ISSN 0898-6207

PRIMATE CONSERVATION

The Journal of the IUCN/SSC Primate Specialist Group

Number 22 2007

Primate Conservation is produced and circulated courtesy of the Margot Marsh Biodiversity Foundation, the Center for Applied Biodiversity Science at Conservation International, the Los Angeles Zoo, and the Department of Anatomical Sciences of the State University of New York at Stony Brook.

SPECIES SURVIVAL COMMISSION
CONSERVATION INTERNATIONAL
MARGOT MARSH BIODIVERSITY FOUNDATION
LOS ANGELES ZOO
STONY BROOK

Primate Conservation
The journal of the IUCN/SSC Primate Specialist Group

Center for Applied Biodiversity Science
Conservation International
2011 Crystal Drive, Suite 500, Arlington, VA 22202, USA

ISSN 0898-6207 Abbreviation: *Primate Conserv.*

DOI: 10.1896/ci.cabs.2007.primate.conserv.22

Editors
Russell A. Mittermeier, Conservation International, Arlington, VA, USA
Anthony B. Rylands, Center for Applied Biodiversity Science, Conservation International, Arlington, VA, USA

IUCN/SSC Primate Specialist Group
Chairman Russell A. Mittermeier, Conservation International, Arlington, VA, USA
Deputy Chair Anthony B. Rylands, Center for Applied Biodiversity Science, Conservation International, Arlington, VA, USA
Coordinator–Section on Great Apes Liz Williamson, Stirling University, Stirling, Scotland, UK
Regional Coordinators–Neotropics
Mesoamerica–Ernesto Rodríguez Luna, Instituto de Neuroetología, Universidad Veracruzana, Xalapa, Mexico
Andean Countries–Erwin Palacios, Conservation International Colombia, Bogotá, Colombia, and Eckhard W. Heymann, Deutsches Primatenzentrum, Göttingen, Germany
Brazil and the Guianas–M. Cecília M. Kierulff, Fundação Parque Zoológico de São Paulo, São Paulo, Brazil
Regional Coordinators–Africa
West Africa–John F. Oates, Hunter College, City University of New York (CUNY), New York, NY, USA
East Africa–David Mbora, Dartmouth College, Hanover, New Hampshire, USA
Regional Coordinator–Madagascar
Jörg U. Ganzhorn, Hamburg University, Hamburg, Germany
Regional Coordinators–Asia
China–Long Yongcheng, Kunming Insitute of Zoology, Yunnan, China
Southeast Asia–Jatna Supriatna, Conservation International Indonesia Program, Jakarta, Indonesia, and Christian Roos, Deutsches Primatenzentrum, Göttingen, Germany
South Asia–Sally Walker, Zoo Outreach Organization, Coimbatore, India
Coordinator–John M. Aguiar, Center for Applied Biodiversity Science, Conservation International, Washington, DC, USA

Layout: Kim Meek, Center for Applied Biodiversity Science at Conservation International, Arlington, VA, USA

IUCN/SSC Primate Specialist Group logo courtesy of Stephen D. Nash, 2002.

Front cover: A female Hainan gibbon (*Nomascus hainanus*) with infant, Island of Hainan, China. With only 17 Hainan gibbons confirmed, surviving in just one small forest block, it is one of the most endangered primates in the world.
Photo courtesy of ©Lee Kwok Shing/Kadoorie Farm & Botanic Garden, Hong Kong

This issue of *Primate Conservation* was kindly sponsored by the Margot Marsh Biodiversity Foundation, Virginia, USA, the Los Angeles Zoo, Los Angeles, California, and the Department of Anatomical Sciences of the State University of New York at Stony Brook, Stony Brook, NY, USA.

Contents

General

Neotropical Region

Madagascar

Africa

Asia

Book Reviews

Primate Conservation 2007 (22): 1– 40

Primates in Peril: The World’s 25 Most Endangered Primates, 2006–2008

Russell A. Mittermeier[1], Jonah Ratsimbazafy[2], Anthony B. Rylands[3], Liz Williamson[4], John F. Oates[5], David Mbora[6], Jörg U. Ganzhorn[7], Ernesto Rodríguez-Luna[8], Erwin Palacios[9], Eckhard W. Heymann[10], M. Cecília M. Kierulff[11], Long Yongcheng[12], Jatna Supriatna[13], Christian Roos[14], Sally Walker[15], and John M. Aguiar[3]

[1]*Conservation International, Arlington, VA, USA*
[2]*Durrell Wildlife Conservation Trust – Madagascar Programme, Antananarivo, Madagascar*
[3]*Center for Applied Biodiversity Science, Conservation International, Arlington, VA, USA*
[4]*Department of Psychology, University of Stirling, Stirling, Scotland, UK*
[5]*Department of Anthropology, Hunter College, City University of New York (CUNY), New York, USA*
[6]*Department of Biological Sciences, Dartmouth College, Hanover, NH, USA*
[7]*Institute of Zoology, Ecology and Conservation, Hamburg, Germany*
[8]*Instituto de Neuroetología, Universidad Veracruzana, Veracruz, México*
[9]*Conservation International Colombia, Bogotá, DC, Colombia*
[10]*Abteilung Verhaltensforschung & Ökologie, Deutsches Primatenzentrum, Göttingen, Germany*
[11]*Fundação Parque Zoológico de São Paulo, São Paulo, Brazil*
[12]*The Nature Conservancy, China Program, Kunming, Yunnan, China*
[13]*Conservation International Indonesia, Jakarta, Indonesia*
[14] *Gene Bank of Primates, Deutsches Primatenzentrum, Göttingen, Germany*
[15]*Zoo Outreach Organisation, Coimbatore, Tamil Nadu, India*

Introduction

Here we report on the fourth iteration of the biennial listing of a consensus of 25 primate species considered to be amongst the most endangered worldwide and the most in need of urgent conservation measures. The first was drawn up in 2000 by the IUCN/SSC Primate Specialist Group, together with Conservation International (Mittermeier *et al.* 2000). The list was subsequently reviewed and updated in 2002 during an open meeting held during the 19th Congress of the International Primatological Society (IPS) in Beijing, China (Mittermeier *et al*. 2002). That occasion provided for debate among primatologists working in the field who had first-hand knowledge of the causes of threats to primates, both in general and in particular with the species or communities they study. The meeting and the review of the list of the World’s 25 Most Endangered Primates resulted in its official endorsement by the IPS, and became as such a combined endeavor of the Primate Specialist Group, the IPS, and Conservation International. A third revision was carried out at a meeting in August 2004, at the 20th Congress of the IPS in Torino, Italy (Mittermeier *et al*. 2006). The list presented here, covering the biennium 2006–2008, is the result of a meeting held during the 21st Congress of the International Primatological Society (IPS), in Entebbe, Uganda, 26–30 June 2006. Our sincere thanks to William Olupot, the organizer of the congress, for making the arrangements.

As was the case for the 2004–2006 report, the texts for each species — reporting on their conservation status and threats — have counted on the extraordinary collaboration and expertise of those who know most about them. We are most grateful indeed for their time and dedication. Their contributions guarantee the authority of this report in describing the reasons why these primates are in such danger, and we hope it will be effective in drawing attention to the plight of each and in garnering support for the appropriate concern and action by those who can contribute to saving them, besides those whose moral obligation it is to do so.

With contributions from: Simon K. Bearder, Warren Y. Brockelman, Thomas M. Butynski, Bosco P. L. Chan, Mathias Craul, Tim R. B. Davenport, Jinie Dela, Anneke M. DeLuycker, Carolyn L. Ehardt, Susie Ellis, John R. Fellowes, Jörg U. Ganzhorn, Ha Thang Long, Frank Hawkins, Eckhard W. Heymann, Paul E. Honess, Steig Johnson, William R. Konstant, Mark Leighton, Le Khac Quyet, David N. M. Mbora, W. Scott McGraw, David Meyers, Pierre Moisson, Sanjay Molur, Alan R. Mootnick, Alba Lucia Morales-Jiménez, Bethan Morgan, Tilo Nadler, K. Anna I. Nekaris, John F. Oates, Gillian L. Olivieri, Lisa M. Paciulli, Erwin Palacios, Erik R. Patel, Andrew Perkin, Phan Duy Thuc, Guy H. Randriatahina, Noel Rowe, Agus Salim, Christoph Schwitzer, Nora Schwitzer, Myron Shekelle, Ian Singleton, Roswitha Stenke, Jacqui L. Sunderland-Groves, Thomas T. Struhsaker, Diego Tirira, Sally Walker, and Xiaoming Wang.

Mittermeier, R. A., W. R. Konstant and A. B. Rylands. 2000. The world's top 25 most endangered primates. *Neotropical Primates* 8(1): 49.

Mittermeier, R. A., W. R. Konstant, A. B. Rylands, T. M. Butynski, A. A. Eudey, J. U. Ganzhorn and R. Kormos. 2002. The world's top 25 most endangered primates – 2002. *Neotropical Primates* 10(3): 128–131. Reprinted in *Lemur News* (8): 6–9.

Mittermeier, R. A., C. Valladares-Pádua, A. B. Rylands, A. A. Eudey, T. M. Butynski, J. U. Ganzhorn, R. Kormos, J. M. Aguiar and S. Walker. (eds.). 2006. Primates in Peril: The World's 25 Most Endangered Primates 2004–2006. *Primate Conservation* (20): 1–28.

The World's 25 Most Endangered Primates: 2006–2008

The 2006–2008 list of the World's 25 Most Endangered Primates has four species from Madagascar, seven from Africa, 11 from Asia, and three from the Neotropics — four lemurs, a galago and the kipunji from Tanzania, three red colobus monkeys, the roloway monkey, a tarsier and the pig-tailed langur from Indonesia, a slow loris from Sri Lanka, three langurs (two from Vietnam and one from Sri Lanka), two snub-nosed langurs (both from Vietnam), two spider monkeys from Colombia and Ecuador, the Peruvian yellow-tailed woolly monkey, two gibbons (China and India) and two of the great apes (the Sumatran orangutan and the Cross River gorilla from Nigeria and Cameroon) (Table 1).

Three species were returned to the list: The roloway guenon (*Cercopithecus diana roloway*) and Miss Waldron's red colobus (*Procolobus badius waldroni*), both previously on the 2002 list, and the Peruvian yellow-tailed woolly monkey (*Oreonax flavicauda*), which was on the first list in 2000.

The World's 25 Most Endangered Primates 2006–2008 are spread through 18 countries (Table 2). Those which stand out are: Madagascar (four species), Vietnam (four species), and Indonesia (three species). In the Neotropical Region, the three species are all Andean.

Four of the World's 25 Most Endangered Primates are species only recently described: The Sahamalaza Peninsula sportive lemur (*Lepilemur sahamalazensis*) was first described by Andriaholinirina and colleagues in 2006; the Rondo dwarf galago (*Galagoides rondoensis*) by Paul Honess in Kingdon (1997); the kipunji, a mangabey (*Rungwecebus kipunji*) by Ehardt and colleagues in 2005; and the grey-shanked douc (*Pygathrix cinerea*) by Nadler in 1997. A fifth, the tarsier of the Island of Siau, Indonesia, has yet to be described by Myron Shekelle and colleagues. Seventy-one primates have been described for the first time since 1990; 42 of them in Madagascar, another 14 from Africa and Asia, and 15 from the Neotropics. Many of these new primates have very restricted distributions (the reason they were not discovered before) and, some are known only from their type localities. With more information becoming available it is possible to predict that many will be future candidates for this list.

Table 1. The World's 25 Most Endangered Primates 2006–2008.

	Madagascar		
1	*Prolemur simus*	Greater bamboo lemur	Madagascar
2	*Eulemur albocollaris*	White-collared lemur	Madagascar
3	*Propithecus candidus*	Silky sifaka	Madagascar
4	*Lepilemur sahamalazensis*	Sahamalaza Peninsula sportive lemur	Madagascar
	Africa		
1	*Galagoides rondoensis*	Rondo dwarf galago	Tanzania
2	*Cercopithecus diana roloway*	Roloway monkey	Côte d'Ivoire, Ghana
3	*Procolobus pennantii pennantii*	Pennant's red colobus	Equatorial Guinea (Bioko Is.)
4	*Procolobus rufomitratus*	Tana River red colobus	Kenya
5	*Procolobus badius waldroni*	Miss Waldron's red colobus	Côte d'Ivoire, Ghana
6	*Rungwecebus kipunji*	Kipunji	Tanzania
7	*Gorilla gorilla diehli*	Cross River gorilla	Cameroon, Nigeria
	Asia		
1	*Tarsius* sp.	Siau Island tarsier	Indonesia (Siau Is.)
2	*Loris tardigradus nycticeboides*	Horton Plains slender loris	Sri Lanka
3	*Simias concolor*	Pig-tailed langur	Indonesia (Mentawai Is.)
4	*Trachypithecus delacouri*	Delacour's langur	Vietnam
5	*Trachypithecus p. poliocephalus*	Golden-headed langur or Cat Ba langur	Vietnam
6	*Semnopithecus vetulus nestor*	Western purple-faced langur	Sri Lanka
7	*Pygathrix cinerea*	Grey-shanked douc	Vietnam
8	*Rhinopithecus avunculus*	Tonkin snub-nosed monkey	Vietnam
9	*Nomascus hainanus*	Hainan black-crested gibbon	China (Hainan Is.)
10	*Hoolock hoolock*	Western Hoolock gibbon	Bangladesh, India, Myanmar
11	*Pongo abelii*	Sumatran orangutan	Indonesia (Sumatra)
	Neotropics		
1	*Ateles hybridus*	Variegated spider monkey	Colombia, Venezuela
2	*Ateles fusciceps*	Brown-headed spider monkey	Colombia, Ecuador
3	*Oreonax flavicauda*	Peruvian yellow-tailed woolly monkey	Peru

Changes in the List

The nine primates lost from the 2004 – 2006 list, were substituted by six which had never before been include amongst the World's 25 Most Endangered, and three which had been listed in previous years. The reasons why species were removed from the list differ. In the case of the Eastern gorillas and the Neotropical species considerable attention is being given to their plight and conservation measures — research, distribution and status surveys, evaluation and mitigation measures for threats, creation and management of protected areas, environmental awareness and community programs — are underway to the extent that some guarantees are evident for their survival in the short- to midterm. There are three species which have coincident ranges in West Africa (Côte d'Ivoire and Ghana), and each jockeys for the position of the flagship — Miss Waldron's red colobus, the white-naped mangabey and the roloway guenon. In 2004 – 2006, the white-naped managabey was the one, in 2006 – 2008 it was the turn of the roloway guenon. They both call for urgent measures to protect their remaining forests and populations. Miss Waldron's red colobus was brought back onto the list (previously 2002 – 2004). Its extinction was even reported in 2000, but hope lingers on with rare signs and reports that there are some still living. Repeated efforts since 2000, however, have still failed to find any in the wild. It is significant that there are three red colobus monkeys on the 2006 – 2008 list — there could (should) undoubtedly be more. Distribution and population surveys and genetic studies are providing new information to help us clarify the complex taxonomy and poorly known ranges of the red colobus monkeys, and it is becoming increasingly evident that many are in very serious difficulties. The red colobus monkeys are uncommonly susceptible to hunting and forest loss, and listing three

Table 2. The distribution by country of the the World's 25 Most Endangered Primates 2006–2008.

Madagascar	
Madagascar	*Prolemur simus, Eulemur albocollaris, Propithecus candidus, Lepilemur sahamalazensis*
Africa	
Cameroon	*Gorilla gorilla diehli*
Côte d'Ivoire	*Cercopithecus diana roloway, Procolobus badius waldroni*
Equatorial Guinea	*Procolobus pennantii pennantii*
Ghana	*Cercopithecus diana roloway, Procolobus badius waldroni*
Kenya	*Procolobus rufomitratus*
Nigeria	*Gorilla gorilla diehli*
Tanzania	*Galagoides rondoensis, Rungwecebus kipunji*
Asia	
Bangladesh	*Hoolock hoolock*
China	*Nomascus hainanus*
India	*Hoolock hoolock*
Indonesia	*Tarsius* sp. (Siau Island), *Simias concolor, Pongo abelii*
Myanmar	*Hoolock hoolock*
Sri Lanka	*Loris tardigradus nycticeboides, Semnopithecus vetulus nestor*
Vietnam	*Trachypithecus delacouri, Trachypithecus p .poliocephalus, Pygathrix cinerea, Rhinopithecus avunculus*
Neotropical Region	
Colombia	*Ateles fusciceps, Ateles hybridus*
Venezuela	*Ateles hybridus*
Ecuador	*Ateles fusciceps*

Table 3. Primates on the 2004 – 2006 list of the world's 25 most endangered primates that were removed from the 2006 – 2008 list.

Madagascar	
Propithecus perrieri	Perrier's sifaka
Galagoides sp.	Mt. Rungwe galago
Africa	
Cercocebus atys lunulatus	White-naped mangabey
Cercocebus sanjei	Sanje mangabey
Gorilla beringei	Eastern gorillas
Asia	
Presbytis hosei canicrus	Miller's grizzled surili
Neotropics	
Leontopithecus caissara	Black-faced lion tamarin
Cebus xanthosternos	Buffy-headed tufted capuchin
Brachyteles hypoxanthus	Northern muriqui

Table 4. The six primates appearing on the list of the world's 25 most endangered primates for the first time, 2006 – 2008.

Madagascar	
Lepilemur sahamalazensis	Sahamalaza Peninsula sportive lemur
Africa	
Galagoides rondoensis	Rondo dwarf galago
Rungwecebus kipunji	Kipunji
Asia	
Tarsius sp.	Siau Island tarsier
Hoolock hoolock	Western Hoolock gibbon
Neotropical Region	
Ateles fusciceps	Brown-headed spider monkey

of them here signals the need for further research and urgent conservation measures for the entire genus.

In the case of the Mt. Rungwe galago, its listing in 2004 resulted in distribution and status surveys that have indicated that it is less threatened than the Rondo dwarf galago to which its place was given. The listing of Perrier's sifaka was given over to the Sahamalaza Peninsula sportive lemur, serving as a representative of the possible and usually probable plight of many of the numerous lemurs described for the first time over the last two years — known only from single localities or desperately small forest patches. The kipunji, a dramatic find in Tanzania in 2003, is known from just two localities. Their populations are small and fragmented, and the place of this mangabey on the 2006 list was ceded by the Sanje River mangabey, which has been receiving increasing and promising attention for the protection of its populations and forests.

Many of the Asian langurs are now severely threatened, not only from subsistence hunting and habitat loss, but also from hunting for body parts and tissues to satisfy the insatiable demands of the Asian peoples for exotic dishes and concoctions of wild animals, for amulets, remedies and aphrodisiacs. Six of the Asian colobines are on this 2006–2008 list, and Miller's grizzled surili was an ephemeral representative of so many others which should also be highlighted. It is significant that 11 of the 25 Most Endangered Primates are from Asia. A list of the most threatened primates in Asia could easily reach 50, all as threatened as any on this list of the World's 25 Most Endangered.

Table 5 shows the four lists produced to date. Eight species have remained on the list since 2000: the silky sifaka (*Propithecus candidus*), four Asian colobines — Delacour's langur (*Trachypithecus delacouri*), the golden-headed or Cat Ba langur (*T. p. poliocephalus*), the grey-shanked douc (*Pygathrix cinerea*), and the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) — the Hainan gibbon (*Nomascus hainanus*), the Cross River gorilla (*Gorilla gorilla diehli*), and the Sumatran orangutan (*Pongo abelii*).

Madagascar

Greater Bamboo Lemur

Prolemur simus (Gray, 1871)
Madagascar
(2002, 2004, 2006)

Formerly in the genus *Hapalemur*, Groves (2001) placed the greater bamboo lemur in the genus *Prolemur* based on a suite of distinctive dental and chromosomal characteristics (Vuillaume-Randriamanantena *et al.* 1985; Macedonia and Stanger 1994; Stanger-Hall 1997). As its common name implies, the greater bamboo lemur is the largest of Madagascar's bamboo-eating lemurs (Albrecht *et al.* 1990). Genetic studies further support its separation from the other bamboo lemurs and suggest that *Hapalemur* may, in fact, be more closely related to the genus *Lemur* (Rumpler *et al.* 1989; Macedonia and Stanger 1994; Stanger-Hall 1997). Historical records (Schwarz 1931) and sub-fossil remains confirm that it was once widespread throughout the island (Godfrey and Vuillaume-Randriamanantena 1986; Wilson *et al.* 1988; Godfrey *et al.* 1999). Documented populations are very patchily distributed and restricted to the south-central portion of the country's eastern rain forests, including those of Kianjavato, Ranomafana and Andringitra National Parks (and the corridor between them), Evendra (near Ivato, southeast of Andringitra), Karianga (near Vondrozo), and possibly the forest fragments south of Ifanadiana (Meier and Rumpler 1987; Wright *et al.* 1987; Sterling and Ramaroson 1996; Goodman *et al.* 2001b; Irwin *et al.* 2005). Recent unpublished reports also indicate its presence in the forests of Karianga, northwest of Manombo (E. E. Louis Jr. pers. comm.) and north up to the region of Moramanga (Dolch *et al.* 2004; Rakotosamimanana *et al.* 2004). Shoots, young and mature leaves, and pith of the bamboo *Cathariostachys madagascariensis* can account for as much as 95% of the diet (Tan 1999, 2000). Other food items include flowers of the traveler's palm (*Ravenala madagascariensis*), and fruits of *Artocarpus integrifolia*, *Ficus* spp. and *Dypsis* spp., and leaves of *Pennisetum clandestinum* (Meier and Rumpler 1987). Observations of animals in the wild and captivity suggest that *P. simus* is cathemeral (Santini-Palka 1994; Tan 1999, 2000). They live in polygynous groups of seven to 11 animals occupying home ranges of 60 ha or more (Sterling and Ramaroson 1996; Tan 1999, 2000). The greater bamboo lemur is threatened by slash-and-burn agriculture, illegal logging, the cutting of bamboo, and hunting with slingshots (Meier 1987; Meier and Rumpler 1987). It has vanished from most of its former range and only a few relatively small populations have been documented thus far in the southeast. Hunting and habitat destruction are the presumed causes. It occurs in the national parks of Ranomafana and Andringitra (although limited by suitable microhabitat within these protected areas). The population in Ranomafana National Park is estimated at no more than 250 adult individuals (P. C. Wright pers. comm.). Opportunities exist to extend protection to lemur populations in neighboring forests, as well as to develop a fairly long corridor of protected forests between Ranomafana and Andringitra, within which it is presumed other greater bamboo lemur populations will be found.

Jörg U. Ganzhorn & Steig Johnson

White-collared Lemur

Eulemur albocollaris (Rumpler, 1975)
Madagascar
(2004, 2006)

The white-collared lemur was formerly classed as a subspecies of *Eulemur fulvus* (Tattersall 1982; Mittermeier *et al.* 1994; Pastorini *et al.* 2000). Recent cytogenetic and molecular genetic analyses support full species status for *Eulemur albocollaris* (Djletati *et al.* 1997; Wyner *et al.* 1999), despite natural hybridization between this taxon and *Eulemur f. rufus* (Sterling and Ramarason 1996; Johnson and Wyner 2000; Wyner *et al.* 2002). The white-collared lemur has one of the most restricted ranges of any *Eulemur* species, occurring only in southeastern Madagascar in a thin strip of rain forest that

Table 5. The four lists of the World's 25 Most Endangered Primates produced to date. The eight species shaded are those which have remained on the list since 2000.

2000	2002	2004	2006
Madagascar			
Hapalemur aureus			
Hapalemur griseus alaotrensis			
	Hapalemur simus	*Prolemur simus*	*Prolemur simus*
		Eulemur albocollaris	*Eulemur albocollaris*
			Lepilemur sahamalazensis
Propithecus perrieri	*Propithecus perrieri*	*Propithecus perrieri*	
Propithecus candidus	*Propithecus candidus*	*Propithecus candidus*	*Propithecus candidus*
Propithecus tattersalli			
Africa			
		Galagoides sp. Mt. Rungwe galago	
			Galagoides rondoensis
	Cercopithecus diana roloway		*Cercopithecus diana roloway*
Cercopithecus sclateri			
Mandrillus leucophaeus			
	Cercocebus galeritus galeritus		
Cercocebus galeritus sanjei	*Cercocebus galeritus sanjei*	*Cercocebus sanjei*	
Cercocebus atys lunulatus	*Cercocebus atys lunulatus*	*Cercocebus atys lunulatus*	
			Rungwecebus kipunji
Procolobus badius waldroni	*Procolobus badius waldroni*		*Procolobus badius waldroni*
		Procolobus pennantii pennantii	*Procolobus pennantii pennantii*
	Procolobus rufomitratus	*Procolobus rufomitratus*	*Procolobus rufomitratus*
Gorilla gorilla beringei	*Gorilla beringei beringei*	*Gorilla beringei*	
Gorilla gorilla diehli	*Gorilla gorilla diehli*	*Gorilla gorilla diehli*	*Gorilla gorilla diehli*
Asia			
			Tarsius sp. (Siau Is.)
		Loris tardigradus nycticeboides	*Loris tardigradus nycticeboides*
	Simias concolor	*Simias concolor*	*Simias concolor*
	Presbytis natunae		
Trachypithecus delacouri	*Trachypithecus delacouri*	*Trachypithecus delacouri*	*Trachypithecus delacouri*
Trachypithecus poliocephalus	*Trachypithecus poliocephalus*	*Trachypithecus p. poliocephalus*	*Trachypithecus p. poliocephalus*
	Trachypithecus leucocephalus		
		Presbytis hosei canicrus	
Pygathrix nemaeus cinerea	*Pygathrix nemaeus cinerea*	*Pygathrix nemaeus cinerea*	*Pygathrix cinerea*
Rhinopithecus avunculus	*Rhinopithecus avunculus*	*Rhinopithecus avunculus*	*Rhinopithecus avunculus*
	Rhinopithecus bieti		
	Rhinopithecus brelichi		
		Semnopithecus vetulus nestor	*Semnopithecus vetulus nestor*
Hylobates moloch			
Hylobates concolor hainanus	*Nomascus nasutus*	*Nomascus hainanus*	*Nomascus hainanus*
			Hoolock hoolock
Pongo abelii	*Pongo abelii*	*Pongo abelii*	*Pongo abelii*
Neotropics			
Leontopithecus rosalia			
Leontopithecus chrysopygus			
Leontopithecus caissara	*Leontopithecus caissara*	*Leontopithecus caissara*	
Cebus xanthosternos	*Cebus xanthosternos*	*Cebus xanthosternos*	
			Ateles hybridus
		Ateles hybridus brunneus	
			Ateles fusciceps
Lagothrix flavicauda			*Oreonax flavicauda*
Brachyteles hypoxanthus	*Brachyteles hypoxanthus*	*Brachyteles hypoxanthus*	

runs from just north of the Manampatrana River south to the Mananara River (Petter and Petter-Rousseaux 1979; Tattersall 1982; Irwin *et al*. 2005). The hybrid zone with *E. f. rufus* is centered on the headwaters region of the Manampatrana River in Andringitra National Park, extending south to the vicinity of Karianga and north to near Ankarimbelo (Irwin *et al*. 2005; S. Johnson unpublished data), and encompassing an area of up to 50% of the range of "pure" *E. albocollaris*. Two isolated populations also occur in the coastal fragments of Manombo Special Reserve and Mahabo Forest near Farafangana. Recent analyses combining ground surveys and Landsat imagery indicate that the total habitat remaining within this species' range is approximately 700 km², with an estimated remaining population of 7,265 ± 2,268 individuals (Irwin *et al*. 2005). Information regarding the natural history of this lemur comes largely from recent studies conducted at Vevembe Forest, with new long-term studies underway at Manombo and Mahabo.

The white-collared lemur has a largely frugivorous diet, supplemented with flowers, leaves, and fungi; *Pandanus* spp. flowers are an especially important food late in the dry season (Johnson 2002). The species is cathemeral (active both day and night) throughout the year. Social groups tend to be multi-male/multi-female and regularly exhibit fission-fusion. Selective logging, hunting and the conversion of its habitat to agricultural land are the greatest threats to the survival of the white-collared lemur. It is found in only two protected areas, the Andringitra National Park and Manombo Special Reserve, but the Andringitra population appears to be largely composed of hybrids (CBSG 2002; Wyner *et al.* 2002). Recent research has identified populations in unprotected forests (Vevembe, for example) that could be added to existing parks and reserves (Johnson and Overdorff 1999). The Missouri Botanical Garden is also presently active in managing and upgrading the protected status of the littoral forest of Mahabo. It should be noted that a possible third *Eulemur* species, *E. cinereiceps*, has been suggested to occur within or near the coastal portion of the range of *E. albocollaris* based on variant museum specimens and captive individuals (Groves 2001; Mittermeier *et al.* 2006). However, the weight of current evidence suggests this taxon is either synonymous with *E. albocollaris* or extinct. All surveyed remaining habitats appear to contain either *E. albocollaris* (Manombo and Mahabo, south of Farafangana) or are too small and/or disturbed to support *Eulemur* (for example, Analalava and Sakanany, north of Farafangana); however, exhaustive ground surveys and genetic sampling should be conducted in the region to confirm these findings.

Steig Johnson & William R. Konstant

Silky Sifaka

Propithecus candidus Grandidier, 1871
Madagascar
(2000, 2002, 2004, 2006)

Propithecus candidus is a large, white, rainforest sifaka found only within a small section of northeastern Madagascar. Surveys for these highly social diurnal indriids suggest that they are patchily distributed and occur at low densities within just a few protected areas: Marojejy National Park, Anjanaharibe-Sud Special Reserve, and (very rarely) the Anjanaharibe and Manandriana portions of Makira Protected Area north of the Antainambalana River. They have been observed primarily in undisturbed forest (except for the Betaolana Corridor) between 700 m and 1,875 m above sea level (Tattersall 1982; Duckworth *et al*. 1995; Schmid and Smolker 1998; Sterling and McFadden 2000; Goodman *et al*. 2003; Rakotondratsimba *et al*. 2007). The behavior and ecology of this species is known mainly from a short study (Kelley and Mayor 2002) and a 14.5-month study at Marojejy National Park (Patel *et al*. 2005; Patel 2005, 2006, 2007, submitted).

The silky sifaka's diet is highly folivorous, including mature and young leaves. They also eat fruit, flowers, seeds, bark, soil, and roots. Silky sifakas are the flagship species of a newly proposed World Heritage Site (Marojejy National Park) and are the species that most tourists come to view. Their social structure appears variable (pair-living and polygynandrous), with group sizes ranging from 2 to 9 individuals. Home ranges can exceed 40 ha (Patel 2006). They inhabit several types of elevation-specific habitats including primary montane rainforest, sclerophyllous forest, and even low ericoid bush at their highest elevations (Goodman 2000). Their primary conservation threat appears to be hunting (Patel *et al*. 2005). Habitat disturbance, such as slash-and-burn agriculture ('tavy'), logging of precious woods (for example, rosewood) and fuel-wood, also occurs within and adjacent to the protected areas where they are found (Patel submitted). The remaining population may be as low as a few hundred individuals and is unlikely to be larger than a few thousand (Mittermeier *et al*. 2006).

Erik R. Patel, David Meyers & Frank Hawkins

Sahamalaza Sportive Lemur

Lepilemur sahamalazensis Andriaholinirina *et al.*, 2006
Madagascar
(2006)

The Sahamalaza sportive lemur (*Lepilemur sahamalazensis*) is one of the numerous lemurs recently described based on genetic and morphometric data (Andriaholinirina *et al.* 2006). Although the range of this medium-sized, nocturnal primate is not precisely known, it is thought to be strictly limited to the Sahamalaza Peninsula in northwestern Madagascar. The peninsula is part of a transition zone between the Sambirano region in the north and the western dry deciduous forest region in the south. The forests in this area contain a mixture of plant species typical of dry forest and some typical of the Sambirano domain (Birkinshaw 2004). *Lepilemur sahamalazensis* depends on these semi-humid forests, of which only a few fragments now remain. Very little is known about the ecology and behavior of the Sahamalaza sportive lemur. During preliminary night observations, individuals were mostly encountered alone or in groups of two. During the daytime, they were found sleeping in tree holes. This suggests that they have a social structure typical for the *Lepilemur* genus, i.e., pair-living animals defending exclusive territories. Encounter rate is high in the forest of Ankarafa (Olivieri *et al.* 2005).

