time feeding and moving (Clutton-Brock 1977; Stanford 1991; Fleagle 1999), and this is evidently the pattern for the two Cat Ba langur groups that we have studied. Infants and juveniles spent considerably more time than the adults in social behavior—grooming and playing. The same is true for the white-headed langur (Li and Rogers 2004), and is associated with their physical and behavioral development and socialization (Poirier *et al.* 1978).

The langurs spent much of their day resting, especially in the morning hours and around mid-day up to 14:00 (more than 70% of each 2-hour period). Other langurs such as Francois' langur (Zhou *et al.* 2007), the Yunnan snub-nosed monkey (*Rhinopithecus bieti*) (Ding and Zhao 2004) and the white-headed langur (Huang *et al.* 2003) are similar in this respect. The two groups spent less time resting in the afternoon (50% to 55% of the two 2-hour periods from 14:00 to 18:00) and more time foraging. Duc *et al.* (2009) found that, while eating similar amounts of leaves through the day, the black-shanked douc langurs (*Pygathrix nigripes*) they studied ate more fruits (energy-rich) in the morning. They argued that this was to compensate for an energy deficit that they accumulate during the night (as suggested Clutton-Brock 1977; Oates 1987). Perhaps for this reason, the Cat Ba langurs spent a little more time foraging early in the morning (about 15% of the time from 06:00 to 08:00) but less than 10% of their



Figure 7. View from one of the fixed observation points showing the preferred limestone karst hill habitat of the Cat Ba langurs on Cat Ba Island. Photo by Johanna Rode, 2009.

time foraging for the rest of the morning and early afternoon up to 14:00. Lacking fruit for this purpose the langurs may be expected to rest more in order to save energy (Ding and Zhao 2004). Considerably more time was spent foraging in the afternoon (around 30%). Morning and afternoon foraging periods and similar patterns of moving have also been found for the white-headed langur (Huang *et al.* 2003), Francois' langur (Yang *et al.* 2007), the Yunnan snub-nosed monkey (Ding and Zhao 2004), and the Nilgiri langur (*Semnopithecus johnii*) (Sunderraj 1998). The preponderance of social activities around noon shown by the Cat Ba langurs has not been mentioned for other langur species.

Time budgets are in most cases influenced by seasonal changes in temperature. Stanford (1991) observed that from summer to winter, capped langurs (*T. pileatus*) increased their time resting from 26% to 41%, and decreased feeding time from 41% to 27%. Huang *et al.* (2003) also found that midday resting periods of the white-headed langur were related to season; their study group spent less time resting in winter (57%) than in Spring (79%) or Summer and Autumn (84%). We studied the Cat Ba langurs in the early summer when the rainy season begins. This would suggest that the time spent resting by Cat Ba langurs would be less in the winter periods and even more in the summer months. This seasonal variation in time budget could influence the probability of observing the langurs, and thus the efficiency of the monitoring program. Long-term research on time budgets of the Cat Ba langurs is required for that reason.

The results of this study show that the Cat Ba langurs spent most of their time on the highest reaches of the cliffs and hills. This contrasts with the study of Li and Rogers (2005) on the white-headed langurs, which were found to use the lower slopes most of the time (60%). Li and Rogers (2005) suggested that this resulted from a preference for the less fragmented and less disturbed habitats found in the denser vegetation of the lower slopes and valleys in the Fusui Precious Animal Reserve where they lived. Like Fusui, the vegetation in the study area on Cat Ba Island was taller and less fragmented on the lower slopes of the hills but the langurs still used the upper slopes more often. This may indicate that the vertical ranging of the langurs was not directly influenced by the vegetation but by hunting. Cat Ba langurs do not have natural predators but have experienced severe hunting in the past (Nadler and Long 2000; Schrudde *et al.* 2009) and are still threatened by the presence of humans close by. Likewise, white-headed langurs were reluctant to go to the ground when humans were near (Li and Rogers 2005).

The Cat Ba langurs called a lot when on the upper slopes, perhaps to maintain contact, perhaps to alert group members of predators, convey behavioral states, attract mating partners or in territory defense (Eschmann *et al.* 2008).

With respect to their vertical ranging behavior, the langurs tended to rest when on the upper slopes of the hills. Tarsiers and baboons do the same (Fleagle 1999), possibly to avoid predation when they are inactive. The same reasoning would apply for the social behavior which decreased on the lower

slopes the hills, as the vigilance levels in primates are usually lower during grooming (Cords 1995). The Cat Ba langurs spent more time foraging on the lower slopes of the hills. The same was found for white-headed langurs, which carried out their maintenance activities such as feeding in the lower and middle slopes (Li and Rogers 2005) as a result of high food diversity (Huang *et al.* 2008). However, one must be careful with these conclusions as the sample size differed for each elevation level, and was especially small for the valley.