This could be due to recent loss of habitat, forcing all animals to concentrate in the few remaining forest fragments.

Total numbers are unknown but, taking into account the limited distribution of *L. sahamalazensis* and the small extent of remaining forest cover, they are probably in their low thousands. The species is present in the recently established Parc National de Sahamalaza – Iles Radama (*Aire Protégée Terrestre, Marine et Côtière*) which is part of the Malagasy protected area network managed through the *Association Nationale pour la Gestion des Aires Protégées* (ANGAP). The Sahamalaza Peninsula is also a UNESCO Biosphere Reserve (declared in 2001). Although the protected area probably covers the entire distribution of *L. sahamalazensis*, forest-clearing for agriculture, and timber-cutting for charcoal and construction continue at an alarming rate. Additionally, as is true for all sportive lemurs, it suffers from a high hunting pressure. These animals are easy and defenceless prey for hunters that find their sleeping sites during the day and cut the tree down or climb it to fetch them. Furthermore, traps are laid, harming not only *L. sahamalazensis* but also the Critically Endangered blue-eyed black lemur (*Eulemur macaco flavifrons*), which has a similar distribution.

The combination of a very limited range containing only little and rapidly decreasing suitable habitat with a high hunting pressure makes this species especially vulnerable. A consortium of the *Association Européenne pour l'Etude et la Conservation des Lémuriens* (AEECL), the Wildlife Conservation Society (WCS), ANGAP, and the local communities is currently establishing structures to ensure better protection of the few remaining forest fragments in the park (Schwitzer *et al.* 2006). Simultaneously, studies are under way to determine the exact distribution of *L. sahamalazensis* as well as the density and size of the remaining population.

Gillian L. Olivieri, Christoph Schwitzer, Nora Schwitzer, Mathias Craul & Guy H. Randriatahina

Africa

Rondo Dwarf Galago

Galagoides rondoensis (Honess in Kingdon, 1997)
Tanzania
(2006)

Weighing approximately 60 g, this is the smallest of all galago species (Honess 1996b). It is distinct from other dwarf galagos in its diminutive size, a bottle-brush-shaped tail, its reproductive anatomy, and its distinctive "double unit rolling call" (Bearder *et al*. 1995; Honess 1996a, 1996b). Current knowledge indicates that this species occurs in two distinct areas, one in southwest Tanzania near the coastal towns of Lindi and Mtwara, the other approximately 400 km further north, above the Rufiji River, in pockets of forest around Dar es Salaam. One further population occurs in Sadaani National Park, approximately 100 km north of Dar es Salaam. Rondo dwarf galagos have a mixed diet of insects and fruit, often feed close to the ground, and move by vertical clinging and leaping in the shrubby understorey. They build daytime sleeping nests, which are often in the canopy (Bearder *et al*. 2003). As with many small primates, *G. rondoensis* is probably subject to predation from owls and other nocturnal predators. Among these, genets, palm civets and snakes are known to invoke intense episodes of alarm calling (Honess 1996b).

The IUCN Red List gives *G. rondoensis* as Endangered B2ab(i–v) (IUCN 2006). It has an extremely limited and fragmented range in a number of remnant patches of Eastern African Coastal Dry Forest (*sensu* Burgess and Clarke 2000, p.18) in Tanzania, namely those at Zaraninge forest (06°08'S, 38°38'E) in Sadaani National Park (Perkin 2000), Pande Game Reserve (GR) (06°42'S, 39°05'E), Pugu/Kazimzumbwi (06°54'S, 39°05'E) (Perkin 2003, 2004), Rondo (10°08'S, 39°12'E), Litipo (10°02'S, 39°29'E) and Ziwani (10°20'S, 40°18'E) forest reserves (FR) (Honess 1996b; Honess and Bearder 1996). Specimens of *G. rondoensis*, originally described as *Galagoides demidovii phasma*, were collected by Ionides from Rondo Plateau in 1955, and Lumsden from Nambunga, near Kitangari, (approximately 10°40'S, 39°25'E) on the Makonde Plateau in Newala District in 1953. Doubts surround the persistence of this species on the Makonde Plateau, which has been extensively cleared for agriculture. Surveys there in 1992 failed to detect any extant populations (Honess 1996b).

No detailed surveys have been conducted to assess population sizes of *G. rondoensis*. Limited distribution surveys have been conducted, however, in the southern (Honess 1996b) and northern coastal forests (27 surveyed) of Tanzania and coastal Kenya (seven surveyed) (Perkin 2000, 2003, 2004). Absolute population sizes remain undetermined but recent surveys have provided estimates of density (3–6/ha at Pande Game Reserve [Perkin 2003] and 8/ha at Pugu Forest Reserve [Perkin 2004]) and relative abundance from encounter rate (3–10/hr at Pande Game Reserve and Pugu/Kazimzumbwi Forest Reserve [Perkin 2003, 2004] and 3.94/hr at Rondo Forest Reserve [Honess 1996b]). There is a clear and urgent need for further surveys to determine population sizes in these dwindling forest patches. The total area of forest in which *G. rondoensis* is currently known to occur does not exceed 92.6 km² (Pande GR: 2.4 km², Rondo FR: 25 km², Ziwani FR: 7.7 km², Pugu/Kazimzumbwi FR: 33.5 km², Litipo FR: 4 km² and Zaraninge forest: 20 km² [Minimum area data source: Burgess and Clarke 2000; Doggart 2003]). The major threat facing this species is loss of habitat. All sites are subject to some level of agricultural encroachment, charcoal manufacture and/or logging. All sites, except Pande GR and Zaraninge forest, are national or local authority forest reserves and as such nominally, but in practice minimally, protected. Given current trends in charcoal production for nearby Dar es Salaam, the forest reserves of Pugu and Kazimzumbwi will disappear over the next 10–15 years (Ahrends 2005). Pande, as a Game Reserve, is perhaps more secure, and Zareninge forest, being in a National Park, is the most protected part of the range of *G. rondoensis*. Conservation action is urgently needed, and more research is required to determine the continuing rate of habitat loss at these sites and to survey new areas for remnant populations.

Across its known range, the Rondo galago can be found sympatric with a number of other galagos, including two much larger species in the genus *Otolemur*: Garnett's galago, *O. garnettii*, and the thick-tailed galago, *O. crassicaudatus*. The Rondo galago is sympatric with the Zanzibar galago, *Galagoides zanzibaricus*, in the northern parts of its range (for example, in Zaraninge forest, Pugu/Kazimzumbwi FR and Pande GR). *G. zanzibaricus* is classified as Lower Risk (Near Threatened) in the 2006 IUCN Red List (IUCN 2006) due to threats to its habitat. In the southern parts of its range (for example, at Rondo, Litipo and Ziwani FRs), the Rondo galago is sympatric with Grant's galago, *Galagoides granti*, which is listed as Data Deficient (IUCN 2006). The Mountain dwarf galago, *Galagoides orinus*, ranked as Data Deficient (IUCN 2006), is restricted to areas of sub-montane and montane forest in the Eastern Arc Mountains further inland in Tanzania. As such *G. orinus* also has a very restricted range, although areas of its preferred habitat are believed to be at less risk of degradation because they are relatively inaccessible.

Paul E. Honess, Andrew Perkin & Simon K. Bearder

Roloway Guenon

Cercopithecus diana roloway (Schreber, 1774)
Ghana and Côte d'Ivoire
(2002, 2006)

There are two subspecies of *Cercopithecus diana*, both highly attractive, arboreal monkeys that inhabit the Upper Guinean forests of West Africa (Grubb *et al*. 2003). The Roloway subspecies is distinguished by its broad white brow line, long white beard and yellow thighs. Groves (2001) considers the two subspecies to be sufficiently distinct to be regarded as full species. Of the two forms, the Roloway, which is known from Ghana and eastern Côte d'Ivoire, is more seriously threatened with extinction. In fact, along with the white-naped mangabey (*Cercocebus atys lunulatus*) and Miss Waldron's red colobus (*Procolobus badius waldroni*), it is among the three most endangered monkeys of the Upper Guinea forest block and a target species of the relentless bushmeat trade (Oates 1996).

As primatologists search the tropical forests of Ghana and Côte d'Ivoire for evidence of living red colobus, they are also documenting the continued decline of both the Roloway guenon and white-naped mangabey, which seem to be found in and to be absent from many of the same forests (Struhsaker and Oates 1995; Oates *et al*. 1996/1997; McGraw 1998a; Kone 2004; Oates 2006). In Ghana, Roloway guenons have been steadily extirpated from both unprotected and protected areas (for example, Bia National Park) and the monkey is nearing extinction in that country if it has not disappeared already. Very recent surveys failed to confirm the presence of Roloways in four reserves in western Ghana including one — Krokosua Hills Forest Reserve — believed to harbor the monkey only several years earlier (Magnuson 2003; Oates 2006). It is possible that Ankasa Resource Reserve still contains a few Roloway individuals (Magnuson 2003), but in 2006 a wildlife guard reported to J. Oates (unpublished) that he had not seen the monkey for several years. A thorough new survey of Ankasa, and of the Dadieso Forest Reserve (where the monkey was also reported in the recent past) should be a high priority.

In neighboring Côte d'Ivoire, the Roloway guenon is not known from any protected areas and the monkey's status is equally dire. Surveys made ten years ago documented Roloways in two forests: the Yaya Forest Reserve and wet forest adjacent to the Ehy Lagoon (McGraw 1998b, 2005). Field surveys made in 2004 failed to document Roloways at additional sites in southern Côte d'Ivoire (Kone and Akpatou 2005) although hunters indicate that Roloways are present in small numbers in the Parc National des Iles Ehotilé (Kone and Akpatou 2005). Intensive and systematic primate inventories must be carried out at both Ehotilé and Ehy.

W. Scott McGraw & John F. Oates

Pennant's Red Colobus

Procolobus pennantii pennantii (Waterhouse, 1838)
Bioko Island, Equatorial Guinea
(2004, 2006)

The endangered Pennant's red colobus monkey *Procolobus pennantii* (Waterhouse, 1838) is presently regarded by the IUCN/SSC Primate Specialist Group as comprised of four subspecies, but their relationships within *P. pennantii,* and with other taxa of red colobus, need clarification (Groves 2001; Grubb *et al*. 2003). Future research may reveal that these four "subspecies" are better referred to as full species. *P. pennantii* takes its name from the form restricted to Bioko Island, Equatorial Guinea, *P. pennantii pennantii*. This endangered subspecies probably has the most restricted range of all of Bioko's 11 primates, and is now found only in a small part of the southwest of the island, within the Gran Caldera and Southern Highlands Scientific Reserve (51,000 ha). *P. p. pennantii* is threatened by bushmeat hunting, most notably since the early 1980's when a commercial bushmeat market appeared in the town of Malabo (Butynski and Koster 1994). Hearn *et al*. (2006) estimated numbers killed for bushmeat at 550 and 350 in the years 2004 and 2005, respectively, and a decline of more than 40% in the population over the 20 years from 1986 to 2006. The average price paid in the Malabo market for an adult *P. pennantii* in 2006 was about US$42. This is well over twice as much as the cost of the readily available, high quality, whole chicken and beef at the same market. Similar high prices are paid on Bioko for all seven species of monkeys and for both species of duikers. Bushmeat on Bioko is, obviously, now a 'luxury food' (Hearn *et al*. 2006). Probably all of the *P. pennantii* killed on Bioko at this time are coming from within the Gran Caldera and Southern Highlands Scientific Reserve, but small numbers may persist in the most remote and rugged parts of Bioko's other protected area, the Pico Basile National Park (330 km^2). The continued high flow of primates, duikers and other wildlife into the Malabo bushmeat market indicates that neither 'protected area' is receiving adequate protection from the government of Equatorial Guinea.

The other three subspecies are: the critically endangered Bouvier's red colobus *P. p. bouvieri* (Rochebrune, 1887) of east-central Republic of Congo; the endangered Niger Delta red colobus *P. p. epieni* Grubb and Powell, 1999, of Nigeria; and the endangered Preuss's red colobus *P. p. preussi* (Matschie, 1900) of southeastern Nigeria and western Cameroon (Oates 1994, 2000; Struhsaker 2005). *P. p. pennantii* and *P. p. preussi* are particularly distinct taxa in terms of their vocalizations, while the vocal repertoire of *P. p. epieni* most closely resembles those of the red colobus in central and eastern Africa (T. T. Struhsaker unpublished data).

To the northwest of the *P. pennantii* complex of subspecies occurs the critically endangered Miss Waldron's red colobus *P. badius waldroni* (Hayman, 1936) of southwestern Ghana and southeastern Côte d'Ivoire (Struhsaker 1999; Oates *et al*. 2000; Groves 2001; Grubb *et al*. 2003). All five of these subspecies are today close to extinction, with very restricted ranges and small numbers as a result of intensive hunting and extensive habitat degradation and loss (Wolfheim 1983; Oates 1994, 1996; Oates *et al*. 2000; Struhsaker 2005; Hearn *et al*. 2006). Neither *P. p. bouvieri* nor *P. b. waldroni* have been observed alive by scientists for at least 25 years, raising concerns that they may be extinct (see profile for Miss Waldron's red colobus in this report).

The red colobus monkeys of West Africa and west Central Africa are probably more threatened than any other taxonomic group of primates in Africa. This is partly due to the fact that red colobus are especially sensitive to habitat degradation and vulnerable to hunters (Oates 1996; Oates *et al*. 2000; Waltert *et al*. 2002; Struhsaker 2005). None of the few protected areas in which any of these five subspecies of red colobus occur is well protected (e.g., McGraw 1998). Of very high priority for the conservation of primate biodiversity in Africa is the need to (1) immediately undertake field surveys to determine the current distributions and abundance of these five subspecies of red colobus, and, at the same time, (2) rigorously protect all of those populations that are known to exist.

Providing adequate protection to viable populations of these five subspecies of red colobus would greatly assist the conservation of numerous sympatric threatened taxa. Among primates, these include: the mainland Preuss's monkey *Cercopithecus preussi preussi*; Bioko Preuss's monkey *C. p. insularis*; Bioko red-eared monkey *C. erythrotis erythrotis*; golden-bellied crowned monkey *C. pogonias pogonias*; Roloway monkey *C. diana roloway*; Bioko greater white-nosed monkey *C. nictitans martini*; Bioko black colobus *Colobus satanas satanas*; white-naped mangabey *Cercocebus atys lunulatus*; mainland drill *Mandrillus leucophaeus leucophaeus*; Bioko drill *M. l. poensis*; western chimpanzee *Pan troglodytes verus*; and Nigeria chimpanzee *P. t. vellerosus*.

If a concerted effort is to be made to save all of the diversity present within the red colobus, then the major international conservation NGOs will need to focus their efforts on this taxonomic group and work closely with national conservation NGOs and national protected area authorities. For *P. p. bouvieri* and *P. b. waldroni*, however, it may already be too late.

Thomas M. Butynski, John F. Oates,
W. Scott McGraw & Thomas T. Struhsaker

Tana River Red Colobus

Procolobus rufomitratus Peters, 1879
Kenya
(2002, 2004, 2006)

The gallery forests of the lower Tana River, Kenya, are home to two Critically Endangered primates, the Tana River red colobus and the Tana River mangabey, *Cercocebus galeritus* Peters, 1879. Along with six other primates, they inhabit small patches of forest along a 60-km stretch of river, from Nkanjonja to Mitapani (01°55'S, 40°05'E). While the other species of monkeys have larger geographic distributions, the red colobus and mangabey are restricted to these forests.

The two species receive some protection in approximately 13 km² of forest within the 169-km² Tana River Primate National Reserve (TRPNR). Forest loss to agriculture, however, has increased greatly over the last 15 years or so, and it is estimated that about 50% of the original vegetation has been lost. In addition, local people continue to depend on the remaining forest for materials to build homes and canoes, for the collection of wild honey and other non-timber products. Further losses of habitat have occurred due to the failure of the Tana Delta Irrigation Project's (TDIP) rice-growing scheme (under the administration of the Tana and Athi Rivers Development Authority and financing from Japan International Cooperation Agency) to protect forest patches on their land. A consequence of this continuing loss and degradation of forest is that the populations of the red colobus and the mangabey are believed to have each declined to fewer than 1,000 individuals. Ominously, new threats are now on the horizon with a proposal to establish a large sugar cane plantation in the TDIP area. This new plantation is likely to result in a large influx of people and an increase in the demand for forest resources.

A 5-year World Bank/GEF project begun in 1996 to enhance conservation and protection of the primates and forests was terminated prematurely due to poor project management. This left responsibility for the conservation and protection of the Tana River's remaining forests and primates entirely to the Kenya Wildlife Service (KWS). Nevertheless, there are some positive developments. In 2005, more than 250 families who farmed within the TRPNR were voluntarily relocated to Kipini (about 90 km away) by the KWS. In addition, there appears to be an increasing concern for forest and biodiversity conservation among the people of the area and a major focus of action among community-based organizations is likely to be reforestation and ecotourism activities over the next few decades. However, given the current level of threat for these primates, it will take many years before there is sufficient change on the ground to reverse the long-standing decline of the populations of the Tana River red colobus and the Tana River mangabey.

David N. M. Mbora & Thomas M. Butynski

Miss Waldron's Red Colobus

Procolobus badius waldroni (Hayman, 1936)
Ghana and Côte d'Ivoire
(2000, 2002, 2006)

Miss Waldron's red colobus, *P. badius waldroni*, of western Ghana and eastern Côte d'Ivoire is teetering on the very brink of extinction (Struhsaker 1999; Oates *et al.* 2000; Groves 2001; Grubb *et al.* 2003). Primatologists have searched its known range since 1993, but have failed to see a living animal (Oates *et al.* 1996/1997; McGraw 1998, 2005; McGraw and Oates 2002). A single skin found in the possession of a hunter near the Ehy Lagoon in southeastern Côte d'Ivoire in early 2002 raised hopes that at least one population of Miss Waldron's red colobus still hangs on, but subsequent fieldwork in this region, including several forest reserves and nearby Isles Ehotiles National Park, has yielded no evidence of living individuals (Kone 2004; Kone and Akpatou 2005; McGraw 2005; Kone *et al.* 2007).

Through a partnership of *Conservation des Espèces et des Populations Animales (CEPA)* and the *Centre Suisse de Recherches Scientifiques en Côte d'Ivoire (CSRS)*, Kone *et al.* (2007) surveyed 14 forest reserves in Côte d'Ivoire between 2004 and 2006, including Isles Ehotiles National Park. These surveys failed to provide any sightings of Miss Waldron's red colobus, only a claim of a single vocalization in Ehotiles in 2006. The forest adjacent to the Ehy Lagoon has not been surveyed since 2002, when no red colobus were found. However, the Ehy forest seems to be the only place in Côte d'Ivoire where a small population of Miss Waldron's red colobus might hang on. The forest is under heavy poaching pressure from Ivorian and Ghanaian hunters, and it is being logged, but Kone *et al.* (2007) have begun an awareness and education campaign in the villages there. Their plans are to build a community-based conservation system centered on the eight villages surrounding the lagoon. A thorough survey of the forest is needed as a matter of urgency.

In Ghana, very recent surveys (Oates 2006) support earlier suspicions that this monkey is almost certainly extinct in that country (Oates *et al.* 1996/1997; Struhsaker and Oates 1995). If any animals have managed to survive, the numbers must be very small and it will take heroic efforts to preserve them. Many forms of red colobus are endangered, including three other forms in West Africa: Pennant's red colobus (*Procolobus pennantii pennantii*) of Bioko Island (see profile in this report), Preuss's red colobus (*P. p. preussi*) of Cameroon, and the Niger River Delta red colobus (*P. p. epieni*). In addition, Bouvier's red colobus (*P. p. bouvieri*) from the Congo Republic has not been seen by scientists for at least 30 years. The plight of these monkeys highlights threats faced by red colobus generally; they have patchy distributions, have suffered extensive habitat degradation and are particularly vulnerable to hunters (Wolfheim 1983; Oates 1996; Grubb and Powell 1999; Oates *et al.* 2000; Struhsaker 2005). Implementation of a red colobus action plan should be a high conservation priority in Africa.

W. Scott McGraw & John F. Oates

Kipunji (formerly the highland mangabey)

Rungwecebus kipunji (Ehardt, Butynski, Jones & Davenport in Jones *et al.* 2005)
(formerly *Lophocebus kipunji* Ehardt, Butynski, Jones & Davenport in Jones *et al.* 2005)
Tanzania
(2006)

The discovery of this new species of monkey in 2003 was the first in Africa in 20 years (Jones *et al.* 2005). First classified as *Lophocebus kipunji*, the highland mangabey, it has since been placed in a new genus *Rungwecebus* Davenport *et al.*, 2006, on the basis of molecular data from an immature male specimen found in a trap in a farmer's field near Mt. Rungwe, Tanzania. While concerns have been expressed with respect to the designation of this new genus (Ehardt and Butynski 2006b), there is growing molecular (Olson *et al.* submitted) and also morphological evidence that *Rungwecebus* is valid. Taxonomic debates aside, this monkey is, without doubt, one of the world's most threatened primates (Davenport 2005; Davenport *et al.* 2006, submitted; Ehardt and Butynski 2006b). It has been assessed as Critically Endangered, following the IUCN Red List categories and criteria (Ehardt and Butynski 2006b; Hoffmann 2006).

The kipunji is believed to be endemic to two areas in Tanzania that are separated by *c.*350 km. The Ndundulu population lives at 1,300 – 1,750 m asl in an area of <700 ha of submontane forest in the Ndundulu Forest Reserve (about 18,000 ha of closed forest) in the Udzungwa Mountains of south-central Tanzania. Only three groups have been confirmed in this population, which is probably no more than 200 individuals in all (C. L. Ehardt unpublished; Ehardt and Butynski 2006b). The Mt. Rungwe-Livingstone population occupies <7,000 ha of degraded submontane and montane forest at 1,750 – 2,450 m asl in the Mt. Rungwe-Livingstone Mountains (about 562 km^2, including the Kitulo National Park) of Tanzania's Southern Highlands (Davenport *et al.* 2006; Davenport *et al.* submitted). The Rungwe-Livingstone population has received more research attention than the Ndundulu population (Davenport 2005; Davenport *et al.* 2006, submitted, in prep.; De Luca *et al.* submitted), although a complete census of both populations has been completed recently (Davenport *et al.* submitted).

The most serious threat to the Mt. Rungwe-Livingstone population is the destruction of its forest habitat, a process which has proceeded unabated in this area for many years. The Livingstone Forest has been incorporated into Kitulo National Park, which should significantly improve protection for the kipunji groups in this area. Mt. Rungwe, however, remains a Catchment Forest Reserve and the level of protection there continues to be inadequate (Davenport 2006). There is already evidence that the Mt. Rungwe-Kitulo portion of the population consists of a number of isolated sub-populations (Davenport *et al.* submitted). The situation is compounded by the imminent loss of the narrow (<2 km wide) Bujingijila Forest Corridor that joins Mt. Rungwe and Livingstone (Davenport 2005). With the loss of this corridor, the Mt. Rungwe-

Livingstone population will be further fragmented. In addition to the continuing loss of habitat, this population continues to be hunted (Davenport 2005, 2006; Davenport *et al.* 2005, in prep.). Current rates of forest degradation and loss, especially through logging and charcoal production, could soon lead to the extirpation of the Mt. Rungwe-Livingstone population. What remains of the Mt. Rungwe-Livingstone forests requires immediate and sustained protection (Davenport and Jones 2005; Davenport 2006).

Of particular concern for the Ndundulu population is its extremely small size and the fact that poachers operate in this area (Ehardt and Butynski 2006b). Although local people have historically hunted in other parts of Ndundulu, there is no evidence that kipunji have been hunted here, and human disturbance in this part of the forest is minimal (Davenport and Jones 2005). The Ndundulu population is very small (Jones *et al*. 2005; Ehardt and Butynski 2006b; Davenport *et al*. submitted) however, and sizes of the groups thought to comprise this population appear to be smaller than those in the Mt. Rungwe-Livingstone population (Davenport *et al*. 2006, submitted; Ehardt and Butynski 2006b). These facts, alone, call into question the viability of this population of kipunji (Ehardt and Butynski 2006b; Davenport *et al.* submitted). Ndundulu Forest Reserve is currently subject to community-based management; however, with sanction from Tanzania's Ministry of Natural Resources and Tourism, Division of Forestry and Beekeeping, Tanzania National Parks is providing rangers to patrol the Ndundulu Forest Reserve, and a ranger post has been established at the edge of Ndundulu Forest.

Found in other forests of the Udzungwa Mountains is another of Tanzania's endemic monkeys, the Sanje mangabey *Cercocebus sanjei* Mittermeier, 1986, known to science only since 1979 (Homewood and Rodgers 1981). This mangabey is currently listed as Endangered (IUCN 2006), but was included in the 2004–2006 list of the World's 25 Most Endangered Primates (Ehardt and Butynski 2006a). Like the kipunji, it occurs in two populations (separated by *c.*100 km) and probably numbers fewer than 1,300 animals (Ehardt *et al.* 2005). The Mwanihana population occurs entirely within the Udzungwa Mountains National Park, where there is adequate protection and management based on continuing ecological research (Ehardt *et al.* 2005; Ehardt and Butynski 2006a). The Udzungwa Scarp population is found within the Udzungwa Scarp Forest Reserve, and is under severe threat as a result of habitat degradation and hunting. Thus far, efforts to extend the Udzungwa Mountains National Park to include the Udzungwa Scarp Forest have been unsuccessful. As such, at least 40% of the world's population of the Sanje mangabey remains at substantial risk of decline and eventual extirpation.

These two of Tanzania's endemic species of monkey, both recently discovered, are threatened with extinction due to habitat loss and hunting. Without significant improvement in the protection of the Mt. Rungwe-Livingstone Forest, where roughly 85% of the kipunji monkeys are found, and of the Udzungwa Scarp Forest, where nearly half of the Sanje mangabeys live, these two flagship species will have been part of Africa's known primate diversity for only a brief period in history.

Carolyn L. Ehardt, Thomas M. Butynski
& Tim R. B. Davenport

Cross River Gorilla

Gorilla gorilla diehli Matschie, 1904
Nigeria and Cameroon
(2000, 2002, 2004, 2006)

The Cross River gorilla (*Gorilla gorilla diehli*) is the most western and northern form of gorilla, and is restricted to the forested hills and mountains of the Cameroon-Nigeria border region at the headwaters of the Cross River. It is separated by about 300 km from the nearest population of western lowland gorillas (*Gorilla gorilla gorilla*), and by around 200 km from the recently-discovered gorilla population in the Ebo Forest of Cameroon. The most recent surveys suggest that between 200 and 300 Cross River gorillas remain. Groups of the gorillas concentrate their activities in eleven localities across a 12,000 km² range, but genetic research has found evidence that despite their scattered distribution these subpopulations continue to maintain contact through the occasional migration of individuals.

There are currently two protected areas within the Cross River gorillas' range in Nigeria: the Afi Mountain Wildlife Sanctuary and the Okwangwo Division of Cross River National Park. In Cameroon, the Kagwene Gorilla Sanctuary is in the process of gazettement, and planning has begun for the creation of a Takamanda National Park. Beyond those protected areas, about half of the remaining Cross River gorillas occur in community-managed forests and a forest reserve (Mone River in Cameroon). There are many human settlements around the forests where the gorillas occur, and some villages are even enclaved within Okwangwo and Takamanda. The encroachment of farms, dry-season fires set to clear forest or improve pasture, and development activities, such as roads, are continuing threats to the integrity of gorilla habitat. However, large tracts of lower elevation forest remain between the localities where the gorillas are presently concentrated and if these areas can be protected, the animals could expand their range and their population. Genetic evidence suggests that the population of Cross River gorillas was much larger in the past, and that a dramatic decline has occurred over the last 200 years, almost certainly due to the introduction of hunting with firearms. After several years of awareness-raising by conservationists and researchers, hunting of Cross River gorillas for bushmeat has been reduced to a low level but it is still a potential threat, as are wire-snare traps set for other animals.

A conservation action plan for Cross River gorillas has been prepared, based on the deliberations of a workshop held in Calabar, Nigeria, in April 2006, organized by the Wildlife Conservation Society and funded by WWF's African Great Ape Programme and the U.S. Fish and Wildlife Service's Great Ape Conservation Fund (Oates *et al*. 2007). Among some of the key recommendations made by this workshop are for education and awareness efforts to be expanded, a transboundary conservation committee to be created, and new surveys to be launched in areas that are predicted by remote-sensing image analysis to support gorillas. The workshop recommended completion of the process to create protected areas at Kagwene and Takamanda, as well as the establishment of conservation systems at Mbe (Nigeria) and at Mone River, Mbulu and Bechati-Fossimondi (Cameroon). All these areas require management plans to be developed and implemented.

About 250 km south from the Cross River population, a small isolated population of gorillas occurs in a small portion of the 1,500 km² forest straddling the Ebo River in southwestern Cameroon, approximately 50 km north of the Sanaga River. Field research undertaken by the Zoological Society of San Diego suggests that five or fewer gorilla groups survive in Ebo, which is also inhabited by ten other diurnal primates, including highly threatened forms such as the drill (*Mandrillus leucophaeus*), Preuss's red colobus (*Procolobus pennantii preussi*), and the Gulf of Guinea chimpanzee (*Pan troglodytes vellerosus*). The taxonomic affinities of the Ebo gorillas are still unclear. Based on measurements of a single skull, they may be most closely related to the gorillas of the inland plateau of Cameroon (south of the Sanaga River), rather than to Cross River gorillas. The Ebo gorilla population only became known to the outside world in 2001; they have been afforded little protection in the past, and the forest's primates are under extreme pressure from bushmeat hunting, given the proximity of the forest to the main urban centers in Cameroon. The Zoological Society of San Diego established a research station there in 2005, and with the full-time presence of researchers, along with technical assistance from WWF's Cameroon Coastal Forests Program, the conservation status of the Ebo Forest has improved and the area is currently being gazetted as a national park.

Jacqui Sunderland-Groves, John F. Oates
& Bethan Morgan

Asia

Siau Island Tarsier

Tarsius sp. Shekelle *et al.,* in prep.
Indonesia
(2006)

The Siau Island tarsier is a new, undescribed species that is Critically Endangered (A1 acd) and faces an imminent threat of extinction. Shekelle and Salim (in press) used GIS data and field surveys to list specific threats. They include: a very small geographic range, of 125 km², and an even smaller area of occupancy, perhaps as little as 19.4 km²; a high density of humans (311 people per km²) that habitually hunt and eat tarsiers for snack food; and an extent of occurrence that is entirely volcanic in its geological composition, with Mount Karengetang, a massive and highly active volcano, dominating more than 50% of the geographic range of this species. Furthermore, there are no protected areas within its range (Riley 2002; Shekelle and Salim in press; Shekelle *et al.* 2007), and all captive breeding programs for tarsiers, including several by leading zoos and primate centers, have been dismal failures, leaving no *ex situ* conservation options for any tarsier species anywhere (Fitch-Snyder 2003). The most reasonable interpretation of the scant data is that population size is very small, in the low thousands at best, and declining (Shekelle and Salim in press). Despite the fact that Sangihe Island is renowned for its Critically Endangered avifauna (Whitten *et al.* 1987; Whitten 2006), Shekelle and Salim (in press) found that the conservation threat for the tarsier on Siau Island was greater, for every variable measured, than that faced by *T. sangirensis* on Sangihe Island, which nevertheless is Endangered (B1 2ab). Thus, in spite of the fact that this species has yet to be described and is almost unknown, sufficient available evidence indicates that it teeters on the brink of extinction on an island where the entire endemic fauna and flora are at risk (Shekelle *et al.* 2007).

In Meyer's (1897) description of *T. sangirensis*, from Sangihe Island, he included a single skull from Siau Island (in the Dresden Museum, B321, from "Siao"). Sangihe and Siau Islands are part of a volcanic arc and are separated by approximately 60 km of deep ocean, greater than 1,000 m in depth. There is no feasible means for recurrent gene flow between these islands today, nor is there any historical indication of a land connection between these islands. Accordingly, Brandon-Jones *et al.* (2004) suggested that the Siau Island population is taxonomically distinct. Shekelle visited the island in March 2005 and found acoustic and morphologic evidence that supported taxonomic separation of the Siau Island population. Aside from the skull in Dresden, there is no evidence in the literature of research on this species. Shekelle's surveys found evidence of tarsiers in only two places, on the shores of a small fresh water pond at the extreme southern end of the island, and on a steep cliff face along the east coast road where it runs next to the ocean. Numerous other sites that looked promising, based upon experience with *T. sangirensis*, turned up no evidence of tarsiers. Interviews with several locals indicated that tarsiers had formerly been common at these sites as recently as 10 years ago, but were now rare or non-existent. They also added that tarsiers were a popular snack food called "*tola-tola*", and that it had formerly been common to eat 5 to 10 at a single sitting after hunting them with air rifles. It is unsurprising that tarsiers are no longer found in these areas.

Myron Shekelle & Agus Salim

Horton Plains Slender Loris, Ceylon Mountain Slender Loris

Loris tardigradus nycticeboides Hill, 1942
Sri Lanka
(2004, 2006)

Slender lorises are small, nocturnal primates occurring in southern India and Sri Lanka. The two recognized species, comprised of six subspecies, are readily distinguished from all other primate taxa by large, close-set eyes, pencil-thin limbs, and a long body with only a hint of a tail. Unable to leap, these ninjas of the night move with a fluid and noiseless locomotion. Though they may be slow when startled, all of the slender lorises studied so far can move several kilometers per night, and have home ranges of 1.5 to 10 ha — not small, considering that the various subspecies range in size from 110 – 350 g.

The smaller of the two species, *Loris tardigradu*s (Linnaeus, 1758), is found only in Sri Lanka's diminishing rainforests. In the 1960s, W. C. Osman Hill used the loris as the symbol of the Wildlife and Nature Protection Society of Sri Lanka, stating that it, being the most mysterious and rarely seen creature of Sri Lanka's jungles, was the most apt symbol for a society dedicated to revealing the unknown in nature. Two subspecies of this taxon, *L. t. tardigradus* and *L. t. nycticeboides*, are little better known today. The first long-term study of the red slender loris, *L. t. tardigradus*, was recently completed by Lilia Bernede of Oxford Brookes University, Oxford, UK. Continuing surveys of this subspecies by Nekaris and field assistants from the University of Ruhuna reveal that it is highly threatened, clinging to Sri Lanka's small remaining rain forest patches, which average only 1,300 ha in size.

The situation for the latter subspecies, *L. t. nycticeboides*, is no brighter. This rare little loris is found only in Sri Lanka's chilly highlands (where temperatures may drop to -4°C). To cope with these extremes, the Horton Plains slender loris has evolved a thick, woolly coat, which swathes its limbs, giving it the superficial appearance of its Southeast Asian counterpart, the greater slow loris, *Nycticebus coucang.* Even in 1942, Osman Hill wrote "That the animal is rare in the Horton Plains is evidenced by the fact that Mr. Tunein-Nolthenius has been on the look out for it for the previous twenty years without success." In 1980, this statement was further qualified by W. W. Phillips who stated that it "would appear to be the rarest of all mammals in Sri Lanka." This mysterious loris first appeared on this list of the World's 25 Most Endangered Primates in 2004, after Nekaris and Perera had carried out surveys for it at its type locality, the Horton Plains. They found only two animals after 60 km of surveys. This yielded an abundance estimate of 0.08 – 0.16 animals/km. A return visit in 2004 by Nekaris and colleagues from the Wildlife Heritage Trust yielded only one observation, giving an abundance estimate of 0.02 animals/km. These exceedingly low density estimates spurred Saman Gamage of the University of Ruhuna to lead a team in search of this most elusive of the lorises. Interestingly, after 21 nights of targeted efforts, abundance estimates generated in 2006 were the same: 0.02 animals/km.

On the brighter side, Gamage's team have found this loris in two new localities, Haggala Strict Natural Reserve, and Bomburella forest. An unusual museum specimen uncovered in the Natural History Museum of Colombo examined by Colin Groves also suggests that the range of this species may extend as far as Sri Lanka's Knuckles Range, expanding its known area of extent from 30 km² to 250 km². A search to identify the lorises in this region will be instigated in 2007 by Sandun Perera of Sabaragamuwa University of Sri Lanka.

Although still imperilled by continued habitat loss, gem mining, agricultural encroachment, as well as being hunted and captured for medicines, as pets, and uses resulting from local folklore, there is a glimmer of hope for this small nocturnal primate. Virtually ignored since its discovery in the 1940s, media exposure from this list has now spurred two studies of this primate by local researchers. It is our hope that in 2008, more populations will be discovered, and that the Horton Plains slender loris can sink back into that dubious comfort of being 'only Endangered.'

K. Anna I. Nekaris

Simakobu or Pig-Tailed Snub-Nose Langur

Simias concolor Miller, 1903
Indonesia (Mentawai Islands)
(2002, 2004, 2006)

The simakobu monkey is serving as the flagship species for a group of endangered primates endemic to the remnants of forest on the 7,000-km² Mentawai Islands. The four main islands are located 85 – 135 km off of the west coast of Sumatra and are home to three other primate species — Kloss's gibbon (*Hylobates klossii*), the Mentawai pig-tailed macaque (*Macaca pagensis*), and the Mentawai Island leaf langur (*Presbytis potenziani*). *Simias concolor concolor* Miller, 1903 inhabits the islands of Sipora, North Pagai, and South Pagai along with several small islets off southern South Pagai. *Simias c. siberu* Chasen and Kloss, 1927 occurs only on Siberut Island. Where *Simias* still occurs on the Pagai Islands, it exists at lower densities than on Siberut.

Although the first simakobu specimens were collected in 1902, researchers did not begin studying the Mentawai primates until the 1970s. In 1996, two simakobu groups were habituated to the presence of humans and studied in Betumonga, in the southwestern region of North Pagai Island. Researchers with the Siberut Conservation Project in the Peleonan Forest in northern Siberut are in the process of habituating more simakobu and other primate groups. Simakobus are arboreal quadrupeds that eat leaves, fruits, and flowers, and exhibit a variable social organization.

All four of the Mentawai primates are affected by habitat disturbance and hunting (Whittaker 2006). Although hunting appears to be declining and opportunistic, human encroachment and timber removal are increasing. Of the four Mentawai primates, simakobus seem to be the most sensitive to logging. On the Pagais, density estimates range from a high of 5.17 simakobus per km² in unlogged forests to a significantly lower density of 2.54 ind/km² in forests that were logged in the 1980s (Paciulli 2004). Twenty-five years ago, simakobus were found in areas of mixed primary and secondary forests on Siberut at densities as high as 220 ind/km² (Watanabe 1981). In 1990, however, no evidence could be found of *Simias* inhabiting several areas on Siberut and the Pagais (Tenaza and Fuentes 1995).

Today, the Mentawai primates continue to exist in some residual forest patches on the Pagais and Sipora, and parts of the 190,500-ha (470,735 acres) Siberut National Park (also a UNESCO Biosphere Reserve) that covers 47% of the island. Thus, while *Simias* and the other Mentawai primates still survive in spite of human encroachment, hunting, and timber removal, the vast majority of the remaining natural habitat lies outside of officially protected areas. Most of these areas are in logging concessions and could very well be lost in the near future as there is talk of clear cutting in 2008 for oil palm plantations.

Lisa M. Paciulli

Delacour's Langur

Trachypithecus delacouri (Osgood, 1932)
Vietnam
(2000, 2002, 2004, 2006)

Delacour's langur is endemic to Vietnam and occurs in a very restricted area of northern Vietnam which comprises about 5,000 km² between 20°–21°N and 105°–106°E. The distribution is closely linked to the limestone mountain ranges in the provinces of Ninh Binh, Thanh Hoa, Hoa Binh and Ha Nam. Currently there are 19 locations where Delacour's langur is or was known to occur. They are isolated populations and when combined total at most only 400 to 450 km². The extirpation of Delacour's langurs has been reported by local people in three localities that we know of. There is a smaller limestone mountain ridge to the west extending to a large limestone region north of Son La, but there is no evidence of Delacour's langurs in this area. The northwestern border of the distribution is Mai Chau between the Da River in the north and the Ma River in the south. The Da River appears to form the northern border of the species' range. The exact southern boundary is unclear. There are some smaller isolated limestone areas south of the Ma River. The only area south of the Ma River where Delacour's langurs have been confirmed is the limestone complex between Lang Chan and Ngoc Lan, but this population is now most probably extirpated. It seems that this species never occurred south of the Chu River.

During the decades following the discovery of Delacour's langur in 1930 there was only scanty information on its existence and distribution. The first sightings of live animals were reported in 1987 from Cuc Phuong National Park. The most important, and for some subpopulations the only factor for the decline in numbers is poaching, which is not primarily for meat, but for bones, organs and tissues that are used in the preparation of traditional medicines. The 19 isolated wild populations of Delacour's langur have been confirmed over 10 years of surveys and monitoring by the Frankfurt Zoological Society. The total population counted in 1999/2000 was about 280 to 320 individuals. The recorded numbers of animals hunted over the 10 years totaled 320, an annual loss of more than 30 individuals, but the real number is undoubtedly higher. Sixty percent of all existing Delacour's langurs occur in isolated populations with less than twenty animals. The loss of these subpopulations, and consequently sixty percent of the entire population, is foreseeable without management, strict regulations and law enforcement. Surveys in 2004 in two protected areas with important subpopulations, Cuc Phuong National Park and Pu Luong Nature Reserve, showed a decline in numbers of 20% in the last 5 years. It is to be expected that the population in unprotected areas which have yet to be surveyed will show a similar tendency. A reasonable estimate of the current population indicates numbers no higher than 200 to 250 individuals.

Four areas where Delacour's langurs occur are protected: Cuc Phuong National Park, Pu Luong Nature Reserve, Hoa Lu Cultural and Historical Site, and the Van Long Nature Reserve (established in 2001). Van Long Nature Reserve is believed to harbor the largest remaining population of about 60 to 80 animals. They are well protected there due to patrols and close cooperation between the provincial forest protection authorities and Frankfurt Zoological Society. Currently two doctoral students are working in the area, studying the biology and population dynamics of the subpopulation. Efforts to save this species are being led by Tilo Nadler, manager of the Vietnam Primate Conservation Program of Frankfurt Zoological Society and director of the Endangered Primate Rescue Center at Cuc Phuong National Park, established in 1993 primarily to safeguard the future of this and other endangered Vietnamese primates. The Endangered Primate Rescue Center is the only facility which keeps this species. The center started a breeding program with five confiscated animals, and 12 individuals have been born since 1996. The aim is to reintroduce the langurs into well-protected areas to establish additional free ranging populations.

Tilo Nadler & William R. Konstant

Golden-headed Langur or Cat Ba Langur

Trachypithecus poliocephalus poliocephalus (Trouessart, 1911)
Vietnam
(2000, 2002, 2004, 2006)

The golden-headed langur, *Trachypithecus p. poliocephalus*, is probably the most endangered of the Asian colobines. This species only occurs on the Island of Cat Ba in the Gulf of Tonkin, northeastern Vietnam. The Cat Ba Archipelago is in the world-famous Ha Long Bay, a spectacular karst formation that was invaded by the sea. The golden-headed langur inhabits tropical moist forest on limestone karst hills, and shares this habitat preference with the six to seven taxa of the *T. francoisi* group. Among these so called karst langurs, the Cat Ba langur and its closest relatives, the white-headed langur, *T. p. leucocephalus* Tan, 1955, in southern China, and the wide-ranging Francois' langur, *T. francoisi* (Pousargues, 1898), the northernmost representative of the genus, display the strictest behavioral adaptations to their karst habitat.

There are no systematic and reliable data available on the historic density of the langur population on Cat Ba Island. According to reports of indigenous people the entire island of Cat Ba (140 km²) and some smaller offshore islands were previously densely populated by langurs. Hunting has been the sole cause for the dramatic and rapid population decline from an estimated 2,400–2,700 in the 1960s to only 53 individuals by 2000. The langurs were poached mainly for trade in traditional medicines. Since the implementation of strict protection measures towards the end of 2000, the langur population on Cat Ba Island increased to a current 65 individuals (+22.5%).

Although the growth of the population is encouraging, the overall status of the species is most critical. As a result of habitat fragmentation, the remaining population is now divided into seven isolated sub-populations, five of which include or consist of all-female groups, thus non-reproducing social units. The estimated effective population size is 29 individuals at most. Only three groups are currently reproducing, and the total reproductive output in this species is accordingly low. Since a peak in births in 2003, the reproductive output of the Cat Ba Langur has stagnated at 1–2 offspring per year.

Cat Ba Island and the surrounding area are nationally and internationally recognized for their importance to biodiversity conservation. Cat Ba National Park was established in 1986. It presently covers more than half of the main island. The Cat Ba Archipelago (some 1,500–2,000 large and small islands, cliffs and rocks) was designated a UNESCO Man and Biosphere Reserve in 2004. Despite this, nature and wildlife protection on Cat Ba Island is deficient. Efforts to effectively conserve the langurs and their habitat face major obstacles because of the lack of partnership and commitment with the local communities and the need to better address their aspirations for development, and due to the steadily increasing human population, besides persistent, severe deficiencies in law enforcement. As elsewhere in the region, poaching is driven by increasingly attractive commercial gains in satisfying the immense local and regional demand for wildlife. The strictest protection regime possible is necessary for the survival of all the mammals and other species on Cat Ba that are, like the langurs, targeted by the Asian wildlife trade.

A conservation program for the golden-headed langur on Cat Ba was initiated in November 2000 by the Zoologische Gesellschaft für Arten- und Populationsschutz (ZGAP), München, in cooperation with Allwetterzoo, Münster, Germany. The aim is to provide for their protection, reduce population fragmentation, and contribute to the conservation of the biodiversity on Cat Ba Island in collaboration with Vietnamese authorities.

Roswitha Stenke, Phan Duy Thuc & Tilo Nadler

Western Purple-faced Langur

Semnopithecus vetulus nestor Bennett, 1833
Sri Lanka
(2004, 2006)

Endemic to Sri Lanka, this langur is restricted to a small area of the wet zone in the west of the country, most of which is threatened due to human activities (crops, infrastructure and industry, settlements, deforestation and forest fragmentation, and hunting). Colombo, the capital city of Sri Lanka, is in the center of its very limited range. Hill (1934) indicated that it was common around the capital, but this is no longer the case. Forest cover in Sri Lanka has declined drastically since the late 1950s, and the area of occupancy of this langur has been reduced to a highly fragmented 1,900 km^2 (Molur *et al*. 2003). Although still quite numerous (>10,000), the declines in numbers are expected to have been precipitous—estimated at more 80% in three generations due to urbanization and development.

Western purple-faced langurs are highly arboreal and need good canopy cover, and there are possibly less than three forests that can support viable populations, none of which are protected areas set aside for conservation. The human-modified areas that sustain much of the langur population, such as gardens and rubber plantations, are under private ownership and changing rapidly due to human population expansion and development; large trees are cut down and entire forest patches are destroyed for housing and development. This severely restricts home ranges, isolating the groups, and resulting in escalated conflict with humans and low juvenile recruitment rates (Dela 1998). Long-term studies by Dela (1998) have shown that this taxon is unique in having subpopulations adapted to a diet high in mature/ripe fruit, a feature as yet unrecorded for any other colobine, and are dependent on fruits cultivated by humans.

The geographical range of the species has a very high human population density, and home ranges are being compressed due to loss of tree cover. Censuses are urgently needed to identify forest areas for conservation and to better quantify the decline of subpopulations in space and time, and to provide a better understanding of their demographics (especially reproductive rates, population turnover and dispersal) in the extremely disturbed habitats where they survive today.

Jinie Dela & Noel Rowe

Grey-shanked Douc

Pygathrix cinerea Nadler, 1997
Vietnam
(2000, 2002, 2004, 2006)

The colobine monkeys of the genus *Pygathrix* are native to Indochina. Until only ten years ago, just two distinct taxa were recognized: the red-shanked douc, *Pygathrix nemaeus*, named by Linnaeus in 1771, in the northern part of Central Vietnam and Central Laos; and the black-shanked douc, *P. nigripes*, from South Vietnam and east Cambodia, described exactly a century later by Milne-Edwards. The grey-shanked douc was first described as a subspecies of the red-shanked douc, but genetic studies have since demonstrated a divergence at species level. It occurs in Central Vietnam between 13°30' and 16°N, and has been recorded in five provinces: Quang Nam, Quang Ngai, Kon Tum, Gia Lai and Binh Dinh. Currently grey-shanked doucs are known only from Vietnam, but records exist close to the border to Laos, and there are photos of hunted animals from southeast Laos and far northeast Cambodia that suggest that the species occurs in small neighboring areas in both countries. Surveys and research on this recently discovered primate have been conducted by the Frankfurt Zoological Society, led by Tilo Nadler, manager of the Vietnam Primate Conservation Program of Frankfurt Zoological Society and director of the Endangered Primate Rescue Center at Cuc Phuong National Park, and Ha Thang Long, biologist at the Rescue Center.

Grey-shanked douc populations are fragmented and estimated to total 600–700 individuals. Their occurrence has been confirmed in eight protected areas: Song Thanh Nature Reserve, Ngoc Linh Nature Reserve, Ba To Cultural and Historical Site, An Toan Nature Reserve, Kon Cha Rang Nature Reserve, Kon Ka Kinh National Park, Mom Ray National Park and A Yun Pa Nature Reserve. However, hunting, the principal threat to the species, is still a problem inside these parks and reserves. Snares are the most commonly used method since gun confiscation programs were carried out in a number of the areas. Often hundreds of traps are installed in trees frequently used by the langur groups, as well as on the ground where they are seen crossing between small forest patches. Trapped animals are often severely injured and mutilated. Forest loss within at least part of the species' range is attributable to the expansion of agriculture, illegal logging and firewood collection. Almost 10,000 ha of forest are destroyed every year in the Central Highlands.

The Endangered Primate Rescue Center has received 37 confiscated grey-shanked douc langurs since 1995, and has begun a breeding program to provide stock for reintroduction in protected forests. Based on information from villagers and forest protection authorities, less than one-quarter of the hunted animals are confiscated alive. Ha Thang Long, the biologist of the Endangered Primate Rescue Center, is studying the species in Central Vietnam specifically to provide recommendations for the establishment of special "Species Protection Areas," which will promote connectivity between the currently isolated populations in the established parks and reserves.

Ha Thang Long & Tilo Nadler

Tonkin Snub-nosed Monkey

Rhinopithecus avunculus Dollman, 1912
Vietnam
(2000, 2002, 2004, 2006)

The Tonkin snub-nosed monkey is one of four unusual, large Asian colobine monkeys of the genus *Rhinopithecus*, all of which possess a characteristic turned-up nose. The three other species are endemic to China, while the Tonkin snub-nosed monkey is found only in northern Vietnam. This species was discovered in 1911, collected on perhaps no more than two occasions over the course of the next 50 to 60 years, and subsequently presumed to be extinct by a number of primatologists until it was rediscovered in 1989. Historically the species occurs only east of the Red River between about 21°09'–23°N. Due to massive deforestation and intensive hunting in recent decades, its distribution has become dramatically restricted.

Currently, there are only four known locations with recent evidence where Tonkin snub-nosed monkeys occur, and these are completely isolated. In 1992, a population was found in Na Hang District, Tuyen Quang Province. As a result of the discovery, a nature reserve was established in 1994. The nature reserve comprises two separate areas: the Ban Bung and Tat Ke sectors. A study in 1993 estimated a population of between 95 and 130 individuals in each sector, respectively, which was probably overestimated. A later study, in 2004–2005, found far lower densities, and estimated only 17–22 individuals in the Tat Ke sector. For the subpopulation of Na Hang Nature Reserve, the most serious threat was a hydropower and flood prevention dam project. Construction began in 2002. Some 10,000 workers moved into the area for dam construction, which has increased the demand for wildlife products and firewood. Conservation activities carried out by several organizations have been unsuccessful, and resulted in a reduction of this subpopulation.

A population of about 70 individuals was estimated for Cham Chu Nature Reserve, also in Tuyen Quang Province. Based on local interviews during a survey reported in 1992 the population was believed to have dropped to only 20–40 individuals. A survey in 2006 provided no sightings and no reliable evidence of the survival of the population. Local reports indicate, however, a small group of 8–12 individuals still in the area. A population of about 60–90 Tonkin snub-nosed monkeys was discovered 2001 in Khau Ca, close to Du Gia Nature Reserve, Ha Giang Province. This is the only population which is not immediately threatened. There, public awareness and community participatory activities are being linked to increased protection efforts under the supervision of Fauna & Flora International (FFI). The total population of the Tonkin snub-nosed monkey is believed to be less than 150 individuals.

Le Khac Quyet, Tilo Nadler & William R. Konstant

Hainan Gibbon

Nomascus hainanus (Thomas, 1892)
China (Island of Hainan)
(2000, 2002, 2004, 2006)

The taxonomy of the crested black gibbons, genus *Nomascus* is still in debate, but experts now believe there are three species: the Hainan gibbon, *Nomascus hainanus*, the most endangered of any of the gibbons and restricted to the island of Hainan (Geissmann 2003; Geissmann and Chan 2004; Wu *et al.* 2004; Zhou *et al.* 2004); the eastern black gibbon, *Nomascus nasutus,* occurring in northeast Vietnam (Nadler 2003), and adjoining Guangxi Zhuang Autonomous Region, China (Chan *et al.* in prep.); and the western black gibbon, *Nomascus concolor*, occurring in central Yunnan, China, and Indochina. A recent study found no molecular differences between the putative subspecies of *N. concolor*, but significant genetic differences between the forms *hainanus* and *nasutus* (Roos *et al.* 2007). The Hainan gibbon and eastern black gibbon differ in their hair coloration (Geissmann *et al.* 2000; Mootnick 2006) and territorial calls (La Q. Trung and Trinh D. Hoang 2004). These characteristics, in association with the newly discovered genetic differences, suggest that the Hainan gibbon and eastern black gibbon be considered distinct species (Roos and Nadler 2005; Roos *et al.* 2007).

Adult male eastern black gibbons are black and can have a slight tinge of brown hair on the chest. Adult male Hainan gibbons are entirely black (Geissmann *et al.* 2000; Mootnick 2006). Adult female Hainan gibbons and eastern black gibbons vary from a buffish to a beige brown and have a black cap (Geissmann *et al*. 2000; Mootnick 2006). The adult female Hainan gibbon has a thin, white face ring that is thicker above the mouth and below the orbital ridge. The hair surrounding the face of the female Hainan gibbon creates a rounded appearance encircling the face. The hair grows outwards on the side of the face and in a more downward direction as it gets closer to the chin. This contrasts with the female northern white-cheeked gibbon (*Nomascus l. leucogenys*), whose facial appearance is slightly similar to the female Hainan gibbon. The hair on the outer sides of the face of the female white-cheeked gibbon grows in a more upward direction giving the face a more triangular appearance. Depending on the amount of humidity, female *Nomascus* can acquire a more orangey color resulting from their sweat (Mootnick 2006). The only account of a live female eastern black gibbon in close proximity was of a female "Patzi" in the Berlin Zoo whose vocalizations were similar to that of the eastern black gibbon, but her pelage differed in that she had a very long and broad black crown streak that went past the nape, and extended to the brow, tapering to a thin face ring and becoming thicker at the chin (Geissmann *et al*. 2000; Mootnick 2006). This female had a narrow blackish-brown chest plate slightly wider than the face, beginning at the throat and tapering at the top of the abdomen. At this time Patzi had more black than what has been observed in the wild or in museum specimens of female eastern black gibbons.

The eastern black gibbon was thought to be extinct in southwestern provinces of China in the 1950s. In the 1960s, it was also feared extinct in Vietnam, but was rediscovered after intensive searches in January 2002 by Fauna and Flora International (FFI) biologists La Q. Trung and Trinh D. Hoang (2004). They found five groups totaling 26 individuals in the remaining 3,000 ha of limestone forest of Phong Nam-Ngoc Khe Mountains, Trung Khanh District, northern Cao Bang Province bordering Guangxi in China. Further surveys by the Vietnam Primate Conservation Programme of FFI and Trung Khanh District rangers in November 2004 located 37 individuals (VNA 2004). Recently, a team of researchers from Kadoorie Farm & Botanic Garden (KFBG) and China confirmed 17 eastern black gibbons in three groups in the Bangliang limestone forest of Jingxi County in Guangxi, neighboring the Phong Nam-Ngoc Khe Mountains of Vietnam. Some of the gibbons observed in Bangliang may be the same individuals counted by Vietnamese counterparts as gibbon groups were seen traveling between the two countries (People's Daily Online 2006; Chan *et al.* in prep.). There is rumor that there might be some eastern black gibbons in Kim Hy Nature Reserve, Bac Kan Province, Vietnam, as well as other border areas in Guangxi, China.

In the 1950s there were estimates of >2,000 Hainan gibbons on the island of Hainan in 866,000 ha of forests across 12 counties (Wang and Quan 1986). By 1989, the Hainan gibbon population was reduced to only 21 gibbons in four groups restricted to Bawangling Nature Reserve (Liu *et al.* 1989). In 1998 the population was said to be 17 (Kadoorie Farm & Botanic Garden 2001). A gibbon survey in October 2003 found two groups, and two lone males, comprising a total of 13 individuals (Fellowes and Chan 2004; Geissmann and Chan 2004; Chan *et al.* 2005; Zhou *et al.* 2005); another survey in 2001–2002 estimated 12–19 individuals in four groups (Wu *et al.* 2004). In recent months three newborns and at least one lone female have been observed, bringing the world total to 17 individuals (Hainan Daily Online 2007a).

Gibbons generally establish long-term pair bonds, but in Bawangling National Nature Reserve (BNNR) there have been repeated observations of two females in the same group both carrying offspring (Liu *et al*. 1989; Bleisch and Chen 1991; Hainan Daily Online 2007a). This "non-traditional" group could be the result of older offspring being unable to locate appropriate mates (Wu *et al.* 2004), limited space to establish new groups (Liu *et al*. 1989), or could reflect habitual bigyny as in the crested black gibbons of Yunnan (Bleisch and Chen 1991; Fan *et al.* 2006). If fresh feces could be collected from these individuals, it is possible that nuclear DNA sequencing could determine the relationships and confirm if observations are being conducted on the same group in different locations.

Since 2003, when the first Hainan Gibbon Action Plan was launched (Chan *et al.* 2005), several teams have continued to work roughly in line with the Plan, though with limited coordination. Conservation actions include surveying the distribution of the Hainan gibbon, providing training of staff to monitor the gibbons, restoring the forest, and community conservation work. One team consists of the KFBG, the Hainan Wildlife Conservation Centre of the Hainan Provincial Forestry Department (HWCC), and BNNR. The second (Franco-Chinese) team consists of East China Normal University of Shanghai (ECNU), the Zoological Society of Paris (PZS), and BNNR. A third team from Fauna and Flora International (FFI) China has also conducted monitoring, training and community work in the recent past.

With only 17 Hainan gibbons and 54 eastern black gibbons confirmed, each surviving in just one small forest block, the Hainan gibbon and eastern black gibbon are among the most critically endangered primates in the world. It is important to gain full support from the surrounding community for conservation of the gibbons and their habitat, possibly by ensuring benefits linked to their compliance with conservation goals, and ensuring longer-term commitment from the government and outside partners. Efforts are underway to contribute to the conservation of the eastern black gibbon in Vietnam with the establishment of community-based protection activities. Since there are unconfirmed reports of gibbon occurrences from other forests, additional surveys need to be conducted in both Guangxi and Hainan (Hainan Daily Online 2007b). There is an urgent need to secure and expand suitable forest for the survival of the few remaining gibbons and their habitats, which will require continued effort and cooperation among all parties.

Alan R. Mootnick, Xiaoming Wang, Pierre Moisson, Bosco P. L. Chan, John R. Fellowes & Tilo Nadler

Western Hoolock Gibbon

Hoolock hoolock (Harlan, 1831)
Bangladesh, India, Myanmar
(2006)

The hoolock gibbon was formerly in the genus *Bunopithecus* with just one species and two subspecies: *B. hoolock hoolock*, the western hoolock gibbon, and *B. hoolock leuconedys* Groves, 1967, the eastern hoolock gibbon from Myanmar and China. Mootnick and Groves (2005) informed that the name *Bunopithecus* was not valid, and placed it in a new genus, *Hoolock*, and at the same time argued that the two forms were distinct species (but see Mootnick 2006). The western hoolock gibbon (*Hoolock hoolock*) occurs in Bangladesh, northeastern India and western Myanmar, west of the Chindwin River. Its range in Myanmar, known from just a few field studies and mostly informal sightings, is restricted to the western parts, delineated from the populations of *Hoolock leuconedys* by the Chindwin River as far as the head waters in the north. In India and Bangladesh its range is strongly associated with the occurrence of contiguous canopy, broad-leaved, wet evergreen and semi-evergreen forests. The species is an important seed disperser; its diet includes mostly ripe fruits, with some flowers, leaves and shoots.

Western hoolock gibbons face numerous threats in the wild, and are now entirely dependent on human action for their survival. The debilitating threats include habitat encroachment to accommodate ever-growing human populations and immigration, forest clearance for tea cultivation, the practice of *jhum*ing (slash-and-burn cultivation), hunting for food and "medicine", capture for trade, and the degradation and decline in quality of their forests that impacts fruiting trees, canopy cover and the viability of their home ranges. Isolated populations face the additional threats arising from the intrinsic effects of small populations. Some populations surviving in just a few remaining trees are subjected to harassment by locals and to lack of food, and are attacked by dogs while attempting to cross clearings between forest patches.

Based on habitat loss over the last 30–40 years, western hoolock gibbons are estimated to have declined from more than 100,000 (Assam state alone was estimated to have around 80,000 in the early 1970s) to less than 5,000 individuals (a decline of more than 90%). The species was known to occur in good numbers in contiguous forests, which have borne the brunt of persistent human impacts. Isolated forest fragments hold just some few families— numbers insufficient for survival in the mid- to long-term. Apart from some border forests between India and Myanmar, the remaining habitat is fragmented, holding minimal populations of this sort. We have documented the extirpation of western hoolock gibbons from 18 locations over the last 3–5 years; eight in Bangladesh and 10 in India. Bangladesh has about 200 western hoolock gibbons in 22 separate locations, twenty of which have less than 20 individuals each: 17 of these have less than 15 individuals, and 14 have less than 10 individuals. About 100 locations with hoolock gibbons have been recorded in India; 77 have less than 20 individuals, and 47 of these have less than 10 individuals. The Population Viability Analysis (PVA) predicts a 95% decline in the population in Bangladesh and a 75% decline in the population in India over the next two decades based on the current effects of human impacts and the intrinsic factors acting on very small and isolated populations.

The population of the western hoolock gibbon in Myanmar has not been surveyed. West of the Ayeyarwaddy-Chindwin River, there is about 50,000 km² of forest in the Rakhine Yoma region, but much of it is degraded and hunted. The area includes the Rakhine Yoma Elephant Range (about 175,500 ha), managed by the Nature and Wildlife Conservation Division of the Forest Department of Myanmar, in Rakhine State, in the lower part of the country (about 17ºN). There are other forested areas farther to the north, including the Chin Hills Complex and the Naga Hills area, but they are considered unsafe for travelers. No published information is available on the current range and status of the western hoolock in Myanmar. Warren Brockelman has been carrying out surveys of the eastern hoolock, *Hoolock leuconedys* Groves, 1967, in accessible protected areas east of the Chindwin River in Myanmar since 2005, and preliminary results indicate that the situation there is considerably more encouraging, with relatively large populations still surviving. The population trends for the western hoolock observed over recent years in Bangladesh and northeast India indicate a very rapid decline in numbers and immediate measures are required by their governments, forest departments, local communities and NGOs.

Sally Walker, Sanjay Molur & Warren Y. Brockelman

Sumatran Orangutan

Pongo abelii Lesson, 1827
Indonesia (Sumatra)
(2000, 2002, 2004, 2006)

Sumatran and Bornean (*Pongo pygmaeus* Linnaeus, 1760) orangutans, now recognized as two distinct species, comprise the genus *Pongo.* While there are considered to be three subspecies of *P. pygmaeus*, the Sumatran orangutan is regarded as a single taxonomic unit. The viability of all taxa is in question, but the Sumatran orangutan faces a more immediate extinction risk than the Bornean, and is considered Critically Endangered.