Overall, studies on closely related species such as the white-headed langur and Francois' langur suggest that vertical ranging patterns and their activity budgets are strongly dependent on food availability, food diversity and probably human presence. This study has discovered similar dependencies for the Cat Ba langurs. Their vertical ranging pattern is likely adapted to the abundant food in the lower parts of the hills as well as to possible threats from humans. However, since food availability/diversity and human presence have not been measured quantitatively in this study we propose further research in this direction to find possible limiting factors in the distribution of Cat Ba langurs across the island.

In our study, the langurs were most often seen between 06:00 and 10:00, while observations in the afternoon were limited to the period between 14:00 and 16:00. The fact that the langurs were seen less in the late afternoon could be explained by their return to the sleeping caves, which generally faced the open water and were obscured from our observation posts. When censusing the population it is essential to detect all individuals of a group, and we found that most individuals were usually seen between 08:00 and 12:00 in the morning, when 'out of sight' rates were smallest for both study groups. The crucial time for monitoring would be from 08:00–10:00, while the optimal hours for detecting all individuals of a group would be until 12:00. Keeping in mind that there is a potential seasonal effect on the time budget, which could alter the probabilities of observing the langurs and getting good counts, the most favorable hours for monitoring could be different in the summer and winter periods.

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Morphometric Assessment of Rhesus Macaques (*Macaca mulatta*) from Bangladesh

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Abstract: The natural distribution of rhesus macaques (*Macaca mulatta*) extends from South to East Asia, with substantial morphological variation among populations from different geographic locations. In the following report we compare morphometric measurements from rhesus macaques from Bangladesh to measurements from free-ranging rhesus in Nepal and captive rhesus populations originating in China and India. Our data indicate that Bangladeshi rhesus are morphologically similar to populations in South Asia, particularly India, and distinct from rhesus macaques originating in China. Our results also indicate that relative to the South Asian population samples, the rhesus macaques originating from China are distinct morphometrically.

Key words: Macaques, Asia, morphology, growth, evolution, Bangladesh

Introduction

Rhesus monkeys are among the best studied of the nonhuman primates owing to their wide use as models for studying human physiology and disease. Their natural range extends from Afghanistan in the west to the eastern-most edge of China and south through central Thailand, and includes a variety of ecological niches. Rhesus macaques are among the handful of nonhuman primate species capable of thriving in human-altered environments, including densely populated urban areas. Research on Bangladeshi rhesus monkeys has provided data on their distribution, conservation status (Green 1978; Gittins and Akonda 1982; Khan and Ahsan 1986; Feeroz *et al.* 1995a; Feeroz 2001), ecology, behavior (Feeroz *et al.* 1995b; Taslima 2002; Sarker *et al.* 2005) and genetics (Feeroz *et al.* 2008). Feeroz *et al.* (1995a) described coat color variation in different local populations of rhesus macaques. To date, however, no morphological analysis of Bangladeshi macaques has been published. Morphometric analyses of other rhesus populations (see Smith *et al.* 1987; Smith and Scott 1989; Smith 1994; Clarke and O'Neil 1999; Hamada *et al.* 2005; Taylor and Schillaci 2008) provide a context for the present comparative intra-species study.

Methods

Between 2006 and 2008, 47 rhesus macaques (*Macaca mulatta*) from five sites in Bangladesh were trapped in conjunction with a large study on simian retroviruses in Asia (Jones-Engel *et al.* 2008) (Fig. 1). The sex and age-class distribution for the sample population is shown in Table 1. A number of morphological measurements were collected while the monkeys were under sedation (Table 2). Monkeys were placed in one of four age categories, based on their pattern of dental eruption and the occlusal wear of the adult third molars (Table 3). We compared these measurements to measurements taken on Nepalese macaques in 2005 (included in Table 1) and to previously published morphometric data from Indian and Chinese rhesus macaques (Hamada *et al.* 2005).

Univariate comparisons of adult morphometric variables were conducted using t-tests, and the nonparametric Mann-Whitney U-test. Growth patterns were assessed by plotting raw values by age category. A multivariate assessment of morphometric variation was achieved through principal components analysis of adult means, and through a cluster analysis of principal component scores.

Results

The results from our univariate comparison revealed significant differences between the Bangladesh adult female rhesus macaques and the adult female rhesus from Nepal in bizygomatic breadth and bifrontal breadth (Table 4).

Table 1. Maximum sample sizes for age- and sex-specific groupings for the free-ranging Bangladesh and Nepal sample populations.

Age category	Bangladesh		Nepal	
	♀	♂	♀	♂
Young juvenile	3	2	5	4
Juvenile	6	5	6	2
Older juvenile	10	1	1	0
Subadult	2	0	0	0
Adult	11	7	9	10
Total	32	15	21	16

Table 2. Morphometric variables used in the study.