The species is endemic to Sumatra, Indonesia, and is now entirely restricted to remaining lowland forests in Nanggroe Aceh Darussalam (NAD) and North Sumatra Provinces. About 7,000 individuals remain (based largely on 2002 satellite imagery), surviving in 13 fragmented habitat units stretching from northern NAD, south to the Batang Toru River in North Sumatra, with a notable gap in their distribution immediately west of Lake Toba. The southernmost populations may be genetically and culturally distinct from their more northern relatives. The largest populations live within NAD province, where until recently, a separatist conflict made monitoring and conservation work problematic.

By far the most significant populations, totaling about 5,600 animals, are found within the Leuser Ecosystem, a 26,000 km² conservation area established by presidential decree that encompasses the smaller Gunung Leuser National Park (10,950 km²; itself part of the Sumatran Rainforest World Heritage Site) and the 1,025 km² Singkil Swamps Wildlife Reserve within its boundaries. The Ecosystem and the national park within it form the only conservation area of note where viable wild populations of the Sumatran orangutan, Sumatran tiger, Sumatran rhinoceros and Sumatran elephant, each of which is endangered in itself, still occur living side by side. The National Park, however, is predominantly high mountains, and as the orangutan is a predominantly lowland creature, rarely being found above 1,000 m asl, the majority occur within the larger Ecosystem but outside the National Park. For example, the Ecosystem harbors *c.*75% of the remaining 7,000 Sumatran orangutans whilst only 24% are found within the National Park and 20% within the Singkil Swamps Wildlife Reserve.

Throughout its range, the primary threat to Sumatran orangutans is logging, both legal and illegal, which often leads to total conversion of forests for agriculture or oil palm plantations. Although exact figures are still unavailable, primary lowland forests in Sumatra have been devastated over the last 20 years. One analysis of satellite imagery concluded that habitat supporting around 1,000 orangutans was being lost each year in the Leuser Ecosystem alone during the late 90's (van Schaik *et al*. 2001). This was largely due to legal logging concessions and conversion of lowland forests to palm oil estates, but also illegal logging and encroachment in some places. Fortunately, however, the rate of habitat loss decreased markedly in many areas during the Aceh civil conflict, as activities in the forests became unsafe, and as a result of a moratorium imposed on logging in the province by the Aceh government. Orangutan populations have nevertheless plummeted in regions that have been affected by logging. Even small scale illegal logging can reduce local orangutan densities by as much as 60% in Sumatra (Rao and van Schaik 1997). At least six of the remaining seven populations containing over 250 individuals have experienced between 10 and 15% annual habitat loss due to logging. Encroachment and conversion, especially by settlers fleeing the conflict in NAD and migrants from Nias Island, have accelerated habitat loss in some parts. Relocation of people from coastal areas and an increase in demand for timber after the 2004 tsunami poses a significant new threat. Several proposed new roads (known as the Ladia Galaska project) will lead to a major increase in fragmentation of remaining orangutan populations. Throughout their range orangutans are sometimes killed as pests along forest edges as they raid agricultural crops, and in the far south of their range they are occasionally still hunted as food. A small but significant pet trade in young Sumatran orangutans also persists.

Key conservation interventions rely heavily on a dramatic and rapid improvement in enforcement of wildlife and forest laws and far greater consideration for environmental issues in spatial planning decisions. Implementing patrols, improving law enforcement, stopping illegal logging, halting legal logging and forest conversion to plantations, promoting forest restoration, halting road construction, addressing human-orangutan conflict, and providing connectivity in the landscape to allow for genetic exchange are all seen as pre-requisites for the species' survival. If current rates of habitat loss persist a further 50% of Sumatran orangutans will vanish within a decade. However, there is as much reason to believe the rate of decline will actually increase due to higher demand for timber, fragmentation by roads, expansion of plantations and general population pressure, as there is for mitigation of these threats. Solutions to conserve the remaining lowland primary forests are urgently needed.

Ian Singleton, Susie Ellis & Mark Leighton

Neotropical Region

Variegated or Brown Spider Monkey

Ateles hybridus I. Geoffroy, 1829
Colombia, Venezuela
(2006)

There are two recognized subspecies of the variegated or brown spider monkey. *Ateles hybridus brunneus* Gray, 1870 is restricted to Colombia, occurring between the lower Ríos Cauca and Magdalena in the Departments of Bolívar, Antioquia and Caldas. *Ateles h. hybridus* occurs east from the right bank of the Río Magdalena extending into western Venezuela. Both subspecies are Critically Endangered due to habitat loss, hunting and the pet trade.

The large size, slow reproductive rate (single offspring at 3–4 year intervals) and generally low population densities of spider monkeys make them especially vulnerable to hunting. Historically, *A. hybridus* has suffered from habitat destruction, and only 0.67% of the current remaining *A. hybridus* distribution is protected. Most of its range has been converted to farms for agriculture and cattle.

Ateles h. brunneus has a small geographic range in a region where forest loss, degradation and fragmentation is widespread. Currently the remaining populations are surrounded by human populations, compounding the already high level of threat. Only 9% of their potential range remains as continuous forest. Surveys have been conducted to determine the density of this subspecies in Maceo and Puerto Berrio (Antioquia). To date just one group of eight individuals has been found in an area of 1,000 ha. A refuge remains, however, in the Serranía San Lucas in southern Bolívar, identified as an important site for the establishment of a national park. A protected area is highly necessary for this subspecies, that also would include two other threatened endemic primates, the white-footed tamarin, *Saguinus leucopus*, and the woolly monkey, *Lagothrix lugens*.

Ateles h. hybridus is extremely endangered due to habitat destruction in both Colombia and Venezuela. This subspecies can be found in three protected areas in Venezuela, but little is known about the population densities and local threats there.

Ateles hybridus can be found in at least six zoos in Colombia, presenting problems of surplus animals and consanguinity. This species is suffering also from the pet trade; about 20 confiscated individuals are currently in residence in four rescue centers and need to be relocated. There is an urgent need for surveys to establish areas with populations of this species and to propose conservation measures. An *ex situ* breeding program is also necessary to maintain healthy and viable captive populations.

Erwin Palacios & Alba Lucia Morales-Jiménez

Brown-headed Spider Monkey

Ateles fusciceps fusciceps Gray, 1866
Ecuador, Colombia
(2006)

Ateles fusciceps lives in Central and South America, from southeast Panama to Ecuador, west of the Andes along the Chocó Ecoregion. It is a diurnal species that inhabits mostly evergreen humid tropical forest. It is strictly arboreal and prefers the uppermost levels of the canopy. The species lives in groups of up to 35 individuals and its diet comprises mainly ripe fruits, but also flowers and leaves of a number of different species. The subspecies *Ateles fusciceps fusciceps* inhabits the Pacific coast of Ecuador and possibly southern Colombia, in an altitudinal range between 100 and 1,700 m above sea level. This subspecies is listed as Critically Endangered (CR) in the Red List of the IUCN as well as the *Red Book of Mammals of Ecuador* (Tirira 2001b), due to its restricted distribution and the small size of its natural populations. Strong hunting pressure and high deforestation rates are the most critical threats for the species; destruction of the humid tropical forest in western Ecuador has surpassed 80% of its original area. Tirira (2003, 2004) presented information on the historical and current distribution of the species, reporting several localities where it is locally extinct, including the type locality (Hacienda Chinipamba, west of Ibarra, Intag sector, Imbabura Province), the whole central coast of Ecuador and the forests of the Ríos Cayapas, San Miguel, Ónzole and Santiago, in the Esmeraldas Province. Currently there are only two areas known where populations of *Ateles fusciceps fusciceps* remain, but their ecological characteristics and conservation status are unknown. One population is found north of the Río Mira, within the protected area "Reserva Etnica Awá" close to the Colombian border; the other, to the south, is largely within the limits of another protected area: the "Reserva Ecológica Cotacachi-Cayapas" and neighboring forest (mainly in a private reserve: "Reserva Biológica Los Cedros"). There is little information on the numbers and population densities of this species in the wild. Gavilanes-Endara (2006) reported 1.2 individuals/km² in the Reserva Biológica Los Cedros. Its presence in Colombia is uncertain, but there is a record of *A. fusciceps* for Barbacoas, Nariño Department, that needs to be confirmed.

Diego Tirira & Alba Lucia Morales-Jiménez

Peruvian Yellow-tailed Woolly Monkey

Oreonax flavicauda (Humboldt, 1812)
Peru
(2000, 2006)

The Peruvian yellow-tailed woolly monkey, *Oreonax flavicauda*, is endemic to Peru, and is found only in a small area in the Tropical Andes. *Oreonax flavicauda* is known to persist only in primary premontane, montane and cloud forest between 1,500 to 2,700 m asl (Leo Luna 1982; Butchart *et al.* 1995; DeLuycker 2007). When *O. flavicauda* was first rediscovered in 1974, populations existed in the Departments of Loreto and La Libertad (Leo Luna 1980), but they have now been restricted to irregular, scattered parts of only two Departments, Amazonas and San Martín. There are no current estimates of remaining population numbers. Indiscriminate clearcutting of primary cloud forest is the principal threat to this species, and its habitat has been largely deforested, resulting in a greatly fragmented landscape.

Very little is known about the ecology and behavior of the yellow-tailed woolly monkey. Results from studies in the early 1980s indicated that the sizes of its multi-male/multi-female groups ranged from 5 to 18 individuals. *Oreonax flavicauda* has been seen to eat a variety of fruits, flowers, leaves, lichens, leaf bases of bromeliads, epiphyte roots and bulbs, and possibly insects (Leo Luna 1982; DeLuycker 2007). In a recent field survey, an unusually large group (17–20 individuals) was encountered in areas relatively close to agricultural plots, which may indicate that due to recent and on-going loss of habitat they are finding less suitable habitat areas. The species appears to be highly sensitive to alterations in its habitat (Leo Luna 1987; DeLuycker 2007). Due to the forest disturbance resulting from illegal logging, *O. flavicauda* decreases its use of the area (Leo Luna 1984), often retreating further into high-altitude forests far away from human settlement in order to use large tracts of forest. In 1981, it was estimated that *O. flavicauda* occurred in low densities, from 0.25 to 1 group per km² (Leo Luna 1987). It is also suspected to have a large home range (DeLuycker 2007). The species is known to be present in the Río Abiseo National Park (2,745 km²), the Alto Mayo Protected Forest (1,820 km²), and the Reserved Zone Cordillera de Colán (641 km²), which was established in 2002 with assistance from the *Asociación Peruana para la Conservación de la Naturaleza* (APECO).

The current area occupied by *O. flavicauda* is unknown. In 1981, it was estimated that its potential forested habitat was at least 11,240 km² (Leo Luna 1984). It was predicted that at least 1,600 km² would be deforested for agriculture by 1991 (Leo Luna 1984). Projecting this value for 15 additional years, and using a very conservative similar rate of deforestation, this leaves an estimated 7,240 km² of potential habitat area. This estimate is probably much lower, due to a high rate of migration to the area combined with unregulated land use. In addition, much or most of this forest is now highly fragmented or isolated from other tracts of forest. *Oreonax flavicauda* has likely declined drastically in numbers due to a big reduction in their area of occupancy and a decrease in the quality of their habitat.

Clearing the forest for agriculture continues at an alarming rate, even in the Protected Forest of Alto Mayo (BPAM). It has been estimated that between 2,300 and 2,500 ha of forest have been destroyed in BPAM (ParksWatch, Peru). The forest of the BPAM is now considerably fragmented, a result of lack of enforcement and a substantial human population living in the Protected Forest itself. The BPAM also suffers from illegal selective logging. Members of several botanical expeditions conducted within the BPAM over the last ten years reported having never seen nor heard *O. flavicauda* there (M. Dillon, personal comm.). Towns that were previously connected only by footpaths are now more accessible due to road construction. For example, Vista Alegre, a town in the Department of Amazonas, and where *O. flavicauda* has been reported, has plans to build a road in the near future; the first in the region. Additionally, *O. flavicauda* has been extirpated from all but the most distant and isolated forests on the eastern side of the Río Alto Mayo. Illegal hunting still occurs, and if the monkeys are encountered, they are likely shot, because of their large size, conspicuousness, and trusting behavior toward humans. The species' velvety, thick, long fur, its skin and skull, and yellow genital hair-tuft are sought after as trophy items, and make this species a target for hunters even when they do not hunt it for subsistence. Infants taken when their mothers are shot are sold in markets as pets.

There is very little information on the biology and natural history of this species, resulting mainly from the difficulties imposed by the mountainous and precipitous terrain where it lives. A complete, range-wide survey of its cloud forest habitat is urgently needed to develop plans to protect the remaining populations of *Oreonax flavicauda*. These surveys should also include population genetic studies, to examine genetic variability and the viability of existing populations. Urgent conservation initiatives necessary for the yellow-tailed woolly monkey's survival include: increased protection within designated parks, reserves, and protected forests, which currently lack enforcement; the establishment of a contiguous area of protected forest, to create a biological corridor; the establishment of a national park or reserve in the semi-isolated Valle de los Chilchos area; control of illegal logging; purchase of land; the provision of alternative economic models for local communities living along buffer zones, in order to prevent further migration into the primary cloud forests; and the implementation of a strong conservation education plan.

Anneke M. DeLuycker & Eckhard W. Heymann

Bibliography

Greater Bamboo Lemur

Prolemur simus

Albrecht, G. H., P. D. Jenkins and L. R. Godfrey. 1990. Ecogeographic size variation among the living and subfossil prosimians of Madagascar. *Am. J. Primatol.* 22: 1–50.

Arrigo-Nelson, S. J. and P. C. Wright. 2004. Survey results from Ranomafana National Park: New evidence for the effects of habitat preference and disturbance on the distribution of *Hapalemur*. *Folia Primatol.* 75: 331–334.

Dolch, R., R. D. Hilgartner, J.-N. Ndriamiary and H. Randriamahazo. 2004. "The grandmother of all bamboo lemurs": evidence for the occurrence of *Hapalemur simus* in fragmented rainforest surrounding the Torotorofotsy marshes, Central Eastern Madagascar. *Lemur News* 9: 24–26.

Godfrey, L. R. and M. Vuillaume-Randriamanantena. 1986. *Hapalemur simus*: Endangered lemur once widespread. *Primate Conserv.* (7): 92–96.

Godfrey, L. R., W. L. Jungers, E. L. Simons, P. S. Chatrath and B. Rakotosaminana. 1999. Past and present distributions of lemurs in Madagascar. In: *New Directions in Lemur Studies*, B. Rakotosaminana, H. Rasimanana, J. U. Ganzhorn and S. M. Goodman (eds.), pp.19–53. Kluwer Academic/ Plenum Publishers, New York.

Godfrey, L. R., E. L. Simons, W. L. Jungers, D. D. DeBlieux and P. S. Chatrath. 2004. New discovery of subfossil *Hapalemur simus*, the greater bamboo lemur, in western Madagascar. *Lemur News* 9: 9–11.

Goodman, S. M., V. R. Razafindratsia, V. Schütz and R. Ratsimbazafy. 2001b. Les lémuriens. In: *Inventaire biologique du Parc National de Ranomafana et du couloir forestier qui la relie au Parc National d'Andringitra*, S. M. Goodman and V. R. Razafindratsia (eds.). Centre d'Information et du Documentation Scientifique et Technique, Antananarivo 17: 231–243.

Irwin, M. T., S. E. Johnson and P. C. Wright. In press. The state of lemur conservation in southeastern Madagascar: Population and habitat assessments for diurnal lemurs using surveys, satellite imagery and GIS. *Oryx* 39.

Macedonia, J. M. and K. F. Stanger. 1994. Phylogeny of the Lemuridae revisited: Evidence from communication signals. *Folia Primatologica* 63: 1–43.

Meier, B. 1987. Preliminary report of a field study on *Lemur rubriventer* and *Hapalemur simus* (nov. species) in Ranomafana-Ifanadiana 312 Faritany Fianarantsoa, Madagascar, July 1986–January 1987. Unpublished report to Ministry of Scientific Research, Antananarivo.

Meier, B. and Y. Rumpler. 1987. Preliminary survey of *Hapalemur simus* and of a new species of *Hapalemur* in eastern Betsileo, Madagascar. *Primate Conserv.*(8): 40–43.

Rakotosamimanana, B., R. R. Ralaiarison, R. C. Ralisoamalala, T. M. Rasolofoharivelo, V. Raharimanantsoa, R. M. Randrianarison, J. G. Rakotondratsimba, D. R. W. Rasolofoson, E. O. Rakotonirainy and T. M. Randriamboavonjy. 2004. Comment et pourquoi les lémuriens diurnes disparaissent peu à peu dans les forêts d'Ambato et de Moramanga (région de Moramanga) Madagascar? *Lemur News* 9: 19–24.

Rumpler, Y., S. Warter, B. Ishak and B. Dutrillaux. 1989. Chromosomal evolution in primates. *Hum. Evol.* 4: 157–170.

Schwarz, E. 1931. A revision of the genera and species of Madagascar Lemuridae. *Proc. Zool. Soc. Lond.* 1931: 399–428.

Stanger-Hall, K. F. 1997. Phylogenetic affinities among the extant Malagasy lemurs (Lemuriformes) based on morphology and behavior. *J. Mammal. Evol.* 4: 163–194.

Sterling, E. J. and M. G. Ramaroson. 1996. Rapid assessment of the primate fauna of the eastern slopes of the Rèserve Naturelle Intégrale d'Andringitra, Madagascar. In: *A Floral and Faunal Inventory of the Eastern Slopes of the Rèserve Naturelle Intégrale d'Andringitra, Madagascar, with Reference to Elevational Variation*, S. M. Goodman (ed.). *Fieldiana: Zool., new series* 85: 293–305.

Tan, C. L. 1999. Group composition, home range size, and diet in three sympatric bamboo lemur species (genus *Hapalemur*) in Ranomafana National Park, Madagascar. *Int.J. Primatol.* 20: 547–566.

Tan, C. L. 2000. Behavior and ecology of three sympatric bamboo lemur species (genus *Hapalemur*) in Ranomafana National Park, Madagascar. Ph. D. thesis, State University of New York, Stony Brook.

Vuillaume-Randriamanantena, M., L. R. Godfrey and M. R. Sutherland. 1985. Revision of *Hapalemur* (*Prohapalemur*) *gallieni* (Standing 1905). *Folia Primatol.* 45: 89–116.

Wilson, J. M., P. D. Stewart and S. V. Fowler. 1988. Ankarana—a rediscovered nature reserve in northern Madagascar. *Oryx* 22: 163–171.

Wright, P. C., P. S. Daniels, D. M. Meyers, D. J. Overdorff and J. Rabesoa. 1987. A census and study of *Hapalemur* and *Propithecus* in southeastern Madagascar. *Primate Conserv.* (8): 84–87.

White-collared Lemur

Eulemur albocollaris

CBSG. 2002. *Evaluation et Plans de Gestion pour la Conservation (CAMP) de la Faune Madagascar: Lémuriens, Autres Mammifères, Reptiles et Amphibiens, Poissons d'eau douce et Evaluation de la Viabilité des Populations et des Habitats des* Hypogeomys antimena *(Vositse).* IUCN/SSC Conservation Breeding Specialist Group (CBSG), Apple Valley, Minnesota.

Djletati, R., B. Brun and Y. Rumpler. 1997. Meiotic study of hybrids in the genus *Eulemur* and taxonomic considerations. *Am. J. Primatol.* 42: 235–245.

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Irwin, M. T., S. E. Johnson and P. C. Wright. In press. The state of lemur conservation in southeastern Madagascar: Population and habitat assessments for diurnal lemurs using surveys, satellite imagery and GIS. *Oryx* 39.

Johnson, S. E. 2002. Ecology and speciation in brown lemurs: white-collared lemurs (*Eulemur albocollaris*) and hybrids (*Eulemur albocollaris* x *Eulemur fulvus rufus*) in southeastern Madagascar. Ph. D. thesis, University of Texas, Austin.

Johnson, S. E. 2006. Evolutionary divergence in the brown lemur species complex. In: *Lemurs: Ecology and Adaptation*, L. Gould and M. L. Sauther (eds.), pp.187–210. Springer, New York.

Johnson, S. E. and D. J. Overdorff. 1999. Census of brown lemurs (*Eulemur fulvus* spp.) in southeastern Madagascar: Methods testing and conservation implications. *Am. J. Primatol.* 47: 51–60.

Johnson, S. and Y. Wyner. 2000. Notes on the biogeography of *Eulemur fulvus albocollaris*. *Lemur News* 5: 25–28.

Mittermeier, R. A., W. R. Konstant, F. Hawkins, E. E. Louis Jr., O. Langrand, J. Ratsimbazafy, R. Rasoloarison, J. U. Ganzhorn, S. Rajaobelina, I. Tattersall and D. M. Meyers. 2006. *Lemurs of Madagascar*, 2nd Ed., Conservation International, Washington, DC.

Pastorini, J., M. R. J. Forstner and R. D. Martin. 2000. Relationships among brown lemurs (*Eulemur fulvus*) based on mitochondrial DNA sequences. *Molec. Phylogenet. Evol.* 16: 418–429.

Petter, J.-J. and A. Petter-Rousseaux. 1979. Classification of the prosimians. In: *The Study of Prosimian Behavior*, G. A. Doyle and R. D. Martin (eds.), pp.359–409. Academic Press, London.

Rumpler, Y. 1975. The significance of chromosomal studies in the systematics of the Malagasy lemurs. In *Lemur Biology*, Vol. 1, I. Tattersall and R. W. Sussman (eds.), pp.25–40. Plenum Press, New York.

Sterling, E. J. and M. G. Ramaroson. 1996. Rapid assessment of the primate fauna of the eastern slopes of the Rèserve Naturelle Intégrale d'Andringitra, Madagascar. In: *A Floral and Faunal Inventory of the Eastern Slopes of the Rèserve Naturelle Intégrale d'Andringitra, Madagascar: With Reference to Elevational Variation*, S. M. Goodman (ed.). *Fieldiana: Zool., new series* 85: 293–305.

Tattersall, I. 1982. *The Primates of Madagascar*. Columbia University Press, New York.

Wyner, Y., R. Absher, G. Amato, E. Sterling, R. Stumpf, Y. Rumpler and R. DeSalle. 1999. Species concepts and the determination of historic gene flow patterns in the *Eulemur fulvus* (brown lemur) complex. *Biol. J. Linn. Soc.* 65:39–56.

Wyner, Y. M., S. E. Johnson, R. M. Stumpf and R. DeSalle. 2002. Genetic assessment of a white-collared x red-fronted lemur hybrid zone at Andringitra, Madagascar. *Am. J. Primatol.* 57: 51–66.

Silky Sifaka

Propithecus candidus

Duckworth, J. W., M. I. Evans, A. F. A. Hawkins, B. J. Stafford and R. J. Wilkinson. 1995. The lemurs of Marojejy Strict Reserve, Madagascar: a status overview with notes on ecology and threats. *Int. J. Primatol.* 16: 545–559.

Garbutt, N. 1999. *Mammals of Madagascar*. Yale University Press, New Haven.

Garbutt, N. 2007. *Mammals of Madagascar: A Complete Guide*. A&C Black Publishers Ltd., London.

Goodman, S.M. 2000. Description of the Parc National de Marojejy, Madagascar, and the 1996 Biological Inventory of the Reserve. *Fieldiana Zool., new series* 97: 1–18.

Goodman, S. M., M. J. Raherilalao, D. Rakotomalala, D., A. Raselimanana, H. Schütz and V. Soarimalala. 2003. Les Lémuriens. In: *Nouveaux Résultats d'Inventaires Biologiques Faisant Référence à l'Altitude dans la Région des Massifs Montagneux de Marojejy et d'Anjanaharibe-Sud*, S. M. Goodman and L. Wilmé (eds.), pp.279–286. Recherches pour le Développement, série sciences biologiques no. 19, Centre d'Information et de Documentation Scientifique et Technique, Antananarivo.

Kelley, E. and Mayor, M. I. 2002. Preliminary study of the silky sifaka (*Propithecus diadema candidus*) in northeast Madagascar. *Lemur News* (7): 16–18.

Mittermeier, R. A., W. R. Konstant, F. Hawkins, E. E. Louis Jr., O. Langrand, J. Ratsimbazafy, R. Rasoloarison, J. U. Ganzhorn, S. Rajaobelina., I. Tattersall, I. and D. M. Meyers. 2006. *Lemurs of Madagascar*. 2nd edition. Tropical Field Guide Series, Conservation International, Washington DC.

Patel, E. R., J. J. Marshall and H. Parathian. 2005. Silky sifaka (*Propithecus candidus*) conservation education in northeastern Madagascar. *Lab. Prim. Newsl.* 44(3): 8–11.

Patel, E. R. 2005. Silky sifaka (*Propithecus candidus*) predation by a fossa (*Cryptoprocta ferox*). *Lemur News* (10): 25–27.

Patel, E. R. 2006. Activity budget, ranging, and group size in silky sifakas (*Propithecus candidus*). *Lemur News* (11): 42 – 45.

Patel, E. R. 2007. Non-maternal infant care in wild silky sifakas (*Propithecus candidus*). *Lemur News* (12). In press.

Patel, E. R. Submitted. Logging of rare rosewood and palisandre (*Dalbergia* spp.) within Marojejy National Park, Madagascar.

Rakotondratsimba, J. G., D. Rasolofoson, O. Rakotonirainy and J. Ratsimbazafy. 2007. Le bloc forestier de Makira charnière de lémuriens. *Lemur News* (12). In press.

Schmid, J. and R. Smolker. 1998. Lemurs of the Reserve Special d'Anjanaharibe-Sud, Madagascar. *Fieldiana Zool., new series* 90: 227–240.

Sterling, E. and K. McFadden. 2000. Rapid census of lemur populations in Parc National de Marojejy, Madagascar. *Fieldiana Zool., new series* 97: 265–274.

Tattersall, I. 1982. *The Primates of Madagascar.* Columbia University Press, New York.

Sahamalaza Sportive Lemur

Lepilemur sahamalazensis

Andriaholinirina, N., J.-L. Fausser, C. Roos., D. Zinner, U. Thalmann, C. Rabarivola, I. Ravoarimanana, J. U. Ganzhorn, B. Meier, R. Hilgartner, L. Walter., A. Zaramody, C. Langer, T. Hahn, E. Zimmermann, E., U. Radespiel, M. Craul, J. Tomiuk, I. Tattersall and Y. Rumpler. 2006. Molecular phylogeny and taxonomic revision of the sportive lemurs (*Lepilemur*, Primates). *BMC Evol. Biol.* 6, 17.

Birkinshaw, C. R. 2004. Priority Areas for Plant Conservation. *Ravintsara* 2(1):14–15.

Lernould, J.-M. 2006. AEECL zoos involved in the discovery of four new lemur species. *EAZA News* (55): 14–15.

MAB. 2001. Biosphere Reserve Information, Madagascar: Sahamalaza – Iles Radama. [Online]. Retrieved on 11 December 2006 from http://www2.unesco.org/mab/br/brdir/directory/biores.asp?code=MAG+02&mode=all.

Olivieri, G. L., M. Craul and U. Radespiel. 2005. Inventaire des lémuriens dans 15 fragments de forêt de la province de Mahajanga. *Lemur News* 10: 11–16.

Rabarivola, C., A. Zaramody, J.-L. Fausser, N. Andriaholinirina, C. Roos, D. Zinner, M. Hauwy and Y. Rumpler Y. 2006. Cytogenetic and molecular characteristics of a new species of sportive lemur from northern Madagascar. *Lemur News* 11, 45–49.

Schwitzer, C., N. Schwitzer, G. H. Randriatahina, C. Rabarivola and W. Kaumanns. 2006. "Programme Sahamalaza": New perspectives for the *in situ* and *ex situ* study and conservation of the blue-eyed black lemur (*Eulemur macaco flavifrons*) in a fragmented habitat. In *Proceedings of the German-Malagasy Research Cooperation in Life and Earth Sciences*, C. Schwitzer, S. Brandt, O. Ramilijaona, M. Rakotomalala Razanahoera, D. Ackermand, T. Razakamanana & J. U. Ganzhorn (eds.), pp.135–149. Concept Verlag, Berlin.

Rondo dwarf galago

Galagoides rondoensis

Ahrends, A. 2005. Pugu Forest: going, going *The Arc Journal* 17: 23.

Bearder, S. K., L. Ambrose, C. Harcourt, P. Honess, A. Perkin, S. Pullen, E. Pimley and N. Svoboda. 2003. Species-typical patterns of infant care, sleeping site use and social cohesion among nocturnal primates in Africa. *Folia Primatol.* 74: 337–354.

Burgess, N. D. and G. P. Clarke. 2000. *Coastal Forests of Eastern Africa.* IUCN – The World Conservation Union, Gland, Switzerland, and Cambridge, UK.

Doggart, N. (ed.). 2003. *Pande Game Reserve: A Biodiversity Survey*. Tanzania Forest Conservation Group, Technical Paper 7. Dar es Salaam, Tanzania.

Honess, P. E. 1996a. New primatological discoveries in Tanzania: a discussion about speciation. *Social Biology and Human Affairs* 61 (1): 7–18.

Honess, P. E. 1996b. Speciation among galagos (Primates, Galagidae) in Tanzanian forests. PhD thesis, Oxford Brookes University, Oxford, UK.

Honess, P. E. and S. K. Bearder. 1996. Descriptions of the dwarf galago species of Tanzania. *African Primates* 2: 75–79.

IUCN. 2006. *2006 IUCN Red List of Threatened Species.* IUCN – The World Conservation Union, Species Survival

Commission (SSC), Gland, Switzerland, and Cambridge, UK. Website: <www.iucnredlist.org>. Accessed: 5 March 2007.

Kingdon, J. 1997. *The Kingdon Field Guide to African Mammals*. Academic Press, London.

Perkin, A. 2000. A Field Study of the Conservation Status and Diversity of Galagos in Zareninge Forest, Coast Region, Tanzania. Report of WWF-Tanzania, Dar-es-Salaam.

Perkin, A. 2003. Mammals. In: *Pande Game Reserve: A Biodiversity Survey*, N. Doggart (ed.) pp.95. Tanzania Forest Conservation Group, Technical Paper 7. Dar es Salaam, Tanzania.

Perkin, A. 2004. *Galagos of the Coastal Forests and Eastern Arc Mtns. of Tanzania—Notes and Records.* Tanzania Forest Conservation Group, Technical Paper 8. Dar es Salaam, Tanzania.

Roloway Guenon

Cercopithecus diana roloway

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Grubb, P., T. M. Butynski, J. F. Oates, S. K. Bearder, T. R. Disotell, C. P. Groves and T. T. Struhsaker. 2003. An assessment of the diversity of African primates. *Int. J. Primatol.* 24: 1301–1357.

Kone. I. 2004. Report on recent primate surveys in the southeast of Ivory Coast. Report, Conservation des Espèces et des Populations Animales (CEPA), Schlierbach, France.

Kone, I. and K. B. Akpatou.2005. Recherche en Cote d'Ivoire de trios singes gravement menaces d'extinction. *CEPA Magazine* 12: 11–13.

Magnuson, L. 2003. Final Brief: Ecology and Conservation of the Roloway Monkey in Ghana. Unpublished report to the Wildlife Division of Ghana, Forestry Commission, Ghana.

McGraw, W. S. 1998a. Three monkeys nearing extinction in the forest reserves of eastern Cote d'Ivoire. *Oryx* 32: 233–236.

McGraw, W. S. 1998b. Surveys of endangered primates in the forest reserves of eastern Cote d'Ivoire. *African Primates* 3(1–2): 22–25.

McGraw, W. S. 2005. Update on the search for Miss Waldron's red colobus monkey (*Procolobus badius waldroni*). *Int. J. Primatol.*26(3): 605–619.

Oates, J. F. 1996. *African Primates: Status Survey and Conservation Action Plan. Revised Edition*. IUCN/SSC Primate Specialist Group, Gland, Switzerland. 80pp.

Oates, J. F. 2006. Primate Conservation in the Forests of Western Ghana: Field Survey Results, 2005–2006. Report to the Wildlife Division, Forestry Commission, Ghana.

Oates, J. F., T. T. Struhsaker and G. H. Whitesides. 1996/1997. Extinction faces Ghana's red colobus and other locally endemic subspecies. *Primate Conserv.* (17): 138–144.