Variable	Definition
Body weight	Weight in kilograms
Trunk length	Linear distance between the sternal notch and the superior margin of the pubic symphysis, measured with a flexible metal measuring tape
Foot length	Maximum length of the foot measured with spreading calipers
Tail length	Length measured from the craniodorsal margin of the first caudal vertebra to the tip of the tail
Bizygomatic breadth	Maximum breadth between the lateral margins of the zygomatic arches measured with spreading calipers
Bifrontal breadth	Maximum breadth between the lateral margins of the frontozygomatic suture measured with spreading calipers
Skull length	Maximum length between prosthion and inion measured with spreading calipers

A significant difference in foot length between adult females from Bangladesh and India was detected, as was a difference in tail length between adult females from Bangladesh and adult females from China. The adult males from Nepal and China differed significantly from the adult males from Bangladesh in trunk and foot lengths. The Chinese adult males also differed significantly from the Bangladesh males in body mass.

Among the populations included in the analysis, the Bangladesh sample exhibited the lowest level of sexual dimorphism. The Bangladesh sample also showed the least variation in sexual dimorphism across traits. A similar condition was observed for the sample from India. The population samples from Nepal and China both exhibited a level of sexual dimorphism approximately 1.12 times greater than that observed for the Bangladesh sample.

Our evaluation of male and female growth for the Bangladesh sample revealed similar patterns of growth until age

Table 3. Age categories based on dental eruption patterns.

	Age Category	Approximate age range ¹	Definition
1	Young juvenile	0.43 to 1.32 years	Complete eruption of deciduous dentition observed without eruption of any adult first molars
2	Juvenile	1.32 to 3.15 years	Eruption of any of the adult first or second incisors without eruption of the adult second molars
3	Older juvenile	3.15 to 4.04 years	Eruption of the adult second molars and premolars without eruption of the adult canines
3.5	Subadult	4.04 to 6.40 years	Eruption of canines without complete eruption of the third molars.
4	Adult	>6.40 years	Complete eruption of adult third molars

¹ based on dental eruption schedule presented in Smith *et al.* (1994).

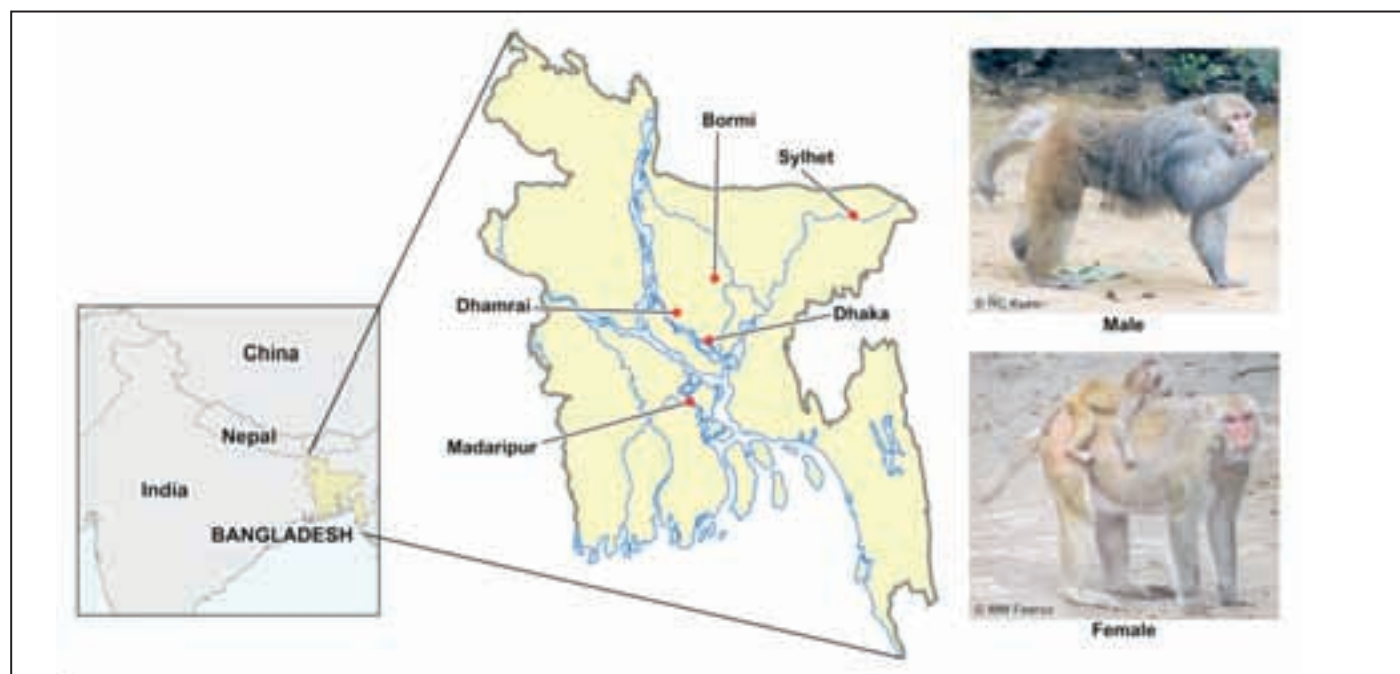


Figure 1. Map of Bangladesh showing the locations of the populations included in the study with photo inserts of *M. mulatta* adult male and female from Bangladesh.

category 3 (approximately 3 to 4 years of age), at which time females exhibit slower rates of size increases (Fig. 2). A comparison of the growth patterns of the Bangladesh and Nepal samples revealed similar patterns with some minor differences apparent for both males and females (Fig. 3). Small sample sizes for some age categories, however, limit interpretation of small pattern differences.