Struhsaker, T. T. and J. F. Oates. 1995. The biodiversity crisis in southwestern Ghana. *African Primates* 1: 5–6.

Bioko Red Colobus

Procolobus pennantii pennantii

Butynski, T. M. and S. H. Koster. 1994. Distribution and conservation status of primates in Bioko Island, Equatorial Guinea. *Biodiv. Conserv.* 3: 893–909.

Gautier-Hion, A., M. Colyn. and J.-P. Gautier. 1999. *Histoire Naturelle des Primates d'Afrique Centrale*. ECOFAC, Libreville.

Hearn, G., W. A. Morra and T. M. Butynski. 2006. Monkeys in trouble: The rapidly deteriorating conservation status of the monkeys on Bioko Island, Equatorial Guinea. Report, Bioko Biodiversity Protection Program, Glenside, Pennsylvania. Website: <http://www.bioko.org>.

Kone, I. 2004. Report on recent primate surveys in the southeast of Ivory Coast. Unpublished report to Conservation des Espèces et des Populations Animales (CEPA), Schlierbach, France.

McGraw, W. S. 1998. Three monkeys nearing extinction in the forest reserves of eastern Côte d'Ivoire. *Oryx* 32: 233–236.

McGraw, W. S. 2005. Update on the search for Miss Waldron's red colobus monkey (*Procolobus badius waldroni*). *Int. J. Primatol.* 26: 605–619.

McGraw, W. S. and J. F. Oates. 2002. Evidence for a surviving population of Miss Waldron's red colobus. *Oryx* 36: 223–226.

Oates, J. F. 1994. The natural history of African colobines. In: *Colobine Monkeys: Their Ecology, Behaviour and Evolution*, A. G. Davies and J. F. Oates (eds.), pp.75–128. Cambridge University Press, Cambridge.

Oates, J. F. 1996. *African Primates: Status Survey and Conservation Action Plan.* Revised edition. IUCN, Gland, Switzerland.

Oates, J. F., T. T. Struhsaker and G. H. Whitesides. 1996/1997. Extinction faces Ghana's red colobus and other locally endemic subspecies. *Primate Conserv.* (17): 138–144.

Oates J. F., M. Abedi-Lartey, W. S. McGraw, T. T. Struhsaker and G. H. Whitesides. 2000. Extinction of a West African red colobus monkey. *Conserv. Biol.* 14: 1526–1532.

Oates, J. F., R. A. Bergl and J. M. Linder. 2004. Africa's Gulf of Guinea forests: Biodiversity patterns and conservation priorities. *Advances in Applied Biodiversity Science* 6: 1–90. Center for Applied Biodiversity Science, Conservation International, Washington, DC.

Struhsaker, T. T. 1999. Primate communities in Africa: The consequence of long-term evolution or the artifact of recent hunting? In: *Primate Communities*, J. G. Fleagle, C. Janson and K. E. Reed (eds.), pp.289–294. Cambridge University Press, Cambridge.

Struhsaker, T. T. 2005. The conservation of red colobus and their habitats. *Int. J. Primatol.* 26: 525–538.

Waltert, M., Lien, K. Faber and M. Muhlenberg, M. 2002. Further declines of threatened primates in the Korup Project Area, south-west Cameroon. *Oryx* 36: 257–265.

Tana River Red Colobus

Procolobus rufomitratus

Butynski, T. M. and G. Mwangi. 1995. Census of Kenya's endangered red colobus and crested mangabey. *African Primates* 1: 8–10.

Butynski, T. M. and G. Mwangi. 1994. Conservation status and distribution of the Tana River red colobus and crested mangabey. Report to Zoo Atlanta, Georgia, Kenya Wildlife Service, National Museums of Kenya, Institute of Primate Research, and East African Wildlife Society, Nairobi, Kenya. 68pp.

Luke, Q., R. Hatfield and P. Cunneyworth. 2005. Rehabilitation of the Tana Delta Irrigation Project Kenya: An Environemtal Assessment. Report to Critical Ecosystem Partnership Fund (CEPF), Conservation International, Arlington, VA. Website: <http://www.cepf.net/ImageCache/cepf/content/pdfs/final_2etdip_5fenvironmental_5fassessment_2epdf/v1/final.tdip_5fenvironmental_5fassessment.pdf>. Accessed 23 February, 2007.

Marsh, C. W. 1985. A survey of Tana River primates. Unpublished report to the Institute of Primate Research, Nairobi, Kenya.

Mbora, D. N. M. and W. C. McGrew. 2002. Extra-group sexual consortship in the Tana River red colobus (*Procolobus rufomitratus*)? *Folia Primatol.* 73: 210–213.

Mbora, D. N. M. and D. B. Meikle. 2004. Forest fragmentation and the distribution, abundance and conservation of the Tana River red colobus (*Procolobus rufomitratus*). *Biol. Conserv.* 118: 67–77.

Mbora, D. N. M. and D. B. Meikle. 2004. The value of unprotected habitat in conserving endangered species: Case study of the Tana River red colobus in eastern Kenya. *Biol. Conserv.* 120: 91–99.

Mbora, D. N. M. and E. Munene. 2006. Gastrointestinal parasites of critically endangered primates endemic to Tana River Kenya; the Tana River red colobus (*Procolobus rufomitratus*) and the crested mangabey (*Cercocebus galeritus*). *J. Parasitol.* 92: 928–932.

Wieczkowski, J. and D. N. M. Mbora. 2000. Increasing threats to the conservation of endemic endangered primates and forests of the lower Tana River, Kenya. *African Primates* 4(1–2): 32–40.

Wieczkowski, J., D. N. M. Mbora, A. Kariuki, A. and S. Strum. 2001. Tana River Primate and Habitat Monitoring Project. Report to Margot Marsh Biodiversity Foundation, Great Falls, Virginia. 13pp.

Miss Waldron's Red Colobus

Procolobus badius waldroni

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Grubb, P., T. M. Butynski, J. F. Oates, S. K. Bearder, T. R. Disotell, C. P. Groves and T. T. Struhsaker. 2003. An assessment of the diversity of African primates. *Int. J. Primatol.* 24: 1301–1357.

Grubb, P. and C. B. Powell. 1999. Discovery of red colobus monkeys (*Procolobus badius*) in the Niger Delta with the description of a new and geographically isolated subspecies. *J. Zool., Lond.* 248: 67–73.

Kone, I. 2004. Report on recent primate surveys in the southeast of Ivory Coast. Report, Conservation des Espèces et des Populations Animales (CEPA), Schlierbach, France.

Kone, I. and K. B. Akpatou. 2005. Identification des sites abritant encore les singes *Cercopithecus diana roloway*, *Cercocebus atys lunulatus* et *Piliocolobus badius waldroni* en Cote d'Ivoire. Report, Conservation des Espèces et Populations Animales (CEPA), Schlierbach, France.

Kone, I., D. Coulibaly, K. Bene, A. Bitty, A. Koffi, A. Boko and R. Kouadio. 2007. Initiation of a community based conservation system in southeastern Cote d'Ivoire for the probable last refuge for the Miss Waldron's red colobus. Report, West African Primates Conservation Action, Abidjan, Côte d'Ivoire.

McGraw, W. S. 1998. Three monkeys nearing extinction in the forest reserves of eastern Cote d'Ivoire. *Oryx* 32: 233–236.

McGraw, W. S. 2005. Update on the search for Miss Waldron's red colobus monkey (*Procolobus badius waldroni*). *Int. J. Primatol.* 26(3): 605–619.

McGraw, W. S. and J. F. Oates. 2002. Evidence for a surviving population of Miss Waldron's red colobus. *Oryx* 36: 223–226.

Oates, J. F. 1996. *African Primates: Status Survey and Conservation Action Plan. Revised Edition*. IUCN/SSC Primate Specialist Group, Gland, Switzerland. 80pp.

Oates, J. F. 2006. Primate Conservation in the Forests of Western Ghana: Field Survey Results, 2005–2006. Report to the Wildlife Division, Forestry Commission, Ghana.

Oates, J. F., T. T. Struhsaker and G. H. Whitesides. 1996/1997. Extinction faces Ghana's red colobus and other locally endemic subspecies. *Primate Conserv.* (17): 138–144.

Oates, J. F., M. Abedi-Lartey, W. S. McGraw, T. T. Struhsaker and G. H. Whitesides. 2000. Extinction of a West African red colobus monkey. *Conserv. Biol.* 14: 1526–1532.

Struhsaker, T. T. 1999. Primate communities in Africa: The consequence of long-term evolution or the artifact of recent hunting? In: *Primate Communities*, J. G. Fleagle, C. Janson and K. E. Reed (eds.), pp.289–294. Cambridge University Press, Cambridge, UK.

Struhsaker, T. T. 2005. The conservation of red colobus monkeys (*Procolobus*) and their habitats. *Int. J. Primatol.* 26(3): 525–538.

Struhsaker, T. T. and J. F. Oates. 1995. The biodiversity crisis in southwestern Ghana. *African Primates* 1: 5–6.

Wolfheim, J. H. 1983. *Primates of the World*. University of Washington Press, Seattle.

Kipunji

Rungwecebus kipunji

Davenport, T. R. B. 2005. Finding kipunji. *Africa Geographic* 13(7): 56–61.

Davenport, T. R. B. 2006. Plants, primates and people. Conservation in the Southern Highlands of Tanzania. *Miombo* (28):7–8.

Davenport, T. R. B. and T. Jones. 2005. The highland mangabey – Africa's first new monkey for 20 years further illustrates the exceptional value of Tanzania's forests. *Arc Journal* 20: 1–6.

Davenport, T. R. B., T. Jones, N, E. Mpunga, S. J. Machaga, D. W. De Luca, R. Laizzer, A. Mndeme and W. S. Mwakilema. 2005. The highland mangabey *Lophocebus kipunji*, Africa's 'newest' monkey. Unpublished Proceedings of the Fifth Annual Scientific Conference, Tanzania Wildlife Research Institute, Arusha.

Davenport, T. R. B., W. T. Stanley, E. J. Sargis, D. W. De Luca, N. E. Mpunga, S. J. Machaga, and L. E. Olson. 2006. A new genus of African monkey, *Rungwecebus*: morphology, ecology, and molecular phylogenetics. *Science* 312: 1378–1381.

Davenport, T. R. B., D. W. De Luca, T. Jones., N. E. Mpunga, S. J. Machaga and G. Picton Phillipps. Submitted. The kipunji *Rungwecebus kipunji* of southern Tanzania: first census and assessments of distribution and conservation status.

Davenport, T. R. B., D. W. De Luca, S. J. Machaga and N. E. Mpunga. In preparation. Diet and feeding behaviour in the kipunji *Rungwecebus kipunji.*

De Luca, D.W., T. R. B. Davenport, G. Picton Phillipps, S. J. Machaga and N. E. Mpunga. Submitted. Home range and activity patterns in the kipunji *Rungwecebus kipunji*.

Ehardt, C. L. and T. M. Butynski. 2006a. Sanje River mangabey. In: Primates in Peril: The World's 25 Most Endangered Primates 2004–2006, R. A. Mittermeier, C. Valladares-Pádua, A. B. Rylands, A. A. Eudey, T. M. Butynski, J. U. Ganzhorn, R. Kormos, J. M. Aguiar and S. Walker (eds.), *Primate Conserv.* (20): 7–8.

Ehardt, C. L. and T. M. Butynski. 2006b. The recently described highland mangabey *Lophocebus kipunji* (Cercopithecoidea, Cercopithicinae): current knowledge and conservation assessment. *Primate Conserv.* (21): 81–88.

Ehardt, C. L., T. P. Jones and T. M. Butynski. 2005. Protective status, ecology and strategies for improving conservation of *Cercocebus sanjei* in the Udzungwa Mountains, Tanzania. *International Journal of Primatology* 26: 557–582.

Hoffmann, M. 2006. African Primate Red List Workshop: assessing the conservation status of African primates. Report, Conservation International, Washington, DC, and Margot Marsh Biodiversity Foundation, Virginia. 10pp.

Homewood, K. M. and W. A. Rodgers. 1981. A previously undescribed mangabey from southern Tanzania. *Int. J. Primatol.* 2: 47–55.

IUCN. 2006. *2006 IUCN Red List of Threatened Species*. Website: <www.iucnredlist.org>. IUCN – The World Conservation Union, Species Survival Commission (SSC), Gland, Switzerland, and Cambridge, UK. Accessed 20 March 2007.

Jones, T. P., C. L. Ehardt, T. M. Butynski, T. R. B. Davenport, N. E. Mpunga, S. J. Machaga and D. W. De Luca. 2005. The highland mangabey *Lophocebus kipunji*: a new species of African monkey. *Science* 308: 1161–1164.

Olson, L. E., W. T. Stanley, K. Hildebrandt, E. Sargis and T. R. B. Davenport. Submitted. Additional molecular data support the phylogenetic position and taxonomic status of *Rungwecebus kipunji* (Primates: Cercopithecidae).

Cross River Gorilla

Gorilla gorilla diehli

Bassey, A. E. and J. F. Oates (eds.). 2001. *Proceedings of the International Workshop And Conference on the Conservation of the Cross River Gorillas*, Calabar, Nigeria, April 6–9, 2001.

Bergl, R. A. 2006. Conservation Biology of the Cross River Gorilla (*Gorilla gorilla diehli*). PhD thesis, Graduate Center, City University of New York, New York.

Bergl, R. A. and L. Vigilant. 2007. Genetic analysis reveals population structure and recent migration within the highly fragmented range of the Cross River gorilla (*Gorilla gorilla diehlii*). *Molec. Ecol.* 16: 501–516.

Groves, C. P. 2005. A note on the affinities of the Ebo Forest gorilla. *Gorilla Journal* (31): 19–21.

Groves, J. L. 1999. Gorillas in the Takamanda Forest Reserve. *Gorilla Journal.* (18): 17–18.

Groves, J. L. 2001. Gorillas of Takamanda, Mone and Mbulu forest, Cameroon. *Gorilla Journal* (22): 27–29.

McFarland, K. L. 2007. Ecology of Cross River Gorillas (*Gorilla gorilla diehli*) on Afi Mountain, Cross River State, Nigeria. PhD thesis, Graduate Center, City University of New York, New York.

Morgan, B. J. 2004. The gorillas of the Ebo Forest, Cameroon. *Gorilla Journal* (28): 12–14.

Morgan, B. J. and J. L. Sunderland-Groves. 2006. The Cross-Sanaga gorillas: The northernmost gorilla populations. *Gorilla Journal* (32): 16–18.

Morgan, B. J., C. Wild and A. Ekobo. 2003. Newly discovered gorilla population in the Ebo Forest, Littoral Province, Cameroon. *Int. J. Primatol.* 24(5): 1129–1137.

Oates, J. F., D. White, E. L. Gadsby and P. O. Bisong. 1990. Conservation of gorillas and other species. Appendix 1 to *Cross River National Park (Okwangwo Division): Plan for Developing the Park and Its Support Zone*. World Wide Fund for Nature, Godalming, UK.

Oates, J. F., K. L. McFarland, J. L. Groves, R. A. Bergl, J. M. Linder and T. R. Disotell. 2003. The Cross River gorilla: Natural history and status of a neglected and critically endangered subspecies. In: *Gorilla Biology: A Multidisciplinary Perspective*, A. B. Taylor and M. L. Goldsmith (eds.), pp.472–497. Cambridge University Press, Cambridge, UK.

Oates, J. F., R. A. Bergl and J. M. Linder. 2004. Africa's Gulf of Guinea Forests: Biodiversity Patterns and Conservation Priorities. *Advances in Applied Biodiversity Science* (6): 1–90. Center for Applied Biodiversity Science, Conservation International, Washington, DC.

Oates, J. F., J. Sunderland-Groves, R. Bergl, A. Dunn, A. Nicholas, E. Takang, F. Omeni, I. Imong, R. Fotso, L. Nkembi and L. Williamson (eds.). 2007. Regional Action Plan for the Conservation of the Cross River Gorilla (*Gorilla gorilla diehli*). Wildlife Conservation Society, New York, and IUCN/SSC Primate Specialist Group, Arlington, VA.

Sarmiento, E. E. 2003. The Cross River gorilla: The most endangered gorilla subspecies. *Primate Conserv.* (19): 65–72.

Sarmiento, E. E. and J. F. Oates. 2000. Cross River gorillas: A distinct subspecies, *Gorilla gorilla diehli* Matschie, 1904. *Am. Mus. Nov.* (3304): 1–55.

Sunderland-Groves, J. L. and J. F. Oates 2003. Priority conservation actions for Cross River gorillas in Cameroon and Nigeria. Report, Wildlife Conservation Society, New York.

Sunderland-Groves, J. L. and B. Jaff. (eds.). 2004. *Developing a Conservation Strategy for the Cross River Gorilla. Proceedings of the 2nd International Workshop and Conference on the Conservation of the Cross River Gorilla.* Wildlife Conservation Society.

Sunderland-Groves, J. L., F. Maisels and A. Ekinde. 2003. Surveys of the Cross River gorilla and chimpanzee populations in Takamanda Forest Reserve, Cameroon. In: *Takamanda: the Biodiversity of an African Rainforest*. J. A. Comiskey, T. C. H. Sunderland and J. L. Sunderland-Groves (eds.), pp. 129–140. Smithsonian Institution Monitoring and Assessment of Biodiversity Program Series 8. Smithsonian Institution, Washington DC.

Siau Island Tarsier

Tarsius sp.

Brandon-Jones, D., A. A. Eudey, T. Geissmann, C. P. Groves, D. J. Melnick. J. C, Morales, M. Shekelle and C.-B. Stewart. 2004. Asian primate classification. *Int. J. Primatol.* 25(1): 97–164.

Fitch-Snyder, H. 2003. History of captive tarsier conservation. In: *Tarsiers: Past, Present, and Future*, P. C. Wright, E. L. Simons and S. Gursky (eds.), pp.277–295. Rutgers University Press, New Brunswick, NJ.

Meyer, A. B. 1897. *Säugethiere vom Celebes- und Philippinen-Archipel, I. Abhandlungen und Berichte der Kaiserlich Zoologische und Anthropologische-Ethnologische Museum zu Dresden* 6(I–VIII): 1–36.

Riley, J. 2002. Mammals on the Sangihe and Taluad Islands, Indonesia, and the impact of hunting and habitat loss. *Oryx* 36(3): 288–296.

Shekelle, M. and S. M. Leksono. 2004. *Rencana Konservasi di Pulau Sulawesi: Dengan Menggunakan* Tarsius *Sebagai* 'Flagship Taxon'. *Biota* IX(1): 1–10.

Shekelle, M., M. Meier, M. Indrawan, I. Maryanto, A. Salim, J. Supriatna, N. Andayani and Wirdateti. 2007. When 'not extinct' is not good news: Conservation in the Sangihe Islands. *Conserv. Biol.* 21(1): 4–6.

Shekelle M. and A. Salim. In press. An acute conservation threat to two tarsier species in the Sangihe Island Chain (North Sulawesi, Indonesia). *Oryx.*

Shekelle, M. *et al.* In preparation. *Tarsius xxxxxx*: a new tarsier species from Siau Island, North Sulawesi [species name withheld prior to publication].

Whitten, T. 2006. Cerulean Paradise-Flycatcher not extinct: Subject of the first cover lives. *Conserv. Biol.* 20(3): 918–920.

Whitten, T., S. D. Nash and K. D. Bishop. 1987. One or more extinctions from Sulawesi? *Conserv. Biol.* 1: 42–48.

Horton Plains Slender Loris, Ceylon Mountain Slender Loris

Loris tardigradus nycticeboides

Bernede, L. In preparation. A Radio-Tracking Study of the Social and Behavioural Ecology of the Red Slender Loris (*Loris tardigradus tardigradus*) in Masmullah Proposed Forest Reserve, Sri Lanka. Phd Thesis, Oxford Brookes University, Oxford, UK.

Hill, W. C. O. 1942. The slender loris of the Horton Plains, Ceylon. *J. Bombay Nat. Hist. Soc.* 43: 73–78.

Nekaris, K. A. I. 2003. Rediscovery of the slender loris in Horton Plains National Park, Sri Lanka. *Asian Primates* 8(03):1–7.

Nekaris, K. A. I. and J. Jayewardene. 2003. Pilot study and conservation status of the slender loris (*Loris tardigradus* and *L. lydekkerianus*) in Sri Lanka, *Primate Conservation* (19): 83–90.

Nekaris, K. A. I. and J. Jayewardene. 2004. Survey of the slender loris (Primates, Lorisidae Gray, 1821: *Loris tardigradus* (Linnaeus, 1758) and *Loris lydekkerianus* Cabrera, 1908 in Sri Lanka. *J. Zool., Lond.* 262: 1–12.

Nekaris, K. A. I., S. N. Gamage and B. V. P. Perera. In press. *Loris tardigradus nycticeboides*. In: *Conservation International's Field Guide to the Primates of South Asia.*

Phillips, W. W. A. 1980. *Manual of the Mammals of Sri Lanka*. 2nd ed. Wildlife and Nature Protection Society, Sri Lanka.

Werner, W. L. 1984. *Die Höhen- und Nebelwälder auf der Insel Ceylon (Sri Lanka). Tropische und subtropische Pflanzenwelt 46*. Steiner, Wiesbaden.

Simakobu or Pig-Tailed Snub-Nose Langur, Pagai

Simias concolor

Chasen, F. N. and C. B. Kloss. 1927. Spolia Mentawiensia—Mammals. *Proc. Zool. Soc. Lond.* 53: 797–840.

Fuentes, A. 1996/1997. Current status and future viability for the Mentawai primates. *Primate Conserv.* (17): 111–116.

Fuentes, A. 2002. Monkeys, humans and politics in the Mentawai Islands: No simple solutions in a complex world.

In: *Primates Face to Face: Conservation Implications of Human-Nonhuman Primate Interactions*, A. Fuentes and L. D. Wolfe (eds.), pp.187–207. Cambridge University Press, Cambridge.

Kobold, S., T. Ziegler and R. Maennel. 2003. The primates of Mentawai and the Siberut Conservation Project. *ZGAP Mitteilungen* 19: 7–9.

Miller, G. S. 1903. Seventy new Malayan mammals. *Smithsonian Miscellaneous Collection* (45): 1–73.

Mitchell, A. H. and R. L. Tilson. 1986. Restoring the balance: traditional hunting and primate conservation in the Mentawai Islands, Indonesia. In: *Primate Ecology and Conservation*, J. G. Else and P. C. Lee (eds.), pp.249–260. Cambridge University Press, Cambridge, UK.

Paciulli, L. M. 2004. The Effects of Logging, Hunting, and Vegetation on the Densities of the Pagai, Mentawai Island Primates. State University of New York at Stony Brook.

PHPA. 1995. *Siberut National Park Integrated Conservation and Development Management Plan (1995–2020). Volume I: Current Conditions and Evaluation; Volume II: Action Plan for Conservation and Development; Volume III: Appendices.* Chemonics International in association with PT. Indeco Duta Utama and PT. Nadya Karsa Amerta, for Ditjen Perlindungan Hutan dan Pelestarian Alam, Departemen Kehutanan, Republik Indonesia, Jakarta.

Tenaza, R. R. and A. Fuentes. 1995. Monandrous social organization of pigtailed langurs (*Simias concolor*) in the Pagai Islands, Indonesia. *International Journal of Primatology* 16: 29–310.

Ting, N., D. J. Whittaker and D. J. Melnick. 2005. The phylogenetic position of the simakobu monkey (*Simias concolor*) based on mitochondrial sequence data. *Am. J. Phys. Anthropol.* Suppl. 40: 206. (Abstract)

Waltert, M., C. Abegg, T. Ziegler, S. Hadi, D. Priata and K. Hodges, K. Submitted. Abundance and community structure of Mentawai primates in the Peleonan Forest, North Siberu.

Watanabe, K. 1981. Variations in group composition and population density of the two sympatric Mentawaian leaf-monkeys. *Primates* 22: 145–160.

Whittaker, D. J. 2006. A conservation action plan for the Mentawai primates. *Primate Conserv.* (20): 95–105.

Yanuar, A., A. Fuentes and K. Studd. 1999. A short report on the current status of the Mentawai snub-nosed langur (*Simias concolor concolor*) on Simalegu Island, South Pagai, Mentawai, Indonesia. *Trop. Biodiv.* 5(3): 299–305.

Delacour's Langur

Trachypithecus delacouri

Nadler, T. 1996. Report on the distribution and status of Delacour's langur (*Trachypithecus delacouri*). *Asian Primates* 6: 1–4.

Nadler, T. 2004. Distribution and status of the Delacour's langur (*Trachypithecus delacouri*) and recommendations for its long-term conservation. In: *Conservation of Primates in Vietnam*, T. Nadler, U. Streicher and Ha Thang Long (eds.), pp.63–71.Frankfurt Zoological Society, Hanoi.

Nadler, T., F. Momberg, Nguyen Xuan Dang and N. Lormee. 2003. *Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys.* Fauna and Flora International and Frankfurt Zoological Society, Hanoi. pp. 145–164.

Ratajszczak, R., R. Cox and Ha Dinh Duc. 1990. A Preliminary Survey of Primates in North Vietnam. Report to World Wide Fund for Nature – WWF, Project 3869, Gland.

Golden-headed Langur or Cat Ba Langur

Trachypithecus poliocephalus poliocephalus

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Nadler, T. and Ha Thang Long. 2000. The Cat Ba Langur: Past, Present and Future. The Definitive Report on *Trachypithecus poliocephalus*—the World's Rarest Primate. Frankfurt Zoological Society, Hanoi. 104pp.

Nadler, T., F. Momberg, Nguyen Xuan Dang and N. Lormee. 2003. *Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys*, pp.55–67. Fauna and Flora International – Vietnam Program and Frankfurt Zoological Society, Hanoi.

Roos, C., T. Nadler, Y. P. Zhang and H. Zischler. 2001. Molecular evolution and distribution of the superspecies *Trachypithecus* [*francoisi*]. *Folia Primatol.* 72: 181–182.

Stenke, R. 2005. Conservation of the Golden-headed Langur (*Trachypithecus poliocephalus poliocephalus*) on Cat Ba Island, Vietnam. Status of the Golden-headed Langur and of Human Impact in Langur Areas. Report to the People's Committee of Hai Phong (Provincial Government). Cat Ba, Hai Phong (in Vietnamese).

Stenke, R. and Chu Xuan Canh. 2004. The golden-headed langur (*Trachypithecus poliocephalus poliocephalus*) on Cat Ba Island—status, threat factors, and recovery options. In: *Conservation of Primates in Vietnam*, T. Nadler, U. Streicher and Ha Thang Long (eds.), pp.72–77. Frankfurt Zoological Society, Hanoi.

Western Purple-faced Langur

Semnopithecus vetulus nestor

Dela, J. D. S. 1998. The ecology and social biology of a selected population of the western purple-faced leaf monkey (*Trachypithecus vetulus nestor = Presbytis senex nestor*). PhD thesis, University of Peradeniya, Peradeniya.

Hill, W. C. O. 1934. A monograph on the purple-faced leaf monkeys (*Pithecus vetulus*). *Ceylon J. Sci. (B)* 19 (Pt.1): 23–88.

Molur, S., Brandon-Jones, D., Dittus, W., Eudey, A., Kumar, A., Singh, M., Feeroz, M. M., Chalise, M., Priya, P. and Walker, S. (eds.). 2003. *Status of South Asian Primates: Conservation Assessment and Management Plan (CAMP) Workshop Report, 2003*. Zoo Outreach Organisation, IUCN/SCC Conservation Breeding Specialist Group – South Asia, Coimbatore, India. viii + 432pp.

Grey-shanked Douc

Pygathrix cinerea

Ha Thang Long. 2000. Records of grey-shanked douc langur (*Pygathrix cinerea*) in the Central Highlands of Vietnam. Report to Frankfurt Zoological Society, Hanoi.

Ha Thang Long. 2004. Distribution and status of the grey-shanked douc langur (*Pygathrix cinerea*) in Vietnam. In: *Conservation of Primates in Vietnam*, T. Nadler, U. Streicher and Ha Thang Long (eds.), pp. 52 – 57. Frankfurt Zoological Society, Hanoi.

Lippold, L. K. and Vu Ngoc Thanh. 2000. The grey-shanked douc langur: Survey results from Tien Phuoc, Quang Nam, Vietnam. *Asian Primates* 7(1 – 2): 1 – 3.

Nadler, T. 1997. A new subspecies of Douc langur, *Pygathrix nemaeus cinereus* ssp.nov. *Zool. Garten* (NF) 67(4): 165 – 176.

Nadler, T., Momberg, F., Nguyen Xuan Dang and Lormee, N. 2003. *Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys,* pp.113 – 143. Fauna & Flora International and Frankfurt Zoological Society, Hanoi.

Pham Nhat. 1993. The distribution and status of the douc langur (*Pygathrix nemaeus*) in Vietnam. *Asian Primates* 3(1 – 2): 2 – 3.

Roos, C. and Nadler, T. 2001. Molecular evolution of the douc langurs. *Zool. Garten* (NF) 71: 1 – 6.

Tonkin Snub-nosed Monkey

Rhinopithecus avunculus

Boonratana, R. and Le Xuan Canh. 1998. Conservation of Tonkin snub-nosed monkeys (*Rhinopithecus* [*Presbyticus*] *avunculus*) in Vietnam. In: *The Natural History of the Doucs and Snub-nosed Monkeys*, N. G. Jablonsky (ed.), pp.207 – 215. World Scientific Publishing, Singapore.

Dong Thanh Hai, Do Quang Huy, Lu Quang Vinh, Nguyen Duc Manh, Nguyen Hai Ha, Ngo Duy Bach and Vu Duc Kham. 2006. A survey of distribution and population status of Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Cham Chu Nature Reserve. Report, Forestry University of Vietnam, Department of Wildlife Manangement, Xuan Mai.

Le Khac Quyet. 2004. Distribution and conservation of the Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in Du Gia Nature Reserve, Ha Giang Province, northeast Vietnam. In: *Conservation of Primates in Vietnam*, T. Nadler, U. Streicher and Ha Thang Long (eds.), pp.58 – 62. Frankfurt Zoological Society, Hanoi.

Le Khac Quyet and S. P. Simmons. 2002. Results of surveys on Tonkin snub-nosed monkey (*Rhinopithecus avunculus*) in the Northeastern Vietnam. Report to Singapore Zoo and Fauna and Flora International, Hanoi.

Nadler, T., F. Momberg, Nguyen Xuan Dang and N. Lormee. 2003. *Vietnam Primate Conservation Status Review 2002. Part 2: Leaf Monkeys*, pp.145 – 164. Fauna and Flora International and Frankfurt Zoological Society, Hanoi.

Hainan Gibbon

Nomascus hainanus

Bleisch, W. V. and N. Chen. 1991. Ecology and behavior of wild black-crested gibbons in China with a reconsideration of evidence of polygyny. *Primates* 32: 539 – 548.

Chan, B. P. L., J. R. Fellowes, T. Geissmann and J. F. Zhang (eds.). 2005. *Hainan Gibbon Status Survey and Conservation Action Plan – Version I (Last updated November 2005)*. Kadoorie Farm and Botanic Garden Technical Report No. 3. KFBG, Hong Kong SAR, iii + 33 pp. <www.gibbons.de/main/books/2005hainan-gibbon-status.pdf>.

Chan, B. P. L., X. F. Tan and W. J. Tan. In preparation. Rediscovery of the Critically Endangered Eastern Black Crested Gibbon *Nomascus nasutus nasutus* (Hylobatidae) in China; with preliminary notes on population size, ecology and conservation status.

Fan P. F., X. L. Jiang, C. M. Liu and W. S. Luo. 2006. Polygynous mating system and behavioural reason of Black Crested Gibbon (*Nomascus concolor jingdongensis*) at Dazhaizi, Mt. Wuliang, Yunnan, China. *Zool. Res.* 27(2): 216 – 220.

Fellowes, J. R. and B. Chan. 2004. Hainan Gibbon: concerted action for the world's most endangered ape. *Living Forests* 7: 22 – 24.

Geissmann, T., Dang X. Nguyen, N. Lormée and F. Momberg. 2000. *Vietnam Primate Conservation Status Review 2000. Part 1: Gibbons.* Fauna and Flora International, Indochina Programe, Hanoi.

Geissmann, T., Trung Q. La, Hoang D. Trinh, Thong D. Vu, Dang, N. Can and Pham, D. Tien. 2003. Rarest ape rediscovered in Vietnam. *Asian Primates* 8(3/4): 8 – 10.

Geissmann, T. 2003. Symposium on Gibbon Diversity and Conservation: Concluding resolution. *Asian Primates* 8(3/4): 28 – 29.

Geissmann, T. and B. Chan. 2004. The Hainan black crested gibbon: Most critically endangered ape. *Folia Primatol.* 75 (Suppl. 1): 116. (Abstract.)

Hainan Daily Online, 2007a. Website: <http://hnrb.hinews.cn/php/20070326/162705.php>.

Hainan Daily Online, 2007b. Website: <http://hnrb.hinews.cn/php/20070326/162706.php>.

Kadoorie Farm & Botanic Garden. 2001. *Report of Rapid Biodiversity Assessments at Bawangling National Nature Reserve and Wangxia Limestone Forest, Western Hainan, 3 to 8 April 1998*. South China Forest Biodiversity Report Series: No. 2. KFBG, Hong Kong SAR, ii + 33pp.

La Q. Trung and Hoang D. Trinh. 2004. Status review of the Cao Vit black crested gibbon (*Nomascus nasutus nasutus*) in Vietnam. In: *Conservation of Primates in Vietnam*, T. Nadler, U. Streicher, and Long T. Ha (eds.), pp.90 – 94. Frankfurt Zoological Society, Hanoi.

Liu, Z. H. and C. F. Tan. 1990. An analysis of habitat structure of the Hainan gibbon. *Acta Theriologica Sinica* 10: 163 – 169. In Chinese with English summary.

Liu, Z. H., S. M. Yu and X. C. Yuan 1984. Resources of the Hainan black gibbon and its present situation. *Chinese Wildlife* 6: 1–4. In Chinese.

Liu, Z. H., Y. Z. Zhang, H. S. Jiang and C. H. Southwick. 1989. Population structure of *Hylobates concolor* in Bawanglin Nature Reserve, Hainan, China. *Am. J. Primatol.* 19: 247–254.

Mootnick, A. R. 2006. Gibbon (Hylobatidae) species identification recommended for rescue and breeding centers. *Primate Conserv.* (21): 103–138.

Nadler, T. 2003. Rediscovery of the Eastern black crested gibbon *Nomascus nasutus* in Vietnam. *The Gibbon's Voice* 6(1): 1–3.

People's Daily Online, 2006. Website: <http://english.people.com.cn/200611/15/print20061115_321610.html.>.

Roos, C. 2004. Molecular evolution and systematics of Vietnamese primates. In: *Conservation of Primates in Vietnam*, T. Nadler, U. Streicher and Ha Thang Long (eds.), pp.23–28. Frankfurt Zoological Society, Hanoi.

Roos, C. and T. Nadler 2005. Molecular evolution and systematics of Indochinese primates. *Primate Rep.* 72(1): 38–39.

Roos, C., V. N. Thanh, L. Walter, and T. Nadler. 2007. Molecular systematics of Indochinese primates. *Vietnamese J. Primatol.* 1: 41-53.

VNA. 2004. Endangered gibbon and rare flora species found. Report on web site of Sci/Tech-Environment, Vietnam News Agency (VNA), Hanoi. <http://www.vnagency.com.vn>. Accessed: 17 November 2004.

Wang, S. and G. Quan. 1986. Primate status and conservation in China. In: *Primates: The Road to Self-sustaining Populations*, K. Benirschke (ed.), pp.213–220. Springer Verlag, New York.

Wu, W., X. M. Wang, F. Claro, Y. Z. Ding, A. C. Souris, C. D. Wang, C. H. Wang and R. Berzins. 2004. The current status of the Hainan black-crested gibbon *Nomascus* sp. cf. *nasutus hainanus* in Bawangling National Nature Reserve, Hainan, China. *Oryx* 38(4): 452–456.

Zhou, J., F. W. Wei, M. Li, J. F. Zhang, D. L. Wang and R. L. Pan. 2005. Hainan Black-crested Gibbon is headed for extinction. *Int. J. Primatol.* 26(2): 453–465.

Western Hoolock Gibbon

Hoolock hoolock

Choudhury, A. 2001. Primates in northeast India: An overview of their distribution and conservation. *ENVIS Bulletin*: *Wildlife and Protected Areas* 1(1): 92–101.

Das, J., M. M. Feeroz, M. A. Islam, J. Biswas, P. Bujarborua, D. Chetry, R. Medhi and J. Bose. 2003. Distribution of hoolock gibbon (*Bunopithecus hoolock hoolock*) in India and Bangladesh. *Zoos' Print Journal* 18(1): 969–976.

Das, J., J. Biswas, R. Medhi, J. Bose, D. Chetry, P. Bujorborua and F. Begum. 2003. Distributional status of hoolock gibbon (*Bunopithecus hoolock*) and their conservation in southern Assam, India. *Tigerpaper* 30(4): 26–29.

Das, J., P. C. Bhattacherjee, J. Biswas and D. Chetry. 2005. *Western Hoolock Gibbon: Socioecology, Threats and Conservation Action Plan*. Department of Zoology, Gauhati University, and Primate Research Centre, Northeast Centre, Guwahati, India. 70pp.

Das, J., J. Biswas, P. C. Bhattacharjee and S. M. Mohnot, S.M. 2006. First distribution records of the eastern hoolock gibbon (*Hoolock hoolock leuconedys*) from India. *Zoos' Print Journal* 21(7): 2316–2320.

Islam, A. and M. M. Feeroz. 1992. Ecology of the hoolock gibbon of Bangladesh. *Primates* 33(4): 451–464.

Kakati, K. 2006. Fragment-living—a study of hoolock gibbons in Assam, India. *Gibbon's Voice* 8(1): 1–4.

Kakati, K. and S. Sathyakumar. 1999. The effect of habitat loss on feeding and ranging behavior of hoolock gibbons (*Hylobates hoolock*) in a small forest fragment in north east India. In: *Fourth International Anthropological Congress of Ales Hrdlicka: Abstracts*, D. Sabik, J. Vigner and M. Vigner (eds.), p.73. World Anthropology at the turn of the Century, Set Out, Prague.

MacKinnon, J. and K. MacKinnon. 1987. Conservation status of the primates of the Indo-Chinese subregion. *Primate Conserv.* (8): 187–195.

Molur, S., D. Brandon-Jones, W. Dittus, A. Eudey, A. Kumar, M. Singh, M. M. Feeroz, M. Chalise, P. Priya and S. Walker. 2003. *Status of South Asian Primates: Conservation Assessment and Management Plan (C.A.M.P.) Workshop Report, 2003*. Zoo Outreach Organisation/CBSG-South Asia, Coimbatore, India. 432pp.

Molur, S., S. Walker, A. Islam, P. Miller, C. Srinivasulu, P. O. Nameer, B. A. Daniel and L. Ravikumar, L. (eds.). 2005. *Conservation of Western Hoolock Gibbon (Hoolock hoolock hoolock) in India and Bangladesh: Population and Habitat Viability Assessment (P.H.V.A.) Workshop Report, 2005.* Zoo Outreach Organisation/CBSG South Asia, Coimbatore, India. 132pp.

Mootnick, A. R. 2006. Gibbon (Hylobatidae) species identification recommended for rescue or breeding centers. *Primate Conserv.* (21): 103–138.

Mootnick, A. R. and C. P. Groves. 2005. A new generic name for the hoolock gibbon (Hylobatidae). *Int. J. Primatol.* 26: 971–976.

Sumatran Orangutan

Pongo abelii

Ellis, S., Singleton, I., Andayani, N., Traylor-Holzer, K. and Supriatna, J. (eds.). 2006. *Sumatran Orangutan Conservation Action Plan*. Conservation International, Jakarta, Indonesia, and Washington, DC.

IUCN. 2004. *2004 IUCN Red List of Threatened Species*. IUCN: The World Conservation Union, Gland.

Rao, M. and van Schaik, C.P. 1997. The Behavioural ecology of Sumatran orangutans in logged and unlogged Forest. *Trop. Biodiv.* 4(2): 173–185.

Rijksen, H. D. 2001. The orangutan and the conservation battle in Indonesia. In: *Great Apes and Humans: The Ethics* *of Co-existence*, B. B. Beck, T. S. Stoinski, M. Hutchins, T. L. Maple, B. Norton, A. Rowan, E. F. Stevens and A. Arluke (eds.), pp.57–70. Smithsonian Institution Press, Washington, DC.

Rijksen, H. D. and E. Meijaard. 1999. *Our Vanishing Relative: The Status of Wild Orangutans at The Close of The Twentieth Century.* Kluwer Academic Publishers, Dordrecht.

Singleton, I., S. Wich, S. Husson, S. Stephens, S. Utami Atmoko, M. Leighton, N. Rosen, K. Traylor-Holzer, R. Lacy and O. Byers (eds.). 2004. *Orangutan Population and Habitat Viability Assessment: Final Report.* IUCN/SSC Conservation Breeding Specialist Group (CSG), Apple Valley, MN.

Van Schaik, C. P., K. A. Monk and J. M. Y. Robertson. 2001. Dramatic decline in orangutan numbers in the Leuser Ecosystem, northern Sumatra. *Oryx* 35(1): 14–25.

Wich, S. A. and M. L. Geurts. 2001. *Orangutan Surveys in Sumatra Utara, Riau and Sumatra Barat.* Survey Report to the Golden Ark Foundation, The Netherlands.

Brown Spider Monkey

Ateles hybridus

Cordero-Rodriguez, G. A. and F. Biord. 2001. Distribution and conservation of the spider monkey (*Ateles hybridus*) in the coastal range of northern Venezuela. *Neotrop. Primates* 9: 8–11.

Defler, T. R. 2003. *Primates de Colombia*. Conservación Internacional, Serie de Guías Tropicales de Campo, Conservación Internacional Colombia, Bogota, Colombia.

Kellogg, R. and E. A. Goldman. 1944. Review of the spider monkeys. *Proc. U. S. Natl. Mus.* 96: 1–45.

Konstant, W. R., R. A. Mittermeier and S. D. Nash. 1985. Spider monkeys in captivity and in the wild. *Primate Conserv.* (5): 82–109.

Mondolfi, E. and J. F. Eisenberg. 1979. New records for *Ateles belzebuth hybridus* in northern Venezuela. In: *Vertebrate Ecology in the Northern Neotropics*, J. F. Eisenberg (ed.), pp.93–96. Smithsonian Institution Press, Washington, DC.

Morales-Jiménez, A. L. 2004. Modeling distributions for Colombian spider monkeys (*Ateles* sp.) using GARP and GIS to find priority areas for conservation. Master's thesis, Social Sciences and Law, Oxford Brookes University, Oxford, UK.

Brown-Headed Spider Monkey

Ateles fusciceps fusciceps

Albuja, L. 1983. Mamíferos ecuatorianos considerados raros o en peligro de extinción. In: *Programa Nacional Forestal*, pp.35–67. Ministerio de Agricultura y Ganadería, Quito.

Albuja, L. 1991. Lista de vertebrados del Ecuador: Mamíferos. *Rev. Politécnica* 16(3):163–203.

Albuja, L., M. Ibarra, J. Urgilés and R. Barriga. 1980. Estudio preliminar de los vertebrados ecuatorianos. Report, Departamento de Ciencias Biológicas, Escuela Politécnica Nacional, Quito. 143pp.

Albuja, L. and P. Mena-Valenzuela. 1990. Mamíferos del noroccidente de Ecuador. Report, Departamento de Ciencias Biológicas, Escuela Politécnica Nacional, Quito. 148pp.

Baker, R. H. 1974. Records of mammals from Ecuador. *Michigan State Univ. Mus. Publ.*, *Biol. Ser.* 5(2): 131–146.

Eisenberg, J. F. 1976. Communication mechanisms and social integration in the black spider monkey, *Ateles fusciceps* and *A. geoffroyi*. *J. Mammal.* 54: 955–957.

Eisenberg, J. F. and K. H. Redford. 1999. *Mammals of the Neotropics. Vol. 3. The Central Neotropics: Ecuador, Peru, Bolivia, Brazil.* The University of Chicago Press, Chicago.

Emmons, L. H. and L. Albuja. 1992. Mammal fauna. In: *Status of Forest Remnants in the Cordillera de la Costa and Adjacent Areas of Southwestern Ecuador. Rapid Assessment Program (RAP). Working Papers* 2, T. A. Parker, III and J. L. Carr (eds*.),* pp.60–62. Conservation International, Washington, DC.

Emmons, L. H. and F. Feer. 1999. *Mamíferos de los Bosques Húmedos de América Tropical, una Guía de Campo*. Editorial FAN, Santa Cruz de la Sierra, Bolivia.

Gavilanez-Endara, M. M. 2006. Demografía, actividad y preferencia de hábitat de tres especies de primates (*Alouatta palliata*, *Ateles fusciceps* y *Cebus capucinus*) en un bosque nublado del noroccidente ecuatoriano. Tesis de licenciatura, Pontificia Universidad Católica del Ecuador, Quito.

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Hilton-Taylor, C. 2000. *2000 IUCN Red List of Threatened Species*. The World Conservation Union (IUCN), Gland, Switzerland, and Cambridge, UK.

Kellogg, R. and E. A. Goldman. 1944. Review of the spider monkeys. *Proc. U. S. Natl. Mus.* 96(3186): 1–45.

Madden, R. H. and L. Albuja. 1986. The conservation status of *Ateles fusciceps fusciceps* in the Reserva Ecológica Cotacachi-Cayapas, northwestern Pacific lowlands, Ecuador, South America. Report, Duke University, Durham and Escuela Politécnica Nacional, Quito. 86pp.

Madden, R. H. and L. Albuja. 1989. Estado actual de *Ateles fusciceps fusciceps* en el noroccidente ecuatoriano. *Rev. Politécnica* 14(3): 113–157.

Mena-Valenzuela, P. and A. Ruiz. 1997. Diversidad y abundancia relativa de los mamíferos de río Negro (Lita, El Cristal), zona de amortiguamiento de la Reserva Ecológica Cotacachi-Cayapas, Esmeraldas, Ecuador. In: *Estudios Biológicos para la Conservación: Diversidad, Ecología y Etnobiología*, P. A. Mena, A. Soldi, R. Alarcón, C. Chiriboga and L. Suárez (eds.), pp.181–194. EcoCiencia. Quito.

Ministerio del Ambiente. 2000. *Regúlase el Control de Cacería y Vedas de Especies de Fauna silvestre en el Territo-*

rio Nacional. Registro Oficial No. 5 del 28 de enero del 2000, Ministerio del Ambiente, Quito.

Ministerio del Ambiente. 2002. *Reconocer como los Libros Rojos Oficiales de Especies Amenazadas del Ecuador.* Registro Oficial No. 50 del 8 de octubre del 2002, Ministerio del Ambiente, Quito.

Rowe, N. 1996. *The Pictorial Guide to the Living Primates*. Pogonias Press, East Hampton, NY.

Sierra, R. 1996. *La Deforestación en el Noroccidente del Ecuador 1983–1993*. EcoCiencia, Quito.

Suárez, L. and M. García. 1986. *Extinción de Animales en el Ecuador, Descripción de 60 Especies Amenazadas*. Fundación Natura, Quito.

Tirira, D. 1999a. *Mamíferos del Ecuador.* Museo de Zoología, Pontificia Universidad Católica del Ecuador y SIMBIOE, Publicación Especial sobre los mamíferos del Ecuador 1. Quito.

Tirira, D. 2000. *Listado Bibliográfico Sobre los Mamíferos del Ecuador*. Boletines Bibliográficos Sobre la Biodiversidad del Ecuador No. 2. Publicación Especial sobre los Mamíferos del Ecuador 3, EcoCiencia and SIMBIOE, Quito.

Tirira, D. 2001a. Mono araña de cabeza café (*Ateles fusciceps*). In: *Libro Rojo de los Mamíferos del Ecuador*, D. Tirira (ed.), pp.105–106. Serie Libros Rojos del Ecuador 1. Publicación Especial sobre los Mamíferos del Ecuador 4, SIMBIOE, EcoCiencia, Ministerio del Ambiente y UICN, Quito.

Tirira, D. 2001b. *Libro Rojo de los Mamíferos del Ecuador*. Serie Libros Rojos del Ecuador 1. Publicación Especial sobre los mamíferos del Ecuador 4, SIMBIOE, EcoCiencia, Ministerio del Ambiente y UICN, Quito.

Tirira, D. 2003. Estado actual del mono araña de cabeza café (*Ateles fusciceps*) (Primates: Cebidae) en el Ecuador. Website: <http://spidermonkey.zoodoue.fr/Estudio-Ateles-fusciceps.htm>, Accessed 3 January 2007.

Tirira, D. 2004. Estado actual del mono araña de cabeza café (*Ateles fusciceps* Gray, 1866) (Primates: Atelidae) en el Ecuador. *Lyonia* 6(2): 17–24.

Tirira, D. 2007. *Guía de Campo de los Mamíferos del Ecuador. Publicación Especial sobre los Mamíferos del Ecuador 6*. Ediciones Murciélago Blanco, Quito. 576pp.

Peruvian Yellow-tailed Woolly Monkey

Oreonax flavicauda

Aquino, R. and F. Encarnación. 1994. Primates of Peru—Los Primates del Perú. *Primate Rep.* 40: 1–127.

Butchart, S. H. M., R. Barnes, C. W. N. Davies, M. Fernandez and N. Seddon. 1995. Observations of two threatened primate species in the Peruvian Andes. *Primate Conserv.* 16: 15–19.

DeLuycker, A. M. 2007. Notes on the yellow-tailed woolly monkey (*Oreonax flavicauda*) and its status in the Protected Forest of Alto Mayo, northern Peru. *Primate Conserv*. (22). In press. Website: < http://www.primate-sg.org/pc.htm>.

Graves, G. R. and J. P. O'Neill. 1980. Notes on the yellow-tailed woolly monkey (*Lagothrix flavicauda*) of Peru. *J. Mammal.* 61: 345–347.

Leo Luna, M. 1980. First field study of the yellow-tailed woolly monkey. *Oryx* 15: 386–389.

Leo Luna, M. 1982. Estudio preliminar sobre la biología y ecológica del mono choro de cola amarilla *Lagothrix flavicauda* (Humboldt, 1812). Tesis, Universidad Nacional Agraria La Molina, Lima.

Leo Luna, M. 1984. The effect of hunting, selective logging, and clear-cutting on the conservation of the yellow-tailed woolly monkey (*Lagothrix flavicauda*). Master's thesis. University of Florida, Gainesville.

Leo Luna, M. 1987. Primate conservation in Peru: a case study of the yellow-tailed woolly monkey. *Primate Conservation* (8): 122–123.

Groves, C. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Mittermeier, R. A., H. de Macedo Ruiz and A. Luscombe. 1975. A woolly monkey rediscovered in Peru. *Oryx* 13: 41–46.

Paredes Esquivel, Ú. M. [online] 2003. Relaciones filogenéticas dentro del género *Lagothrix* "mono choro" (Primates: Atelidae). Tesis para optar el título profesional de Biólogo con Mención en Zoología. Universidad Nacional Mayor de San Marcos, Lima, Perú. http://www.cybertesis.edu.pe/sisbib/2003/paredes_eu/html/index-frames.html [last checked: 27 February 2007].

Parker, T. A. and L. J. Barkley. 1981. New locality for the yellow-tailed woolly monkey. *Oryx* 16: 71–72.

ParksWatch, Peru, 2007. Alto Mayo Protected Forest. Website: <http://www.parkswatch.org/parkprofile.php?l=eng&country=per&park=ampf&page=thr> Accessed: 5 March, 2007.

Authors' addresses

Aguiar, John M. Center for Applied Biodiversity Science, Conservation International, 2011 Crystal Drive, Suite 500, Arlington, VA 22202, USA, e-mail: <j.aguiar@conservation.org>.

Bearder, Simon K. Nocturnal Primate Research Group, Department of Anthropology, School of Social Science and Law, Oxford Brookes University, Oxford OX3 0BP, UK, e-mail: <skbearder@brookes.ac.uk>.

Brockelman, Warren Y. Center for Conservation Biology, Institute of Science and Technology for Research and Development, Mahidol University, Salaya, Phuttthamonthon 4 Road, Nakhon Pathom 73170, Thailand, e-mail: <wybrock@cscoms.com>.

Butynski, Thomas M. Senior Conservation Biologist, Bioko Biodiversity Protection Program, Arcadia University, P. O. Box 149, 10400 Nanyuki, Kenya, e-mail: <TButynski@aol.com>.

Chan, Pui Lok Bosco. Species Protection Coordinator, China Programme, Kadoorie Farm & Botanic Garden, Lam Kam

Rd, Tai Po, New Territories, Hong Kong SAR, China, email: <boscokf@kfbg.org>.

Craul, Mathias. Institute of Zoology, University of Veterinary Medicine Hannover, Bünteweg 17, 30559 Hannover, Germany, e-mail: <mathias.craul@tiho-hannover.de>.

Davenport, Tim R. B. Country Director, Tanzania Programme, Wildlife Conservation Society, P. O. Box 1475, Mbeya, Tanzania, e-mail: <tdavenport@wcs.org>.

Dela, Jinie. 45/1 Gunatilleke Mawatha, Etambogada, Panadua, Sri Lanka, e-mail: <jini@sltnet.lk>.

DeLuycker, Anneke M. Department of Anthropology, Washington University, St. Louis, Missouri, 63130, U.S.A., e-mail: <amdeluyc@artsci.wustl.edu>.

Ehardt, Carolyn L. Department of Anthropology, University of Texas at San Antonio, San Antonio, TX 78249, USA, e-mail: <Carolyn.Ehardt@utsa.edu>.

Ellis, Susie. Executive Director, International Rhino Foundation, c/o 138 Strasburg Reservoir Road, Strasburg, VA 22657, USA, e-mail: <sellis@shentel.net>.

Fellowes, John R. China Programme, Kadoorie Farm & Botanic Garden, Lam Kam Rd, Tai Po, New Territories, Hong Kong SAR, China, e-mail: <jrfellowes@yahoo.com>.

Ganzhorn, Jörg U. Institute of Zoology, Ecology and Conservation, Martin Luther King Platz 3, 20146 Hamburg, Germany, e-mail: <ganzhorn@zoologie.uni-hamburg.de>.

Heymann, Eckhard W. Abteilung Verhaltensforschung & Ökologie, Deutsches Primatenzentrum, Kellnerweg 4, D-37077 Göttingen, Germany, e-mail: <eheyman@gwdg.de>.

Honess, Paul E. Department of Veterinary Services, University of Oxford, Parks Road, Oxford OX1 3PT, UK, e-mail: <paul.honess@vet.ox.ac.uk>.

Johnson, Steig. Department of Anthropology, 2500 University Drive, University of Calgary, Calgary, Canada AB T2N 1N4, e-mail: <steig.johnson@ucalgary.ca>.

Ha Thang Long. Frankfurt Zoological Society, Endangered Primate Rescue Center, Cuc Phuong National Park, Nho Quan District, Ninh Binh Province, Vietnam, e-mail: <thg_long@yahoo.com>.

Hawkins, Frank. Africa Program, Conservation International, 2011 Crystal Drive, Suite 500, Arlington, VA 22202, USA, e-mail: <f.hawkins@conservation.org>.

Kierulff, M. Cecilia M. Fundação Parque Zoológico de São Paulo, Av. Miguel Stefano 4241, Água Funda, São Paulo 04301-905, São Paulo, Brazil, e-mail: <kierulff@uol.com.br>.

Konstant, **William R.** 403 Poplar Road, Flourtown, Pennsylvania 19031, USA, e-mail: <bkonstant@houstonzoo.org>.

Leighton, Mark. Harvard University, Peabody Museum, 11 Divinity Avenue, Cambridge, MA 02138, USA, e-mail: <leighton@fas.harvard.edu>.

Le Khac Quyet. Fauna and Flora International – Vietnam Programme, IPO Box 78, 55 To Hien Thanh, Hanoi, Vietnam, e-mail: <quyet.khac.le@ffi.rg.vn>.

Long, Yongcheng. The Nature Conservancy, China Program, 8th floor, Building of theYunnan Provincial Meteorological Bureau, 77 Xichang Rd, Kunming Yunnan 650034, China, e-mail: <ylong@tnc.org.cn>.

Mbora, David. Department of Biological Sciences, Dartmouth College, Hanover, NH 03755, USA, e-mail: <David.N.M.Mbora@dartmouth.edu>.

McGraw, W. Scott. Department of Anthropology, The Ohio State University, 124 West 17th Avenue, Columbus, Ohio 43210-1364, USA, e-mail: <mcgraw.43@osu.edu>.

Meyers, David M. Wildlife Conservation Society, BP 8500, Antananarivo 101, Madagascar, e-mail: <meyersconsult@yahoo.com>.

Mittermeier, Russell A. Conservation International, 2011 Crystal Drive, Suite 500, Arlington, VA 22202, USA, e-mail: <r.mittermeier@conservation.org>.

Moisson, Pierre. Directeur, Parc Zoologique et Botanique, 51 rue du jardin zoologique, 68100 Mulhouse, France, e-mail: <pierre.moisson@agglo-mulhouse.fr>.

Molur, Sanjay. Wildlife Information Liaison Development 29-1, Bharathi Colony, Peelamedu, Coimbatore, Tamil Nadu 641004, India, e-mail: <herpinvert@gmail.com>.

Mootnick, Alan R. Director, Gibbon Conservation Center, P.O. Box 800249, Santa Clarita, CA 91380-0249 USA, e-mail: <gibboncenter@earthlink.net>.

Morales-Jiménez, Alba Lucia. Fundación BioDiversa, Colombia and New York Consortium in Evolutionary Primatology (NYCEP), Department of Anthropology, New York University, New York, NY 10003, USA, e-mail: <albalucia@fundacionbiodiversa.org>.

Morgan, Bethan. Principal Investigator, Conservation and Research for Endangered Species (CRES), Zoological Society of San Diego, BP 3055 Messa, Yaoundé, Cameroon, e-mail: <BMorgan@SanDiegoZoo.org>.

Nadler, **Tilo.** Frankfurt Zoological Society, Endangered Primate Rescue Center, Cuc Phuong National Park, Nho Quan District, Ninh Binh Province, Vietnam, e-mail: <t.nadler@mail.hut.edu.vn>.

Nekaris, K. Anna I. Nocturnal Primate Research Group, Department of Anthropology, School of Social Science and Law, Oxford Brookes University, Oxford OX3 0BP, UK, e-mail: <anekaris@brookes.ac.uk>.

Oates, John F. Department of Anthropology, Hunter College, City University of New York (CUNY), 695 Park Avenue, New York, NY 10021, USA, e-mail: <john.oates@hunter.cuny.edu>.

Olivieri, Gillian L. Institute of Zoology, University of Veterinary Medicine Hannover, Bünteweg 17, 30559 Hannover, Germany, e-mail: <gillian.olivieri@tiho-hannover.de>.

Paciulli, Lisa M. Department of Anthropology, 117 Gannett Center, Ithaca College, Ithaca 14850, NY, USA, e-mail: <lpaciulli@ithaca.edu>.

Palacios, Erwin. Conservation International Colombia, Carrera 13 # 71-41, Bogotá DC, Colombia, e-mail: <epalacios@conservation.org>.

Patel, Erik R. Behavioral and Evolutionary Neuroscience Division, Department of Psychology, Cornell University, Ithaca, NY 14853, USA, e-mail: <erp8@cornell.edu>.

Perkin, Andrew. C/o Tanzania Forest Conservation Group (TFCG), P.O. Box 23410, Dar es Salaam, Tanzania, e-mail: <bwanakomba@yahoo.co.uk>.

Phan Duy Thuc. ‘Cat Ba Langur Conservation Project’, Cat Ba National Park; Cat Hai, Hai Phong, Vietnam, e-mail: <pduythuc@yahoo.com>.

Randriatahina, Guy H. Département de Biologie Animale, Faculté des Sciences, Université d’Antananarivo, Madagascar, e-mail: <sahamalaza@aeecl.org>.

Ratsimbazafy, Jonah. Durrell Wildlife Conservation Trust – Madagascar Programme, B.P. 8511, 101 Antananarivo, Madagascar, e-mail: <jonah.ratsimbazafy@durrell.org>.

Rodríguez-Luna, Ernesto. Instituto de Neuroetología, Universidad Veracruzana, Apartado Postal 566, Xalapa, 91000 Veracruz, México, e-mail: <errodriguez@uv.mx>.

Roos, Christian. Gene Bank of Primates, Primate Genetics, German Primate Center, Kellnerweg 4, 37077 Goettingen, Germany, e-mail: <croos@dpz.gwdg.de>.

Rowe, Noel. Primate Conservation, Inc., 1411 Shannock Road, Charlestown, RI 02813-3726, USA, e-mail: <nrowe@primate.org>.

Rylands, Anthony B. Center for Applied Biodiversity Science, Conservation International, 2011 Crystal Drive, Suite 500, Arlington, VA 22202, USA, e-mail: <a.rylands@conservation.org>.

Salim, Agus. The Nature Conservancy in Indonesia, Ecoregional and GIS Manager, Jalan Wijaya XIII No.9, Jakarta 12160, Indonesia. *Current address*: Jl. Palem Putri VIII No.5 – 7, Taman Yasmin V, Bogor 16113, Indonesia, e-mail: <asalim@cbn.net.id>.

Schwitzer, Christoph. Bristol Zoo Gardens, Clifton, Bristol BS8 3HA, UK, e-mail: <cschwitzer@bristolzoo.org.uk>, and Association Européenne pour l’Etude et la Conservation des Lémuriens (AEECL), Mulhouse, France, e-mail: <pd@aeecl.org>.

Schwitzer, Nora. WG Primatology, Zoologischer Garten Koeln, Cologne, Germany, e-mail: <nora.schwitzer@hotmail.de>.

Shekelle, Myron. Center for Biodiversity and Conservation Studies, Faculty of Mathematics and Science, University of Indonesia, Depok 16424, Indonesia. *Current address*: Department of Biological Sciences, National University of Singapore, 14 Science Drive 4, Singapore 117543, e-mails: <dbssm@nus.edu.sg>, <shekelle@tarsier.org>.

Singleton, Ian. Sumatran Orangutan Conservation Programme, P.O. Box 1472, Medan 20000, North Sumatra, Indonesia, e-mail: <mokko@indo.net.id>.

Stenke, Roswitha. ‘Cat Ba Langur Conservation Project’, Cat Ba National Park; Cat Hai, Hai Phong, Vietnam, e-mail: <Rosi.Stenke@fpt.vn>.

Sunderland-Groves, Jacqui L. Wildlife Conservation Society, Cross River Gorilla Project, c/o Limbe Botanic Garden, P.O. Box 437, Limbe, South West Province, Cameroon, e-mail: <Takamanda@aol.com>.

Supriatna, Jatna. Conservation International Indonesia, Jl. Pejaten Barat 16A, Kemang, Jakarta 12550, Indonesia, e-mail: <j.supriatna@conservation.org>.

Tirira, Diego. Museo Ecuatoriano de Ciencias Naturales. Murciélago Blanco, Apdo. 17-17-761, Quito, Ecuador, e-mail: <diego_tirira@yahoo.com>.