The results from the multivariate analysis suggest that the Chinese macaques are distinctive when all variables are considered simultaneously. A plot of the first two principal components that explain over 89% of the total variation revealed separation of males and females along the first principal component, and separation of the Chinese male and female samples from the South Asian samples along the second principal component (Fig. 4). All positive eigenvector loadings for the first principal component indicate that it describes size variation, while subsequent components describe variation in shape (Table 5). A plot of second and third principal components describing over 92% of the shape variation again shows that the Chinese samples are distinct (Fig. 5). The eigenvector directions and magnitudes mapped onto the bivariate plot of shape components indicates the second component is defined by variation in tail length relative to body mass and foot length. The Nepal and Indian samples are separated along the third principal component which is defined primarily by variation in bizygomatic breadth and trunk length.

A UPGMA cluster analysis of the second and third principal components describing shape variation grouped the samples from India and Bangladesh together. The Nepal samples joined the India and Bangladesh grouping to form a larger cluster to the exclusion of the Chinese samples (Fig. 6). Two primary groups are therefore apparent: one South Asian and one East Asian.

Discussion

To date there has been no systematic characterization of the morphology of rhesus macaques from Bangladesh. The results of our study suggest that the rhesus macaques from Bangladesh are more similar morphometrically to rhesus macaques from South Asia, particularly India. The rhesus macaques of Chinese origin are distinct. Short tail length seems to be the primary trait distinguishing the Chinese rhesus from the South Asian samples. Fooden (2000) indicated that tail length in *M. mulatta* does vary slightly with latitude (also see Fooden and Albrecht 1999), consistent with Allen's rule (Allen 1877). More interesting, perhaps, is Fooden's observation of a strong negative correlation between tail length and longitude. The Chinese rhesus in the present study exhibited the shortest tails.

The female macaques from Bangladesh exhibited a mean body weight (7.73 kg, SD=1.43) generally comparable to the other populations in the study, but much larger than the species average reported by Fooden (2000) (5.34 kg, SD=1.34). A similar condition was observed for male body weight. In our study, the male rhesus macaques exhibited the lowest mean body weight estimate (8.66 kg, SD=2.66) among the geographic populations. This estimate, however was greater than Fooden's (2000) reported mean male body weight for the species (7.70 kg, SD=2.33). The reason for this difference is not immediately apparent but may be a product of provisioning or access to human food sources (e.g., crops or garbage) for our Bangladesh and Nepal populations.

A comparison of male and female growth patterns for the Bangladesh sample revealed divergent trajectories after age category 3 (approximately 3 to 4 years of age), eventually leading to observed dimorphism in adult dimensions. This sexual dimorphism is more pronounced for cranial traits than for body weight and trunk length. Interestingly, the overall level of sexual

Table 4. Comparison of adult body size variables among populations of *M. mulatta*. Shaded values differ significantly ($\alpha=0.05$) from those observed for the population sample from Bangladesh.

	Bangladesh			Nepal			India			China		
	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n
Female												
Body mass	7.73	1.43	10	6.9	1.26	5	7.90	1.90	17	7.80	1.40	36
Trunk length	35.57	2.20	10	36.10	2.44	8	34.23	2.83	16	35.63	2.14	36
Foot length	15.45	0.71	10	15.02	0.61	5	14.71	0.89	13	15.99	0.80	24
Tail length	23.09	2.37	10	21.98	2.18	8	22.09	1.80	16	18.86	1.58	14
Bizygomatic br.	81.45	5.47	11	76.19	5.88	8	82.90	5.20	13	84.20	3.80	23
Bifrontal br.	69.27	2.83	11	66.33	2.16	9						
Skull length	114.0	4.49	10									
Male												
Body mass	8.66	2.66	7	9.76	1.47	9	9.80	2.50	6	12.10	1.80	15
Trunk length	37.11	2.49	7	40.06	1.80	8	37.25	3.75	6	39.62	2.56	15
Foot length	16.41	1.42	7	18.01	0.92	9	16.17	1.22	5	17.77	1.15	10
Tail length	25.71	4.18	7	26.33	1.97	8	24.96	0.99	6	21.77	3.26	9
Bizygomatic breadth	91.00	8.41	7	90.20	7.14	8	96.80	10.50	5	96.60	4.30	11
Bifrontal breadth	74.67	4.72	6	74.19	2.90	8						
Skull length	123.43	8.34	7									

Note: Formal comparisons between the Bangladesh samples and those from India and China were made using a t-test based on published estimates of means and standard deviations, while comparisons made between the samples from Bangladesh and Nepal were made using a Mann-Whitney U-test based on the raw data

dimorphism in the Bangladesh sample is low relative to the other population samples. The observed differences in sexual dimorphism invites speculation that there may be variation within the species in the magnitude of male-male competition for mates.