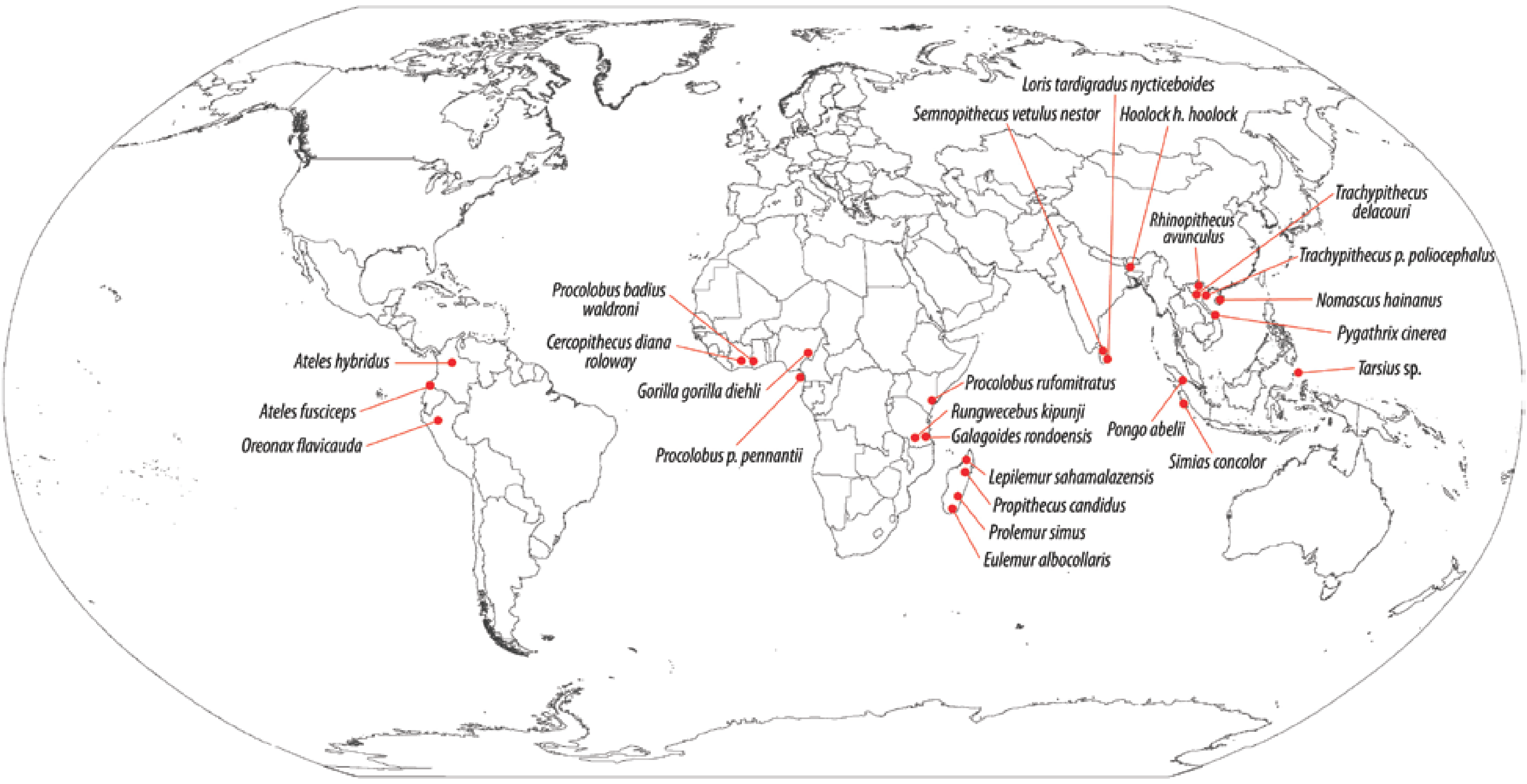
Walker, Sally. Zoo Outreach Organisation, Post Box 1063, 29-1, Bharathi Colony, Peelamedu, Coimbatore, Tamil Nadu 641004, India, e-mail: <sallyrwalker@aol.com>.

Wang, Xiaoming. Shanghai Key Laboratory of Urbanization and Ecological Restoration, East China Normal University, 3663 Zhongshan Rd, Shanghai 200062 China, e-mail: <xmwang@ecnu.edu.cn>.

Williamson, Liz. Department of Psychology, University of Stirling, Stirling FK9 4LA, Scotland. UK, E-mail: <e.a.williamson@stir.ac.uk>, <sga_coordinator@conservation.org>.

Received for publication: May 2007
Revised: June 2007

The World's 25 Most Endangered Primates 2006–2008



11 June 2007

Madagascar

Greater Bamboo Lemur
Prolemur simus

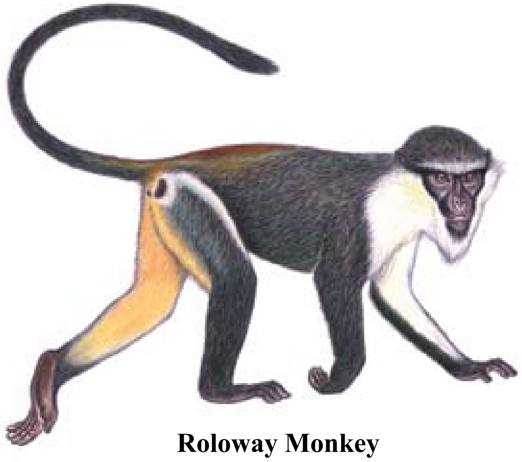
White-collared Lemur
Male (left), Female (right)
Eulemur albocollaris

Silky Sifaka
Propithecus candidus

Sahamalaza Peninsula Sportive Lemur
Lepilemur sahamalazensis

Africa

Rondo Dwarf Galago
Galagoides rondoensis



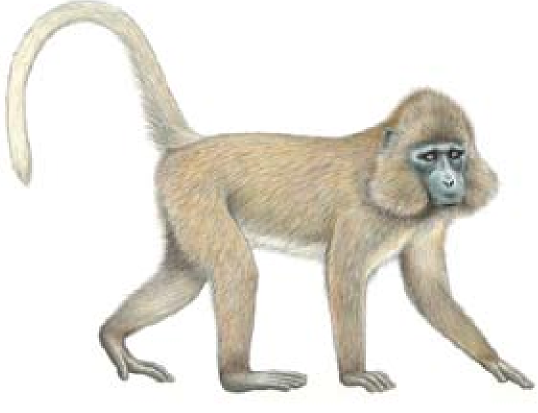
Roloway Monkey
Cercopithecus diana roloway

Africa, *continued*

Pennant's Red Colobus
Procolobus p. pennantii

Tana River Red Colobus
Procolobus rufomitratus

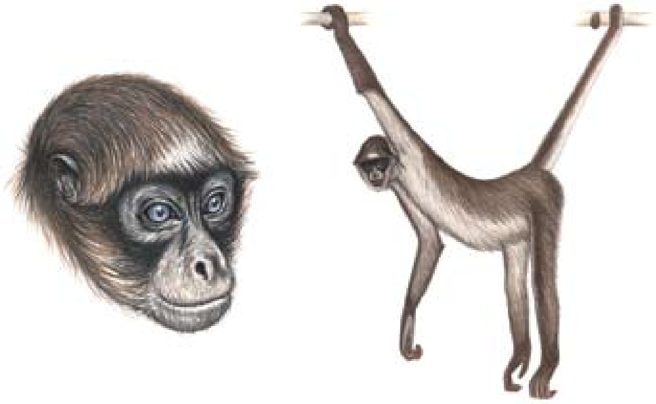
Miss Waldron's Red Colobus
Procolobus badius waldroni



Kipunji or Highland Mangabey
Rungwecebus kipunji

Cross River Gorilla
Gorilla gorilla diehli

Neotropical Region



Variegated Spider Monkey
Ateles hybridus

Brown-headed Spider Monkey
Ateles fusciceps

Peruvian Yellow-tailed Woolly Monkey
Oreonax flavicauda

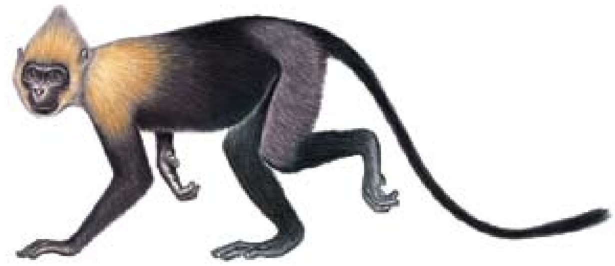
Asia

Horton Plains Slender Loris,
Ceylon Mountain Slender Loris
Loris tardigradus nycticeboides

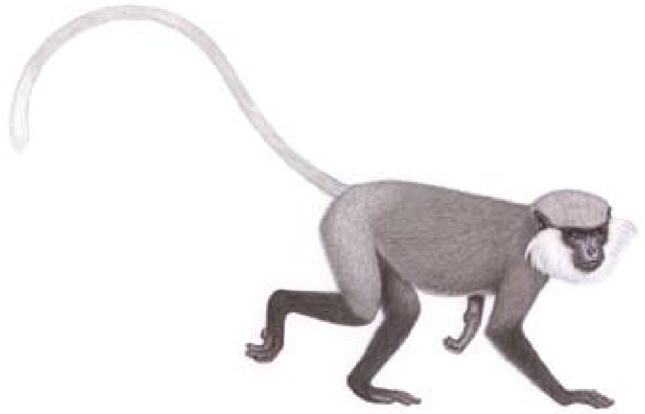
Pagai Pig-tailed Snub-nosed Monkey
or Simakobu
Simias concolor

Asia, *continued*

Delacour's Langur
Trachypithecus delacouri

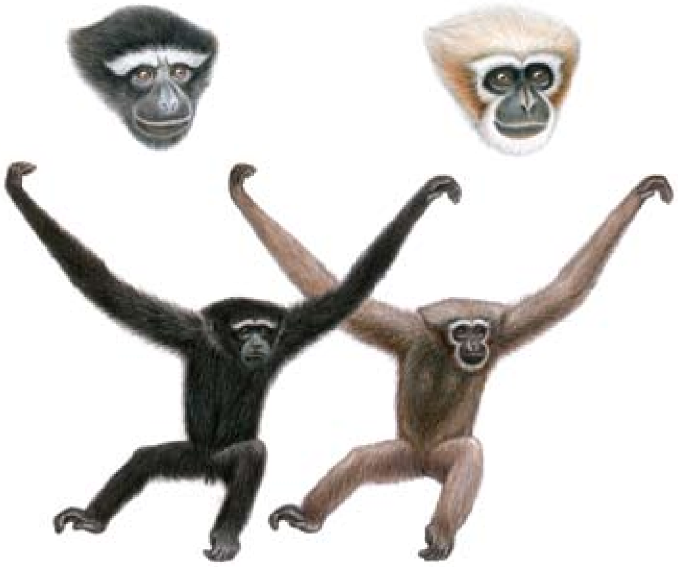


Golden-headed Langur or Cat Ba Langur
Trachypithecus poliocephalus poliocephalus



Western Purple-faced Langur
Semnopithecus vetulus nestor

Tonkin Snub-nosed Monkey
Rhinopithecus avunculus



Western Hoolock Gibbon
Hoolock hoolock

Grey-shanked Douc
Pygathrix cinerea

Siau Island Tarsier
Tarsius sp.

Asia, *continued*

Hainan Black-crested Gibbon
Nomascus hainanus

Sumatran Orangutan
Pongo abelii

All illustrations ©Conservation International / Stephen D. Nash.

Primate Conservation 2007 (22): 41–47

Notes on the Yellow-tailed Woolly Monkey (*Oreonax flavicauda*) and Its Status in the Protected Forest of Alto Mayo, Northern Peru

Anneke M. DeLuycker

Department of Anthropology, Washington University, St. Louis, Missouri, USA

Abstract: Populations of the yellow-tailed woolly monkey (*Oreonax flavicauda*) persist in increasingly isolated, threatened cloud forests in scattered areas of the departments of San Martín and Amazonas, in northern Peru. No long-term research has been conducted on this species in more than 20 years. The range of *O. flavicauda* continues to suffer rapid and widespread deforestation. From June to August 2004, I was involved in selecting a site for an extended study of its behavior and ecology. Here I document the species' continued existence and status in the Bosque de Protección (Protected Forest) of Alto Mayo. Three sightings of *O. flavicauda* provided a group size of 17–20 individuals — higher than previous sightings by Mariela Leo Luna in the early 1980s, who observed an average group size of nine. The difficulty we encountered in finding groups in the study area suggests that yellow-tailed woolly monkeys have a large home range. This and its large body size, low density, low reproductive rate, its restriction to cloud forest and its limited geographic range, combined with a high rate of deforestation in the region, make the species especially susceptible to extinction. Urgently needed are a range-wide census of remaining habitat and populations, and educational initiatives and sustainable-use projects to ensure that the Alto Mayo Protected Forest is a truly protected area.

Resumen: Las poblaciones del mono choro de cola amarilla (*Oreonax flavicauda*) se encuentran cada vez más aisladas y amenazadas en las áreas esparcidas de los bosques de nubes en los departamentos de San Martín y Amazonas, en el norte de Perú. Ningún estudio a largo plazo se ha dirigido en esta especie en más de 20 años. El propósito de este estudio fue documentar la existencia continuada de esta especie y su estado en uno de sus áreas del hábitat, el Bosque de Protección de Alto Mayo. Un sitio se seleccionó para el estudio extendido de junio hasta agosto, 2004. Se tomaron los datos de comportamiento y ecológicos en esta especie. El medio tamaño del grupo visto (17–20 individuos) era más alto que se han registrados por Mariela Leo Luna en 1982, quien observó un promedio de nueve individuos. Las observaciones limitadas a pesar de la búsqueda extensa y continuada dentro del área sugieren que esta especie tenga un rango grande. El rango grande, su tamaño del cuerpo grande, su baja densidad, su natalidad baja, su especialización en los bosques de nubes y su rango restringido, combinado con una proporción alta de deforestación en esta área se pone esta especie especialmente susceptible a la extinción. Las iniciativas de educación y los proyectos del uso sostenibles dentro del Bosque de Protección son esenciales para esta área. Yo insisto que se tome una medida inmediata para asegurar una área verdaderamente protegido para esta especie, debido a la frecuencia alta de deforestación en la región.

Key Words: Primate conservation, *Lagothrix*, New World, Atelidae, cloud forest, behavioral ecology

Introduction

The yellow-tailed woolly monkey (*Oreonax flavicauda*) inhabits the cloud forests of the northeastern slopes of the Andes Mountains, from 1,500 to 2,700 m a.s.l., in the Peruvian departments of San Martín and Amazonas, between 5º30'–8º30'S and 77º30'–78º00'W (Mittermeier *et al.* 1975, 1977; Graves and O'Neill 1980; Leo Luna 1980; Leo Luna and Ortiz 1981; Parker and Barkley 1981). Restricted to a narrow habitat belt in tropical montane cloud forests, it is the largest endemic primate found in Peru, as well as among the most endangered and least known (Leo Luna 1987). *O. flavicauda* is threatened by an extremely high rate of clear-cutting of its cloud forest habitat and is listed as Critically Endangered on the *2006 IUCN Red List of Threatened Species* (IUCN 2006) and as Endangered on Appendix I of CITES (2005).

The yellow-tailed woolly monkey was first described in 1812 by Alexander von Humboldt. Flat, trimmed skins collected in 1802, which were used as saddle blankets by Peruvian muleteers in the Province of Jaén, consistuted the

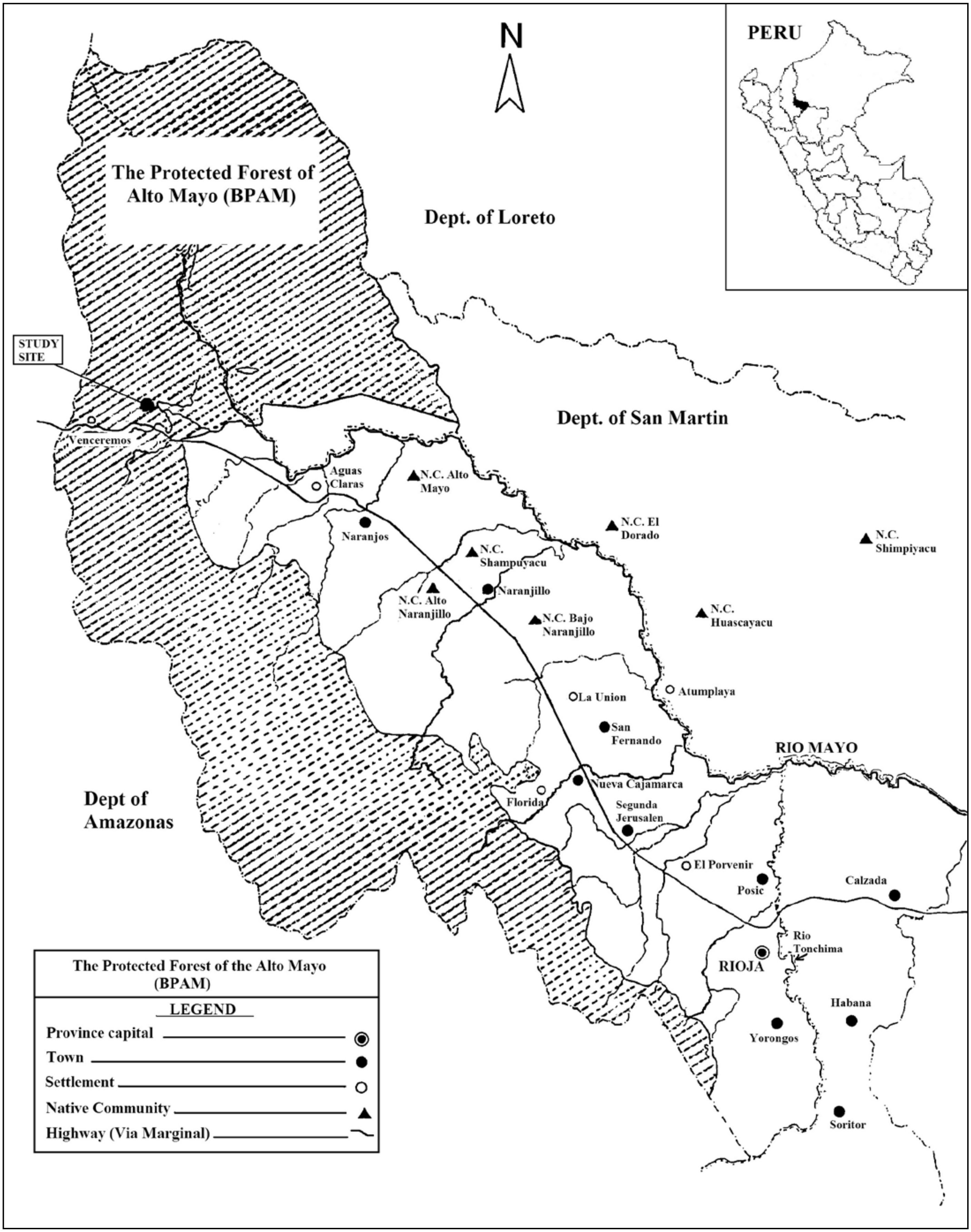


Figure 1. Location of study, Bosque de Protección de Alto Mayo (BPAM), Department of San Martín, Peru. "A" = Location of field site. (Map adapted from the *Boletín Informativo del ANP*: INRENA, 2004).

basis of the description. The name he gave was *Simia flavicauda*. No type specimen was preserved, and Humboldt was under the misconception that they were a species of howling monkey (Fooden 1963). Poeppig (1832) later mentioned monkeys from Yurimaguas (Department of Loreto), which he believed to be the same species (Fooden 1963). In 1925, an animal collector named Watkins collected two specimens from La Lejia (Department of Amazonas); the animals were not identified as *Lagothrix flavicauda* until 1963 by Fooden (Fooden 1963).

In 1926, R. W. Hendee collected three specimens at Pucatambo (80 km east of Chachapoyas, Department of San Martín; 1,500 m a.s.l.), and deposited them in the British Museum of Natural History. Oldfield Thomas (1927a) subsequently described the specimens as a new species and subgenus of woolly monkey, *Lagothrix (Oreonax) hendeei*. Later that year, on the basis of several features of the deciduous dentition of a juvenile specimen, and comparing his observations with Humboldt's description of *S. flavicauda*, Thomas (1927b, 1927c) raised the subgenus to a full genus: *Oreonax hendeei*. Cabrera (1958) and Hill (1962) also recognized Thomas's name *hendeei*, but they maintained Hendee's woolly monkey in the genus *Lagothrix*. Cabrera (1958) particularly pointed out its similarity to the Colombian montane woolly monkey, *Lagothrix lagothricha lugens*. It was Fooden (1963) who, analyzing Thomas's (1927a, 1927b, 1927c) and Humboldt's (1812) descriptions and comparisons, attributed instead Humboldt's name of *flavicauda*, and also considered it a member of the genus *Lagothrix*. It was beleived to be extinct in the wild until it was rediscovered by an expedition in 1974 (Mittermeier *et al.* 1975, 1977; Macedo-Ruiz and Mittermeier, 1979). Following a cranial morphological reassessment of the atelids, Groves (2001) returned the yellow-tailed woolly monkey to Thomas's (1927c) genus *Oreonax*. *Oreonax flavicauda* has extremely long, thick, dark reddish-coppery fur, the mouth is surrounded by a characteristic patch of white hair, and there is a small band of yellow hair on the ventral side at the tip of the tail. Adult males have a long golden-blonde genital tuft of fur up to 15 cm in length (Macedo-Ruiz and Mittermeier, 1979). Since its rediscovery in 1974, there has been only one extended study on their behavior and ecology; that of Mariela Leo Luna (1980, 1982a, 1982b, 1987, 1989). Two brief opportunistic sightings of yellow-tailed woolly monkeys were made by Graves and O'Neill (1980) and Parker and Barkley (1981). No long-term study or even monitoring has been carried out on this species since 1982. A short survey was carried out in 1995, recording various sightings of a single group, during an expedition in the Cordillera de Colán, Amazonas Department, Peru (Butchart *et al.* 1995).

The purpose of this study was to investigate the possibility of conducting a long-term behavioral-ecological study on *O. flavicauda* to collect preliminary data, and to examine the current status of this species in the Bosque de Protección (Protected Forest) of the Alto Mayo in the Department of San Martín, northern Peru.

Sightings of Yellow-tailed Woolly Monkeys

From June to August 2004, we searched for yellow-tailed woolly monkeys at three different sites, one of which was selected for extended study. The Bosque de Protección de Alto Mayo (BPAM) (5°23′04″S to 6°10′56″S, 77°45′53″W to 77°12′17″W) is located in the northern part of the Department of San Martín (Fig. 1) in tropical, humid montane rain forest (Young and León 2000). Estimates of average annual temperature range from 18°C to 24°C (Reading *et al*. 1995). The driest months are from July to September and the wettest from October to April (Nobre *et al*. 1991; Peru, PEAM 2004). The BPAM, created in 1987, is approximately 182,000 ha in size (Dillon and Vega 2003), but there has been much indiscriminate cutting, and the forests there are threatened (Young and León 1995).

The northern part of the BPAM was selected due to ease of access from the main highway (Via Marginal, a two-lane asphalt highway; construction completed in 2003), and on the basis of prior surveys by Leo Luna during 1978, 1980, and 1981, which indicated a high density of *O. flavicauda* in the region of the settlement of Venceremos (Leo Luna 1984) (Fig. 1). We talked to locals about the monkeys, and most of the *campesinos* (farmers) who claimed to have seen them were either hunters or had come across them while cutting trees. Two locations were investigated near the settlements of Aguas Claras and Aguas Verdes, but no monkeys were seen there and the terrain proved extremely steep and rocky. Information given by *campesinos* led us to choose the third site for investigation. It was near the settlement of Afluente, near the confluence of the ríos Serranoyacu and Afluente (5°39′52.0″S, 77°41′34.1″W, 1,243 m a.s.l.). Yellow-tailed woolly monkeys were located in the sector of Playa Azul (5°39′34.6″S, 77°40′37.1″W), a straight-line distance of approximately 3 km northeast into the forest from the main highway. From prior surveys of the BPAM zones, and according to the Holdridge system (1967), the forest of Playa Azul is "Very Humid Tropical Pre-Montane Forest (bmh-PT)." (Peru, ONERN 1976). The monkeys were seen three times at elevations between 1,505 m and 1,545 m a.s.l. in the canopy from 20 to 30 m above the ground. During June and July there were heavy rains, but August was drier, with long periods lacking rainfall. The rains were accompanied by dense fog that hid the upper canopy.

The first sighting (22 June 2004) was at 15:27. Observations ended at 16:30, when the monkeys left the area. The monkeys were first seen on an established trail, about 5 m from it (1,505 m a.s.l.). There were approximately 10–12 individuals in the group. We could not ascertain the exact numbers or the age and sex composition because they were moving too fast. We did see, however, adult males, adult females, subadult males, subadult females, pregnant females, juveniles, and infants. Adult males were distinguished by the large, yellow scrotal tuft (*mechón*) and their larger size. The pelage of the body and face of the adult males seemed to be slightly darker than in the females. Adult females were identified by their large size (roughly equal to that of the males), and a long and prominent clitoris. They also had a genital hair tuft but it was smaller and less-noticeable. Subadults were more difficult to identify. Some individuals were seen with a smaller genital tuft, lighter reddish-brown body coloration, and were slightly smaller than the adults. Those with no apparent clitoris were scored as subadult males. Note that according to Leo Luna (1982a) subadults do not have a genital tuft. Juveniles were young offspring moving independently, of roughly half the size of adults, They tended to remain near or next to adults. Infants were still dependent on the mother (not moving independently). Both juveniles and infants lack the yellow ventral hairs at the tip of the tail, which characterize subadults and adults. We followed the monkeys along the trail (1,545 m a.s.l.) until an adult male started shaking branches, looking toward us, and giving short barks (Fig. 2).

The second sighting (7 July 2004) was at 15:40 and lasted until 17:30, when the monkeys moved off and we lost them. The group was traveling approximately 10 m from the trail (1,510 m a.s.l.). We located them by their soft grunting noises and because of the movement of branches as they traveled through the canopy. Group size was larger; approximately 25–30 individuals. On seeing us, an adult male started to bark loudly and repeatedly, remaining close to us. The group was followed to a second point along the trail (1,516 m a.s.l.). We observed the monkeys eating fruit from the *sacha caimito* tree (*Lucuma* sp.; Sapotaceae) and *higuerón* (*Ficus* sp.; Moraceae).

The third sighting (11 August 2004) occurred at 07:00. We first heard soft sounds of moving branches in the canopy. We assumed they were leaving from their sleeping site of the previous night. There were approximately 15-16 individuals. At 08:40, the group began to move northwesterly. The monkeys were seen in the following trees: *roble* (*Tabebuia* sp., Bignoniaceae), *higuerón*, *papahuillo* (unidentified), *cascarilla* (*Cinchona pubescens*, Rubiaceae), and *moena* (unidentified, Lauraceae). They eat both the fruits and leaves of *higuerón*, and the leaves of *papahuillo*. At 09:24, a hawk or *gavilan monero* (species unidentified, but probably Black-and-Chestnut Eagle *Oroaetus* or a Hawk Eagle *Spizaetus*) flew directly over the monkeys, many of them resting silently in the trees. The entire group immediately began alarm calling. The calls lasted about a minute. At 09:41, the group moved to another point along the trail (1,516 m a.s.l.) and began feeding on the leaves and fruit of *higuerón* (*Ficus* sp.). Individuals would occasionally pick up dead branches covered with moss and inspect them by sniffing or breaking them apart with their hands. They were probably searching for insects. At 11:54, an adult male started to make a sharp bark call. The main group moved away, but some observers stayed behind to watch a subadult female, separated from the rest of the group, and also making a sharp, high-pitched barking noise. From 12:40 until 15:30, we followed this female, who continued calling for about 30 minutes and then rested in a tree for two hours. She then moved off and we lost contact. We heard her calling in the same area in the morning of the next day.

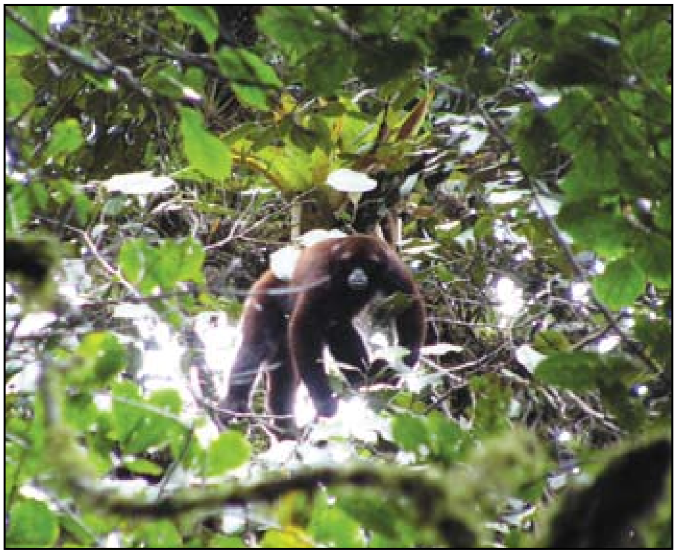


Figure 2. Adult male yellow-tailed woolly monkey (*Oreonax flavicauda*).

Leo Luna (1982a) reported an average group size of nine, ranging from five to 18 individuals. Butchart *et al*. (1995) saw a group of 10. Graves and O'Neill (1980) and Parker and Barkley (1981) reported group sizes of six and seven individuals, respectively. We saw larger groups — ranging from 17 to 20 individuals, and as high as 30 — which may be due to lack of available habitat (less dispersal). The differences in group size may also be merely the result group fissioning or fusing during certain times of year, or when food resources are more or less available in the habitat.

We saw just one other monkey in the area — the white-fronted capuchin, *Cebus albifrons*, on three occasions. Other mammals we saw included *Nasua nasua* (coati) and *Felis concolor* (puma), and we saw signs (tracks or signs of feeding) of *Agouti* sp. (*majaz*), *Dasyprocta* sp. (*añuje*), *Tayassu pecari* (white-lipped peccary), and *Cuniculus paca* (paca). People reported the presence of the spectacled bear (*Tremarctos ornatus*) but we did not see it; however, a recently captured infant bear was being kept as a pet in the town of El Progresso, about 35 km from Afluente. Notable birds seen were the Andean cock-of-the-rock (*Rupicola peruviana*) and the crested quetzal (*Pharomachrus antisianus*). Snakes were more commonly seen in August, the beginning of the dry season. They included *jergón* or fer-de-lance (*Bothrops atrox wiedi*) and coral snakes (*Micrurus*).

Additional Records

We also visited the town of Vista Alegre, Department of Amazonas, where people reported that *O. flavicauda* was still to be found in the surrounding forests (pristine primary cloud forest). We failed to see them, however. This area would benefit from protected status and carefully managed ecotourism initiatives, and the impression gained was that the local people would be supportive. Recently (11 April 2006), Peruvian naturalists Eduardo Ormaeche and Fernando Angulo encountered a group of four yellow-tailed woolly monkeys during an excursion to the Gocta waterfalls (1,800 m a.s.l.), about 35 km from Pedro Ruiz, Department of Amazonas, and a 4-hour hike into the forest from the main highway. They watched an adult male alarm-calling and shaking and throwing branches at the observers. This area has great potential for ecotourism because of the scenic waterfalls and other endangered fauna, but some areas of forest are already being lost (E. Ormaeche pers. comm.).

The Aguaruna native community of Yarau, Department of San Martín, is east of the Río Mayo. On showing photos of the yellow-tailed woolly monkeys to several people, they confirmed the presence of the monkeys in the higher altitude cloud forests there (7- to 8-hour hiking distance from the main village). Positive identification was given by detailed descriptions of the monkey, including the *mechón* or genital tuft of the males and the white around the mouth, both characteristics that distinguish them from *L. lagothricha* and any of the other large primates of this region. One member of the community had a headdress made from the skin of a yellow-tailed woolly monkey, shot about a year ago. The fur was extremely thick and of reddish-brown coloration and descriptions of the monkey confirmed the identification. If the yellow-tailed woolly monkeys still exist in the high altitude forests of this region, then this would be an indication of an additional range for this species.

Conservation Status

The cloud forests of the yellow-tailed woolly monkey are rapidly being cut down and fragmented. Previous studies and surveys (Leo Luna 1982a, 1982b; Butchart *et al*. 1995) as well as my observations, indicate that *O. flavicauda* occurs only in cloud forest above 1,400 m. These forests cover precipitous cliffs, impassable terrain, and are often densely foggy — aspects that militate for their survival. Just during the three months that this study took place, however, two large farm plots were clear-cut in the area where we searching for the monkeys. The deforestation was illegal because the remaining forested land is the property of the state (within the boundaries of the BPAM). Some *campesinos* in the area show strong opposition to outside interference and legislation, fearing that the government will take their land away from them. During my study, I and my Peruvian field guides presented talks and gave out leaflets to inform people of the monkeys' presence and the importance of protecting them. We explained the reasons for my study and, although some continued to be mistrustful, there was also much interest and concern for the forest by other *campesinos*. Educational talks given at the schools raised awareness and much interest. The children were given posters to color and one child made a paper lantern of a yellow-tailed woolly monkey to celebrate the Independence Day festival. It is clear that educational initiatives are an important and necessary facet of any conservation effort in this region.