In conclusion, the results of our comparative morphometric study of the rhesus macaques from Bangladesh indicates this population is broadly similar to other South Asian populations, but differs, like other South Asian populations, from the rhesus macaques of Chinese origin.

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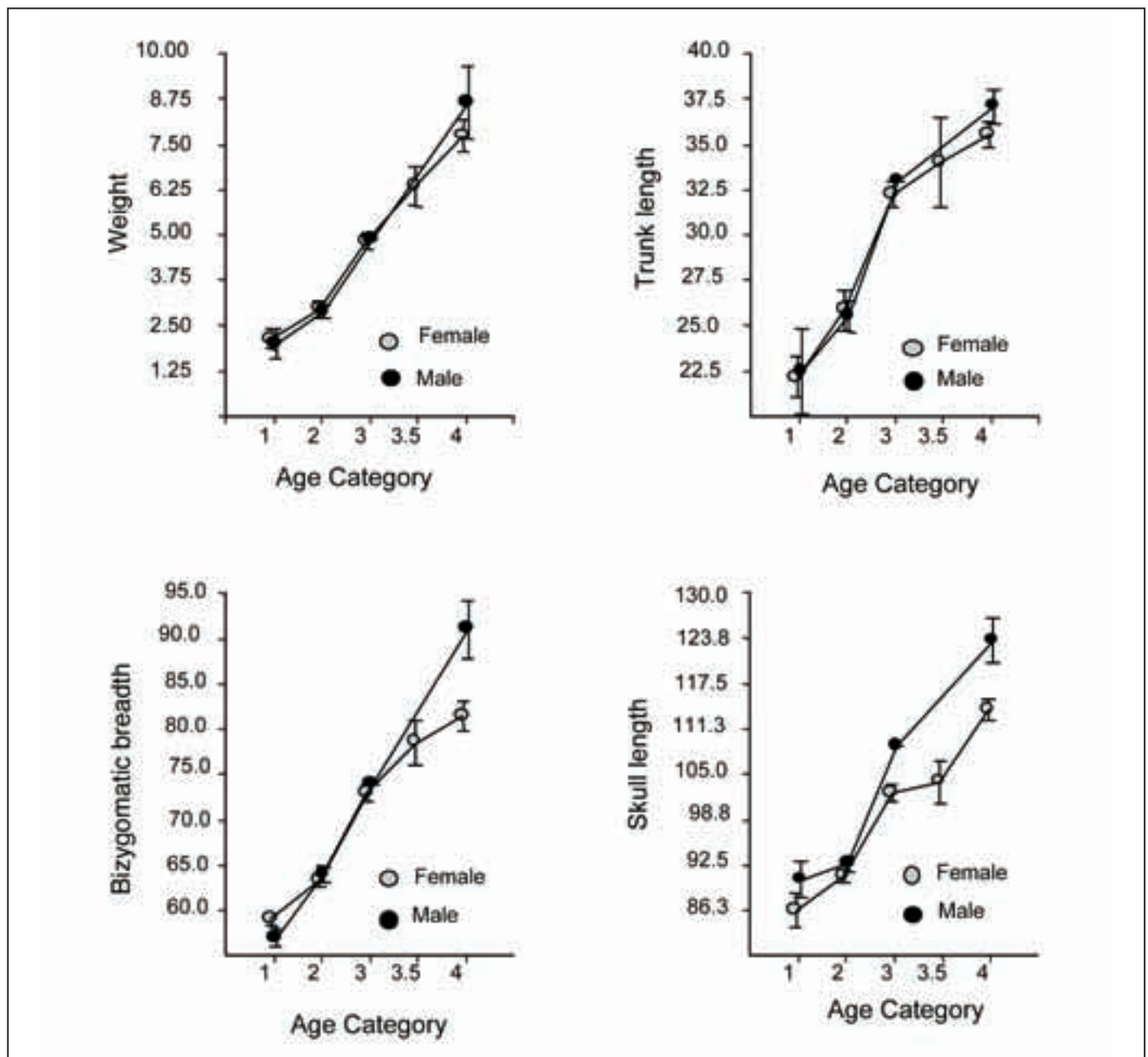


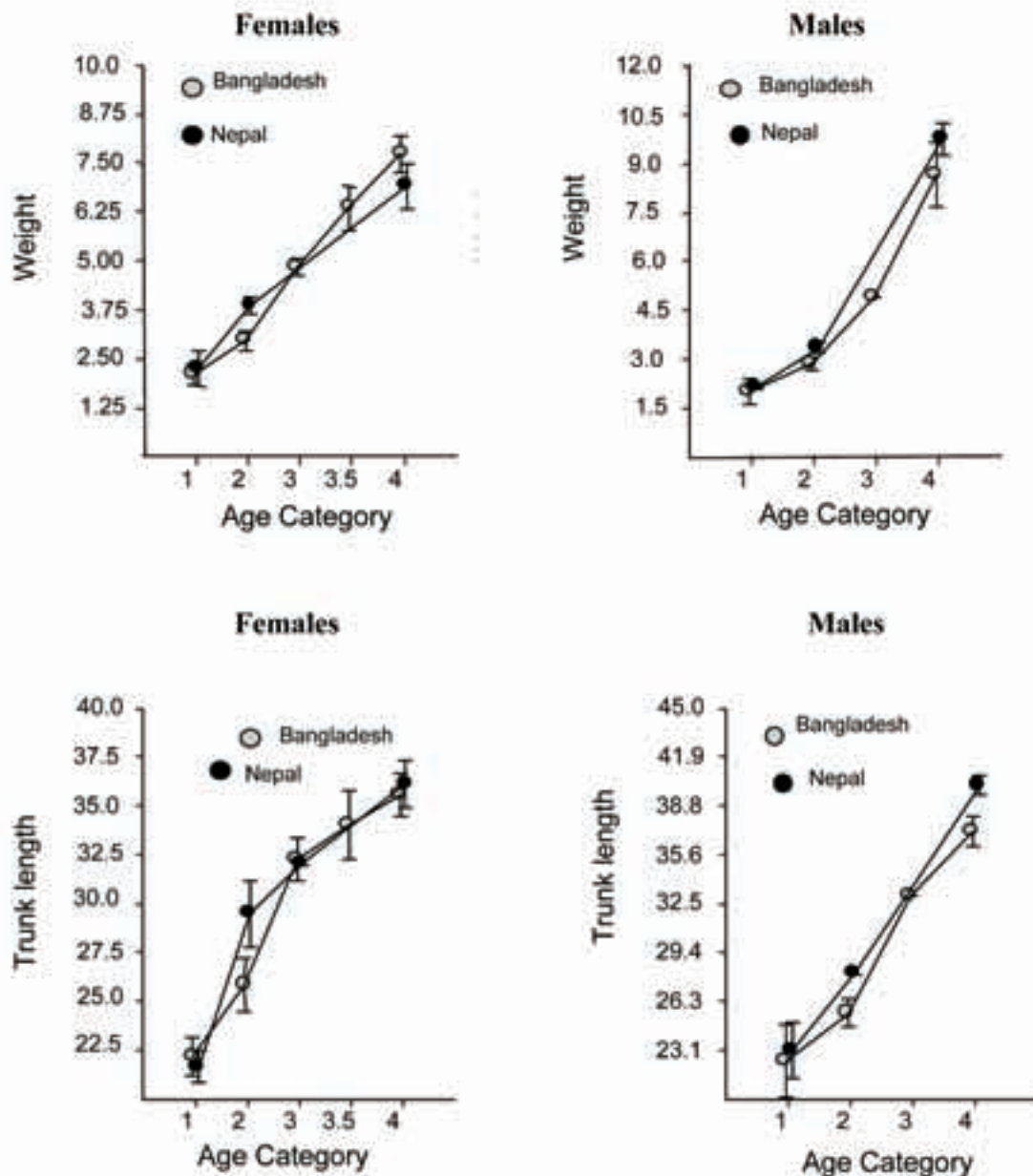
Figure 2. Bivariate plots describing sex-specific growth trajectories.

Table 5. Sexual size dimorphism scores for adult *Macaca mulatta*¹.

	Bangladesh	Nepal	India	China
Body mass	1.120	1.414	1.241	1.551
Trunk length	1.043	1.110	1.088	1.112
Foot length	1.062	1.199	1.099	1.111
Tail length	1.113	1.198	1.129	1.154
Bizygomatic breadth	1.117	1.184	1.168	1.147
Mean	1.091	1.221	1.145	1.215
Median	1.113	1.198	1.129	1.147
Range	0.077	0.304	0.153	0.440

¹ Sexual dimorphism scores calculated as the male mean/female mean**Table 6.** Eigenvector loadings and eigenvalues from the principal components analysis of adult means.

Variable	PC1	PC2	PC3	PC4	PC5
Weight	0.480	-0.330	0.266	-0.681	0.355
Foot	0.490	-0.121	-0.442	0.512	0.537
Trunk	0.488	0.007	-0.519	-0.211	-0.669
Tail	0.279	0.931	0.113	-0.124	0.166
Bizygomatic	0.461	-0.099	0.673	0.463	-0.332
Eigenvalue	3.663	0.816	0.426	0.073	0.022
% of variation	73.258	16.322	8.516	1.489	0.431
Cumulative %	73.23	89.55	98.07	99.56	100

**Figure 3.** Bivariate plots describing growth trajectories for the Bangladesh and Nepal samples.

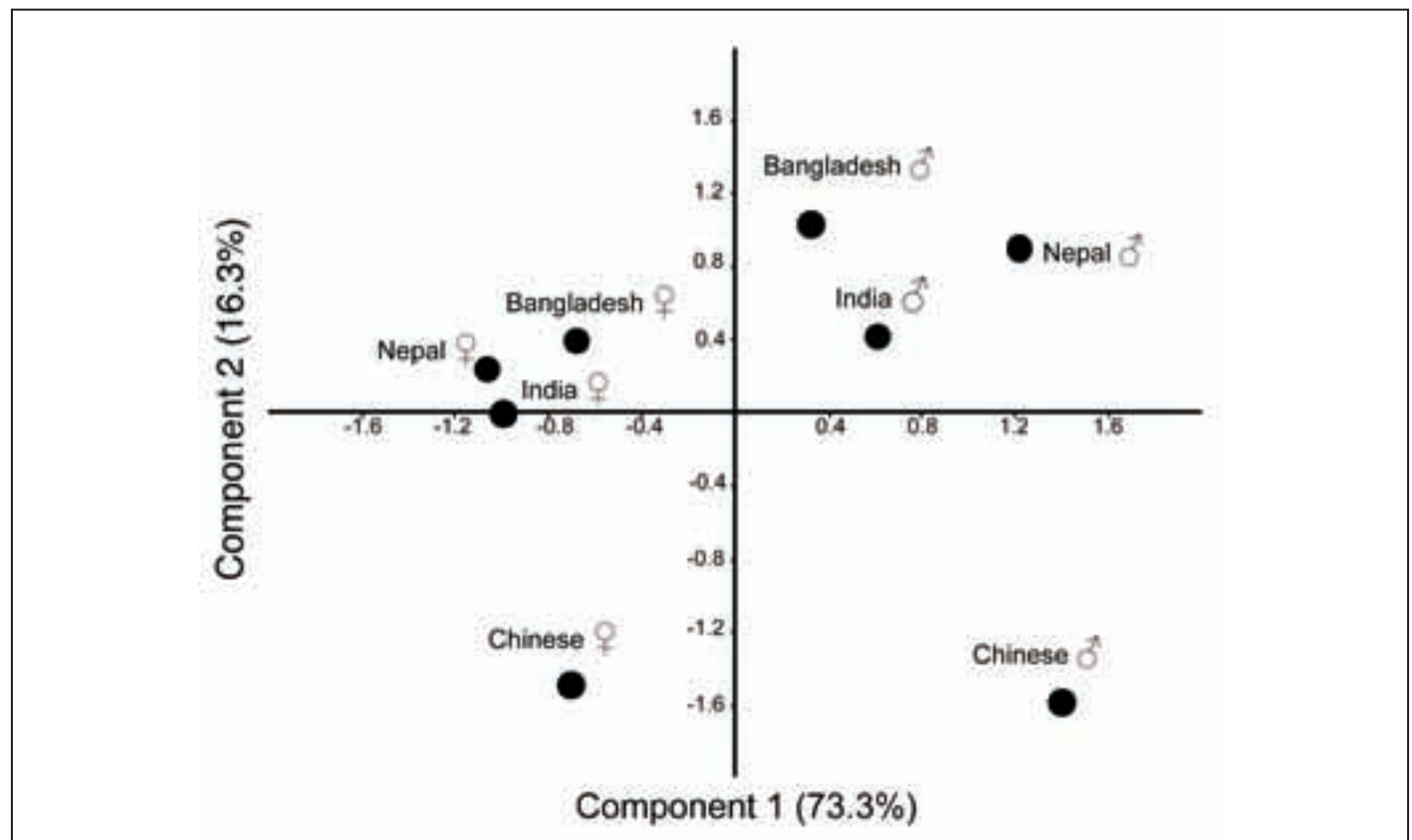


Figure 4. Plot of scores for the first two principal components extracted from a matrix of means for five morphometric variables.

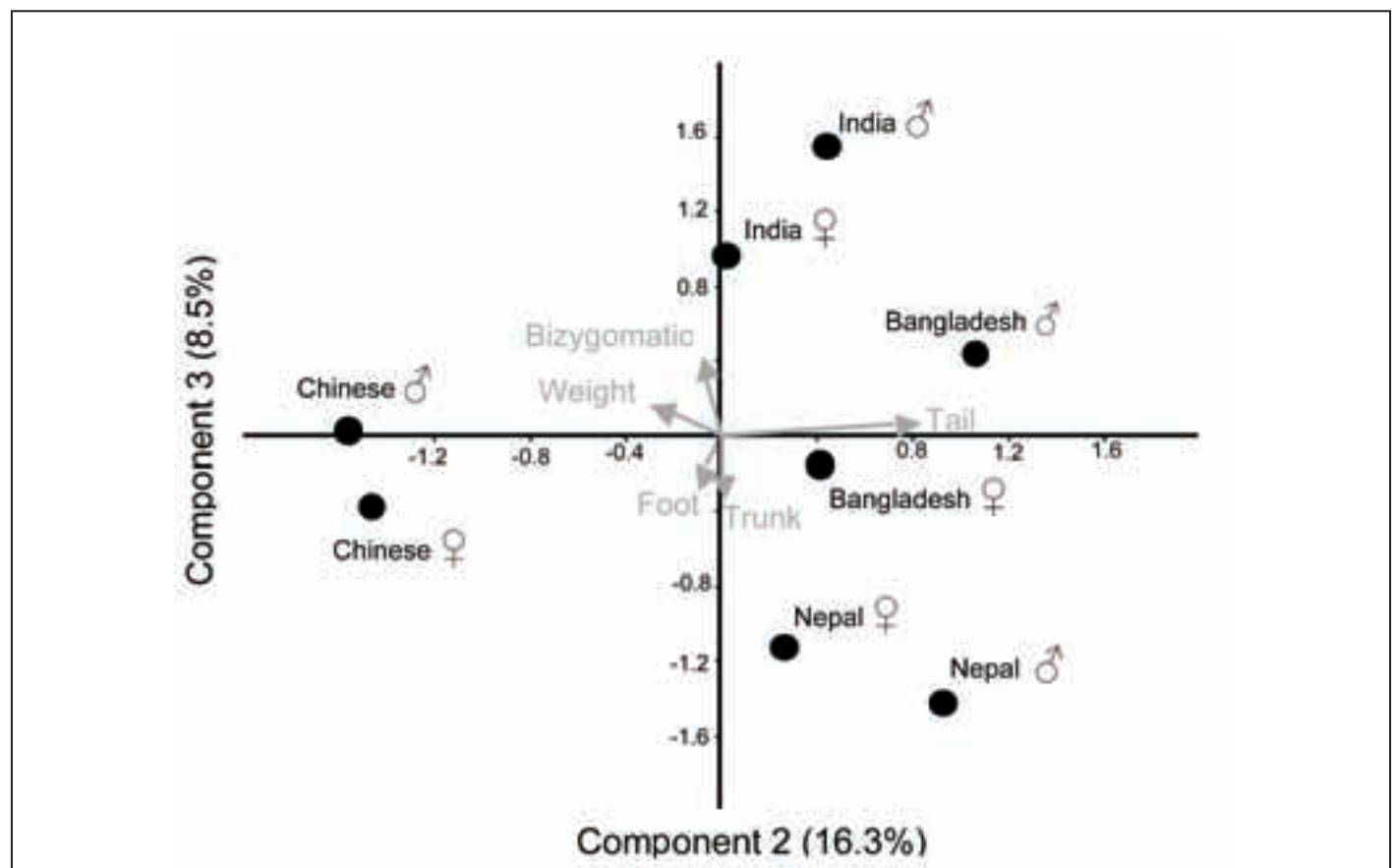


Figure 5. Plot of scores for the second and third principal components extracted from a matrix of means for five morphometric variables. Gray arrows mark the direction and magnitude of eigenvector loadings.

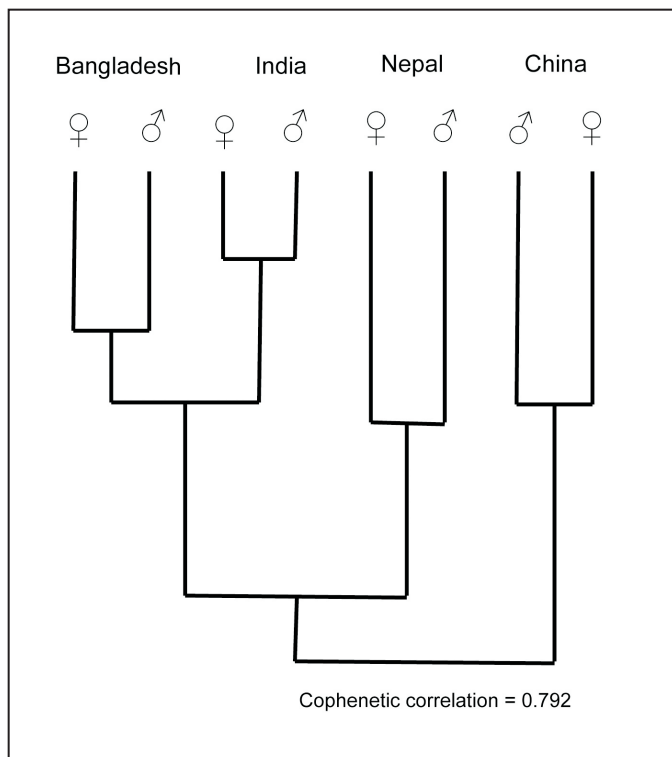


Figure 6. Dendrogram from UPGMA cluster analysis of the second and third principal components describing shape.

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