Most of the *campesinos* we interviewed responded that they did not hunt the monkeys; the main reason being an aversion due to their close resemblance to humans. They hunt mainly agouti and paca (*majaz* and *añuje*), using *trampas* (traps) — a gun connected to a trap-line. People in other nearby communities (*caserios*) do still occasionally hunt yellow-tailed woolly monkeys (Fig. 3), and one local we interviewed showed us a skin and skull of an adult male that he had kept as a trophy. Occasionally, hunters kill a mother to take the baby for a pet. Even though the monkeys tend to occupy inaccessible and rocky terrain, their large groups, large size, conspicuousness (alarm-calling and branch-shaking), and confiding behavior make them easy targets for hunters when they do enter more populated areas (e.g., forest along highways) or when the locals come across them as they walk to and from their farms. Most locals who collect firewood and timber (*madereros*), fruits, and other forest resources carry rifles.

The *campesinos* of this area, and in all areas in the Bosque de Protección, are immigrants, former *cerranos* (people from the sierras) who fled to the area during the height of guerilla activity (mostly the Sendero Luminoso) during the 1970s and 80s. The prospect of free and unoccupied terrain enticed them further still and stimulated a greater influx that is still growing at an exponential rate. Most of the occupation occurred before the Bosque de Protección was decreed in 1987, but settlers continue to migrate to the area. As a result, the Department of San Martín has the third highest population growth rate in the country (4.7% over 10 years: Instituto Nacional de Estadística e Informática [INEI] — Estimaciones de Población por Departamentos, Provincias y Distritos, 1995–2000; San Martín, Peru).

Figure 3. A farmer poses with a recently killed adult male *Oreonax flavicauda*, near the settlement of Afluente (Alto Mayo), Peru.

Most of the *campesinos* of the Afluente settlement either grow coffee or raise cattle (both milk and beef). Contrary to some reports, coca is still being grown in the remotest areas of the forest, although not as intensively as it was in the 1980s and early 90s. There are still large tracts where it is cultivated for processing and sale. *Campesinos* from the Afluente area are fearful of entering areas where coca is being grown (a half day to a day's hike) for fear of being shot or harassed by distrustful, wary coca growers.

The Bosque de Protección has no real protection; it has laws and regulations set on paper, but no enforcement. The forest has only three park guards allotted to its 182,000 ha. Within the Bosque de Protección itself, there is no large expanse of forest left remaining, and very few areas that have not been settled or cultivated. The forest as such is highly fragmented, even at the higher altitudes. The areas that have not yet been farmed are simply too rocky and inaccessible. The soils are extremely poor, and the elimination of the forest creates a serious risk of erosion and flooding, especially in the higher forests (Selva Alta) because of the steeper slopes (most are greater than 70%) where there are coffee plantations. The coffee grown on the slopes is not shade-grown, and all trees are cut. It is estimated that 48.2% of the deforested areas of the Selva Alta is undergoing severe erosion and degradation of soils, with the majority of cases being irreversible (Peru, APODESA 1991).

As such, the BPAM has afforded little protection to the forest and the yellow-tailed woolly monkey. The only other protected area for the species is the Río Abiseo National Park (274,500 ha), in the south of the Department of San Martín. This park also has problems of invasion and deforestation and is currently closed to tourism due to the lack of park management.

Due to the few contacts that we achieved with these monkeys over the three months of the survey (six people over approximately 48 days, hiking from sunrise to sunset), it would seem likely that the species has very large home ranges. All forests in the area have already been reduced to fragments or are currently being degraded. Harcourt (1998) has argued that large home range size is the strongest correlate of vulnerability to logging. This observation, along with their large size (10 kg: Peres 1994) and low average density (0.25 to 1 group per km^2: Leo Luna 1987) over their geographic range makes them particularly vulnerable to deforestation. Other intrinsic life history variables that increase the likelihood of extinction are its low reproductive rate (assumed to be similar to *L. lagothricha*, which has an interbirth interval of 34 months) and its restricted range (actual potential habitat area is unknown, but in 1987, Leo Luna estimated 11,103 km^2). The fact that this species has a narrow latitudinal and altitudinal limit and is confined to primary cloud forest indicates that it will not adapt well to change. A current census of the population of yellow-tailed woolly monkeys in the entire remaining forests of the Bosque de Protección and the surrounding forests in the Department of Amazonas is urgently needed. Efforts are needed to create and combine large reserves or parks in both the departments of San Martín and Amazonas. Widespread and rapid ongoing deforestation throughout its geographic range means that a vital step will be to ensure a truly protected area for this species.

Acknowledgments

This study was funded with grants from the Margot Marsh Biodiversity Foundation, the Lincoln Park Zoo Neotropical Field Research Grant, Primate Conservation, Inc., and the Fulbright Association. Sincere thanks to my field assistants, Juan Barbosa Herrera, Julio Emilio Hidalgo, José Linares Mendoza, Elsa Llaja Díaz, and for additional assistance in the field to Pinto, Agapo, and Linder Lopez. I am grateful to Carlos and Helene Palomino for providing lodging, logistical support and advice throughout the study. I also thank Gilberto Iberico of INRENA, Ing. Grimaldo Garcia Rengifo, Hugo Vela Diaz, Magna Consuelo López del Castillo, Benito Chuquivale, Victor Manchado, Francisco Torres, Norith Lopez Sandoval, Angel Heredia, Albertina Nanchijam, Rosse Mary Vásquez Rios and family, and Oscar Chavez Leon (Mayor of Naranjos) for their valuable information and assistance. Thanks also to Luis Julca and Geiner Angeles, who were guides to Vista Alegre.

Literature Cited

Butchart, S. H. M., R. Barnes, C. W. N. Davies, M. Fernandez and N. Seddon. 1995. Observations of two threatened primates in the Peruvian Andes. *Primate Conserv.* (16): 15–19.

Cabrera, A. 1958. Catalogo de los mamíferos de América del Sur. *Rev. Mus. Argentino de Cienc. Nat. "Bernardino Rivadavia"* 4(1): 1–307.

CITES. 2005. Convention on International Trade in Endangered Species of Wild Fauna and Flora. Appendix I. Website: www.cites.org/eng/app/appendices.shtml. Accessed 16 April 2006.

Dillon, M. O. and I. S. Vega. 2003. Floristic Inventory of the Bosque de Protección del Río Alto Mayo (San Martín, Perú). Report, National Geographic Society, Washington, DC.

Fooden, J. 1963. A revision of the woolly monkeys (genus *Lagothrix*). *J. Mammal.* 44: 213–247.

Graves, G. R. and J. P. O'Neill. 1980. Notes on the yellow-tailed woolly monkey (*Lagothrix flavicauda*) of Peru. *J. Mammal.* 61: 345–347.

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Harcourt, A. 1998. Ecological indicators of risk for primates, as judged by species' susceptibility to logging. In: *Behavioral Ecology and Conservation Biology*, T. Caro (ed.), pp.56–79. Oxford University Press, New York.

Hill, W. C. O. 1962. *Primates Comparative Anatomy and Taxonomy V. Cebidae Part B*. Edinburgh University Press, Edinburgh.

Holdridge, L. R. 1967. *Life Zone Ecology.* Tropical Science Center, San José, Costa Rica.

IUCN 2006. *2004 IUCN Red List of Threatened Species.* Website: www.iucnredlist.org. Accessed 16 April 2006.

Leo Luna, M. 1980. First field study of the yellow-tailed woolly monkey. *Oryx* 15: 386–389.

Leo Luna, M. 1982a. Estudio preliminar sobre la biología y ecológica del mono choro de cola amarilla *Lagothrix flavicauda* (Humboldt, 1812). Tesis, Universidad Nacional Agraria La Molina, Lima.

Leo Luna, M. 1982b. Conservation of the yellow-tailed woolly monkey (*Lagothrix flavicauda*) in Peru. *Int. Zoo Yearb.* 22: 47–52.

Leo Luna, M. 1987. Primate conservation in Peru: A case study of the yellow-tailed woolly monkey. *Primate Conserv.* 8: 122–123.

Leo Luna, M. 1989. Biología y conservación del mono choro de cola amarilla (*Lagothrix flavicauda*), especie en peligro de extinción. In: *La Primatologia en Latinoamérica*, C. J. Saavedra, R. A. Mittermeier and I. B. Santos (eds.), pp.23–30. World Wildlife Fund US, Washington, DC.

Leo Luna, M. and E. Ortiz. 1981. Evaluación preliminar de la distribución y situación del mono choro amarilla (*Lagothrix flavicauda*). Informe técnico, Dirección de Conservación — PAHO, Ministerio de Agricultura, Lima.

Macedo-Ruiz, H. de and R. A. Mittermeier. 1979. Redescrubimiento del primate peruano *Lagothrix flavicauda* (Humboldt 1812) y primeras observaciones sobre su biología. *Rev. Cienc. Univ. Nac. Mayor San Marcos* 71: 79–92.

Mittermeier, R. A., H. de Macedo-Ruiz and A. Luscombe. 1975. A woolly monkey rediscovered in Peru. *Oryx* 13: 41–46.

Mittermeier, R. A., H. de Macedo-Ruiz, A. Luscombe and J. Cassidy. 1977. Rediscovery and conservation of the Peruvian yellow-tailed woolly monkey (*Lagothrix flavicauda*). In: *Primate Conservation*, H.S.H. Prince Rainier III of Monaco and G. H. Bourne (eds.), pp.95–115. Academic Press, New York.

Nobre, C. A., P. J. Sellers and J. Sjukla. 1991. Amazonian deforestation and regional climate change. *J. Climate* 4: 957–988.

Parker, T. A. and L. J. Barkley. 1981. New locality for the yellow-tailed woolly monkey. *Oryx* 16: 71–72.

Peres, C. A. 1994. Which are the largest New World monkeys? *J. Hum. Evol.* 26(3): 245–249.

Peru, APODESA. 1991. *Sistema de Información Geográfica (SIG) de la Selva Alta del Perú: Resultados 1ra Etapa*. Apoyo al Desarrollo con Sistemas Automatizados (APODESA), Instituto Nacional de Desarrollo (INADE). Editor FUNDEAGRO, Lima.

Peru, ONERN. 1976. *Mapa Ecologico del Peru.* Oficina Nacional de Evaluación de Recursos Naturales (ONERN), Lima, Peru.

Peru, PEAM. 2004. Boletín Meteorológico e Hidrológico del Alto Mayo, 1996–2004. El Proyecto Especial Alto Mayo (PEAM), Moyobamba, Departamento de San Martín, Peru.

Reading, A. J., R. D. Thompson and A. C. Millington. 1995. *Humid Tropical Environments*. Blackwell Publishers, Oxford.

Thomas. O. 1927a. A remarkable new monkey from Peru. *Ann Mag. Nat. Hist.* 9(19): 156–157.

Thomas, O. 1927b. The Godman-Thomas Expedition to Peru — V. On mammals collected by Mr. R. W. Hendee in the Province of San Martín, N. Peru, mostly at Yurac Yacu. *Ann. Mag. Nat. Hist*. 9(19): 361–375.

Thomas, O. 1927c. The Godman-Thomas Expedition to Peru — VI. On mammals from the upper Huallaga and neighbouring highlands. *Ann. Mag. Nat. Hist.* 9(20): 594–608.

Young, K. R. and B. León. 1995. Distribution and conservation of Peru's montane forests: Interactions between the biota and human society. In: *Tropical Montane Cloud Forests*, L. S. Hamilton, J. O. Juvik and F. N. Scatena (eds.), pp.363–376. Springer, New York.

Young, K. R. and B. León. 2000. Biodiversity conservation in Peru's eastern montane forests. *Mountain Res. Dev.* 20(3): 208–211.

Author's address:
Anneke M. DeLuycker, Department of Anthropology, Washington University, St. Louis, MO 63130, USA. E-mail: <amdeluyc@artsci.wustl.edu>.

Received for publication: April 2006
Revised: April 2006

Primate Conservation 2007 (22): 49–54

Where Have All the Titis Gone? The Heterogeneous Distribution of *Callicebus moloch* in Eastern Amazonia, and Its Implications for the Conservation of Amazonian Primates

Stephen F. Ferrari[1], Urbano L. Bobadilla[2] and Claudio Emidio-Silva[3]

[1]*Departamento de Biologia, Universidade Federal de Sergipe, São Cristóvão, Brazil*
[2]*Departamento de Biologia, Universidade Luterana Brasileira, Canoas, Brazil*
[3]*Programa Parakanã, Tucuruí, Brazil*

Abstract: Primate populations were surveyed quantitatively at three sites in the Xingu-Tocantins interfluvium in southeastern Amazonia, the easternmost limit of the distribution of the red-bellied titi, *Callicebus moloch*. At least 101 km was walked at a given site, and total transect length was 812 km. Despite the typical abundance of other species, no sightings (or vocalizations) of *C. moloch* were recorded at any site. This contrasts with other studies in the same interfluvium, and surveys in other areas of southeastern Amazonia. While the determinants of the absence — or marked rarity — of *C. moloch* from the sites remain unclear, it does appear to be a natural phenomenon, possibly related to specific local conditions. The identification and evaluation of such determinants will be important for understanding the ecology and zoogeography of the genus. In the meantime, these results highlight potential problems for the conservation and management of wild populations, not only of titis, but possibly many other species of Amazonian primates.
Key Words: *Callicebus moloch*, population density, zoogeography, ecology, Amazonia, conservation

Resumo: Populações de primatas foram levantadas quantitativamente em três sítios do interflúvio Xingu-Tocantins, no sudeste da Amazônia, no limite oriental da distribuição do zogue-zogue de ventre vermelho, *Callicebus moloch*. Foi percorrido um mínimo de 101 km em um dado sítio, e o percurso total foi de 812 km. Apesar da abundância típica de outras espécies, nenhum avistamento (ou vocalização) de *C. moloch* foi registrado em qualquer sítio. Estes resultados contrastam com outros estudos no mesmo interflúvio e em outras áreas do sudeste da Amazônia. Os determinantes da ausência — ou escassez acentuada — de *C. moloch* dos sítios permanecem desconhecidos, mas parecem ser um fenômeno natural, possivelmente relacionados a condições locais específicas. A identificação e avaliação destes fatores serão importantes para o entendimento da ecologia e zoogeografia do gênero. Neste meio tempo, os resultados destacam problemas em potencial para a conservação e manejo de populações silvestres, não somente de zogue-zogues, mas possivelmente várias outras espécies de primatas amazônicas.
Palavras-chave: *Callicebus moloch*, densidade populacional, zoogeografia, ecologia, Amazônia, conservação

---

Introduction

The geographic ranges of Amazonian primates have traditionally been defined on the basis of the distribution of major river systems, which play a fundamentally important role in the zoogeography of most genera (Ayres and Clutton-Brock 1992). This tradition was reinforced by the fact that, until very recently, the vast majority of recorded localities were clustered along the banks of major rivers (see for example, Hershkovitz 1977, 1990). It has also reinforced the implicit assumption that primate populations are distributed more or less uniformly within the limits defined by these rivers.

In recent years, the more systematic exploration of Amazonian interfluvia, facilitated in many cases by the construction of highways, has updated our knowledge not only of the zoogeography, but also of the diversity of many platyrrhine genera, most notably *Mico* (see Van Roosmalen *et al*. 2000) and *Callicebus* (see Van Roosmalen *et al*. 2002; Wallace *et al*. 2006). Detailed surveys have also revealed local variations in distribution and abundance, related primarily to ecological factors such as habitat characteristics, in particular differences between flooded or floodplain and terra firma forests, and interspecific competition (Ferrari and Lopes 1990, 1996; Peres 1993, 1997a; Iwanaga and Ferrari 2002; Ferrari 2004).

The Tocantins and Xingu rivers are the principal barriers to the dispersal of primates in southeastern Amazonia, where they delimit the distribution of a number of platyrrhine taxa, including four genera (Ferrari and Lopes 1996). The Tocantins forms the easternmost limit of the distribution of Amazonian titis, and the red-bellied titi, *Callicebus moloch*, is known from a total of ten localities east of the Xingu (Mascarenhas and Puorto 1988; Ferrari and Lopes 1990; Hershkovitz 1990). However, detailed surveys at three sites in the Xingu-Tocantins interfluvium, presented here, indicate that *C. moloch* is either extremely rare in or absent from large tracts of forest within this area. The patchy distribution of the species appears to be a natural phenomenon, rather than a result of habitat disturbance or hunting pressure, but the factors involved remain unclear.

Methods

Primate populations were surveyed at three sites in the Tocantins-Xingu interfluvium (Fig. 1, Table 1) in 1996 and 1997. All three sites present relatively large tracts of primary Amazonian terra firma forest, but also patches of both secondary forest and distinct ecosystems such as inundated, or *igapó* forest (especially at the Ferreira Penna Scientific Station [ECFPn], in the Caxiuanã National Forest). Detailed descriptions of sites 1, 2 and 3 are given, respectively, in Lisboa (1997, 2001), Bobadilla (1998) and Emidio-Silva (1998). The principal difference between the sites is related to their location within the interfluvium, which can be divided into a lowland floodplain to the north, and the Brazilian Shield to the south, with associated differences in forest structure and composition (Brazil, MME-DNPM Projeto RADAM 1974; Ferrari and Lopes 1990, 1996; Lisboa *et al.* 1997). Site 1 represents the lowland floodplain, whereas sites 2 and 3 are located on the Brazilian Shield.

As in previous studies in southeastern Amazonia (for example, Johns 1986; Ferrari and Lopes 1996; Lopes and Ferrari 2000; Ferrari *et al.* 2003), primate populations were surveyed using standard line transect methods (see Brockelman and Ali 1986). A straight-line trail system was established in the terra firma forest at each location, with a total length of 65, 15.5 and 9.5 km, respectively, at sites 1, 2 and 3. Trails were cleared causing a minimum of impact, swept clean of debris and marked with flagging at 100 m intervals. During surveys, in 1996 and 1997, trails were walked at an average speed of 1–1.5 km per hour and, at each encounter with a primate group, the species and composition of the group were recorded, in addition to other information not relevant here (see Bobadilla and Ferrari 2000).

Results

A total of 292 sightings of primates were recorded during the 812 km surveyed at the three study sites (Table 2), at an average rate of 3.6 sightings per 10 km of transect. This sighting rate compares favorably with those recorded at other sites in southeastern Amazonia (Lopes and Ferrari 2000; Ferrari *et al.* 2002, 2003). Four species, *Alouatta belzebul*, *Cebus apella*, *Chiropotes satanas*, and *Saguinus niger*, were recorded at all three sites, and provided the vast majority (287) of sightings. A fifth species, *Saimiri sciureus*, was not seen at site 1 during the present study, but it has been observed within the study area. The overall lack of records of *Saimiri* may have been at least partly due to its specific habitat preferences and ranging behavior (Terborgh 1983).

One other species, *Mico argentatus*, has a limited distribution in the Xingu-Tocantins interfluvium, where it is restricted to the lowland floodplain (Ferrari and Lopes 1990), and is thus absent from sites 2 and 3. The species occurs at site 1 (Ferrari and Lopes 1996), but is found exclusively in secondary forest habitats, where it may reach relatively high densities (Veracini 1997). It has never been observed within the present study area.

The total lack of records of *Callicebus moloch* from all three sites is less easily accounted for. Titis appear to be at least as abundant at other sites in this interfluvium (Mascarenhas and Puorto 1988; Ferrari and Lopes 1990) as they are west of the Xingu (Martins *et al.* 1988; Ferrari *et al.* 2003) or elsewhere in the Amazon basin (Peres 1997a; Ferrari *et al.* 2000).

Ferrari *et al.* (2003) recorded *C. moloch* in both continuous and fragmented forest east of the Rio Tapajós, normally at median densities, although the species was absent from some sites, possibly due to the effects of habitat fragmentation. Even if local conditions at the present study sites were to reduce the visibility of the species during surveys for some reason, it seems unlikely that they would also suppress the characteristic vocal duetting that is typical of all titi species (Emmons *et al.* 1998). Audible over distances of more than one kilometer, and normally performed on a daily basis, the duet is a sure sign of the presence of titis at most sites.

There is also little evidence of hunting pressure at any site, not least because titis are almost never targeted because of their small body size. The relative abundance of the larger species (*Alouatta*, *Cebus* and *Chiropotes*) at all three sites also indicates that primates suffer little pressure. The Parakanã do hunt primates, but very rarely, and only *Alouatta* and *Cebus*—coincidentally, the two species recorded most frequently at site 3.

Additional evidence confirms that *C. moloch* is absent from large areas of continuous forest at sites 1 and 3. Perhaps the most reliable evidence is that provided by experienced Parakanã hunters, who unanimously confirm the absence of *Callicebus* from site 3. However, as more than half of the Parakanã territory is still uninhabited (Emidio-Silva 1998), it is probably premature to exclude *C. moloch* from the whole of the reservation. Similarly, while the sum of the evidence from site 1 (ECFPn)—which now includes a number of long-term studies of primate ecology (Veracini 1997; Jardim and Oliveira 1997; Pina *et al.* 2001; Tavares and Ferrari 2001) and additional surveys (Martins *et al.* 2005)—leaves little doubt as to the absence of *Callicebus*, some local residents have reported its presence in areas neighboring the Caxiuanã

Table 1. Characteristics of the sites surveyed in southeastern Amazonia (see Figure 1).

Site	Coordinates	Characteristics
1. Ferreira Penna Scientific Station (ECFPn)	1°42'S, 51°28'W	33,000 ha, in a much larger (>300,000 ha) area of primary forest (Caxiuanã National Forest), unlogged primary forest, negligible hunting pressure
2. Fazenda Arataú	3°50'S, 50°20'W	7,500 ha, isolated forest fragment, moderately logged, negligible hunting pressure
3. Parakanã Indigenous Territory (T.I. Parakanã)	4°28'S, 49°56'W	351,697 ha, partially isolated, no logging, primates rarely hunted

Table 2. Main results of primate surveys at the three study sites.

Site	Km surveyed	Sightings of primates (sightings/10 km surveyed)	Species most sighted (n records)	Species least sighted (n records)
1	533	202 (3.8)	*Alouatta belzebul* (112)	*Chiropotes satanas* (6)
2	101	58 (5.7)	*Chiropotes satanas* (21)	*Saimiri sciureus* (4)
3	178	32 (1.9)	*Alouatta belzebul* (11) *Cebus apella* (11)	*Saimiri sciureus* (1)

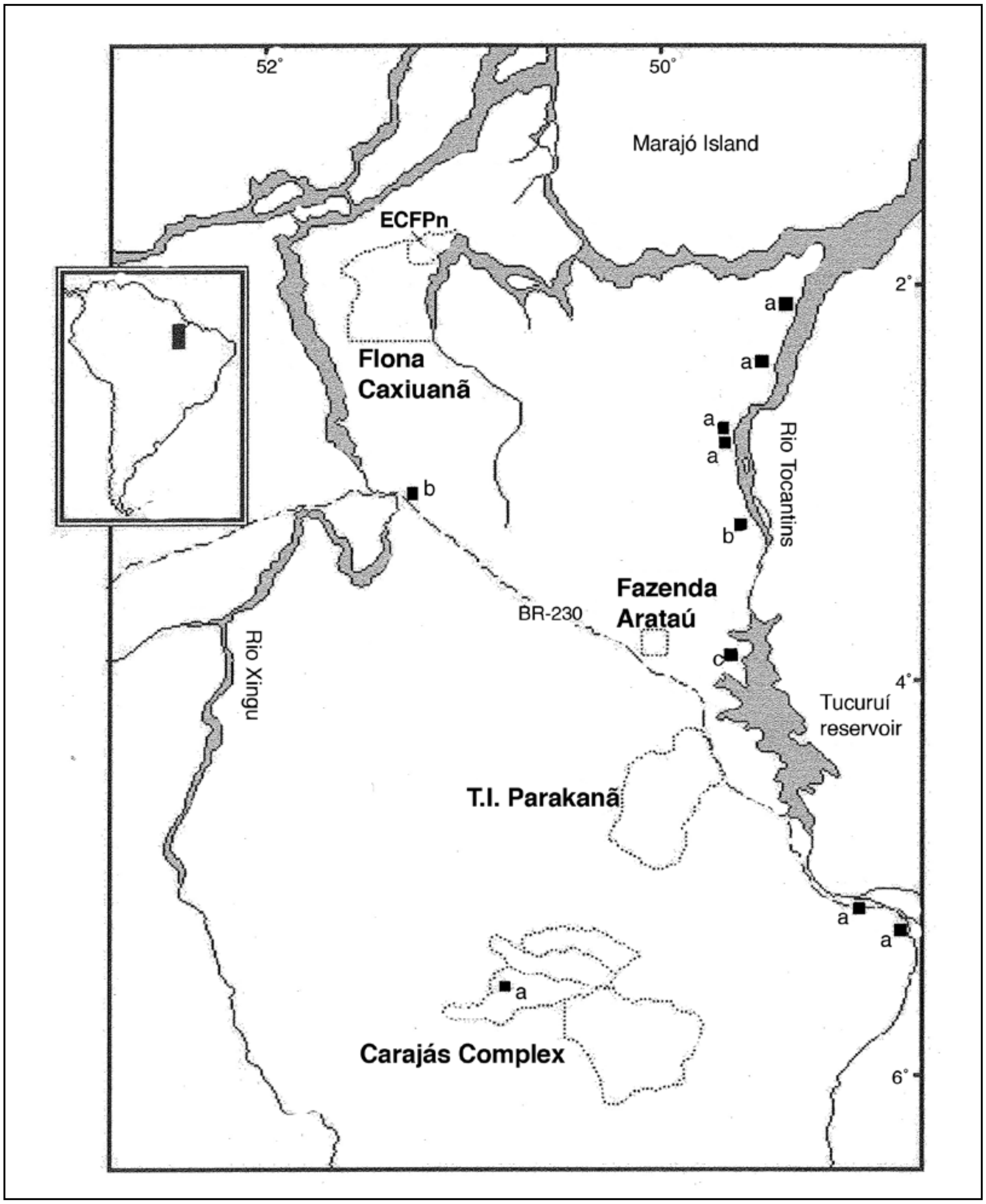


Figure 1. The Xingu-Tocantins interfluvium in southeastern Amazonia showing the sites surveyed in the present study (see Table 1), and collecting and sighting localities of *Callicebus moloch*, according to: (a) Hershkovitz (1990), (b) Ferrari and Lopes (1990), and (c) Mascarenhas and Puorto (1988).

National Forest. The results from both sites 2 and 3 also contradict considerably those of the rescue operation in the area of the Tucuruí reservoir (Mascarenhas and Puorto 1988), less than 50 km to the east (Figure 1), where *Callicebus moloch* was the third most frequently captured species, after *Alouatta belzebul* and *Cebus apella*.

Discussion

The results of the surveys indicate that titis are naturally absent (or extremely rare) from extensive tracts of continuous terra firma forest within the Xingu-Tocantins interfluvium. Exact limits are unclear, but if the sites surveyed here are typical, the species may be absent from a large portion of the forest between the two rivers. Obviously, any estimate of population size based on the assumption of a homogeneous distribution within this area would require substantial revision. There are few clues to the determinants of the observed pattern, although it seems likely that ecological factors are involved, as in the case of the silvery marmoset, *Mico argentatus*, a second species with a heterogeneous distribution in this interfluvium (Ferrari and Lopes 1990, 1996). In this case, however, *M. argentatus* is present at site 1, but is absent from Tucuruí, where *Callicebus* is apparently abundant. So, even if similar ecological factors are involved, they clearly have different effects on the distribution of the two species.

One pattern apparent from the distribution of sites (Fig. 1) is a possible association with riparian habitats, given that most of the localities are distributed along the Tocantins. This may be a sampling artifact, but it could also reflect specific habitat preferences. As the Tocantins has a long history of human colonization, it may even be that *C. moloch* prefers anthropogenic habitats over pristine terra firma forest. This may include the ECFPn, where human impact is negligible. Interestingly, Wallace *et al*. (1998, 2000) identified a possibly similar situation in eastern Bolivia, where *Callicebus donacophilus* was absent from large preserves of primary terra firma forest close to the Brazilian border, but abundant in the anthropogenic landscape further south.

While *Callicebus moloch* is not under any immediate threat of extinction at the present time, the results of this study highlight a number of potential problems for the conservation of both this and other Amazonian primates. To begin with, the species is apparently absent from two of the sites (1 and 3) with the best potential for the long-term conservation of the region's primates (Ferrari *et al*. 1999).

One other key site is the Carajás complex (Fig. 1), which includes a fully-protected area (the 103,000-ha Tapirapé Biological Reserve), national forests and indigenous lands (Companhia Vale do Rio Doce 2007). *Callicebus moloch* is known to occur in this area, although little is known of its exact distribution and abundance, and Toledo *et al*. (1999) report that a population of the exotic *Callicebus brunneus* may have been established in the area, derived from animals released from captivity. Otherwise, the interfluvium is characterized by widespread deforestation, promoted by a number of "mega-projects", including the Carajás Mining Project, existing (Tucuruí) and planned (Belo Monte) hydroelectric dams, and the Trans-Amazon highway (BR-230), which bisects the region.

On a broader scale, these findings underscore a problem that may become increasingly important as the Amazon basin is colonized. Many species — not only of primates, but also of many other groups of organisms — are known from a very small sample of localities within an apparently vast geographic range. In most cases, it is assumed that the species occupies all the available habitat between localities or river barriers (Ayres and Clutton-Brock 1992), but there is increasing evidence of major lacunae in the distribution of many species (Ferrari 2004), a prime example being the red howler (*Alouatta seniculus*) in southwestern Amazonia (Peres 1997b; Iwanaga and Ferrari 2002). In the case of one other eastern Amazonian endemic, the Ka'apor capuchin (*Cebus kaapori*), an apparently very patchy distribution, combined with extremely low population densities almost certainly determined the delay in the discovery of the species until the end of the twentieth century (Queiroz 1992). These same characteristics have also contributed decisively to the current status of *C. kaapori* as one of the most endangered of Amazonian primates (Ferrari and Queiroz 1994; IUCN 2006).

Clearly, more reliable data are needed for many, if not most species of Amazonian primates, especially those with relatively large geographic ranges. In the meantime, it may be necessary to revise conservation parameters for some species, including their status, where estimates are based on potentially problematic data. As shown here, such caution may be especially important for the planning of protected areas.

Acknowledgments

This study was supported by the Goeldi Museum/ECFPn, Grupo Queiroz Galvão and Programa Parakanã/Eletronorte, and by grants from WWF-Brasil, The Brazil Science Council (*Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq*) (Process no. 307506/2003-7) and the Brazilian Higher Education Authority (*Fundação Coordenação de Aperfeicoamento de Pessoal de Nível Superior – CAPES*). We thank two anonymous reviewers for their helpful comments.

Literature Cited

Ayres, J. M. and T. H. Clutton-Brock. 1992. River boundaries and species range size in Amazonian primates. *Am. Nat.* 140: 531–537.

Bobadilla, U. L. 1998. Abundância, Tamanho de Agrupamento e Uso do Hábitat por Cuxiús de Uta Hick *Chiropotes satanas utahicki* Hershkovitz, 1985 em Dois Sítios na Amazônia oriental: Implicações para a Conservação. Masters dissertation, Universidade Federal do Pará, Belém.

Bobadilla, U. L. and S. F. Ferrari. 2000. Habitat use by *Chiropotes satanas utahicki* and syntopic platyrrhines in eastern Amazonia. *Am. J. Primatol.* 50: 215–224.

Brazil, MME-DNPM Projeto RADAM. 1974. *Projeto RadamBrasil, Folha SA 22. Belém: Geologia, Geomorfologia, Solos, Vegetação e Uso potencial da Terra*. Ministério de Minas e Energia (MME), Departamento Nacional de Produção Mineral (DNPM), Rio de Janeiro.

Brockelman, W. Y. and R. Ali. 1986. Methods of surveying and sampling forest primate populations. In: *Primate Conservation in the Tropical Rainforest*, C. W. Marsh and R. A. Mittermeier (eds.), pp.21–62. Alan R. Liss, Inc., New York.

Companhia Vale do Rio Doce. 2007. Conservation units and reserves. http://www.cvrd.com.br/cvrd_us/cgi/cgilua.exe/sys/start.htm?sid=427

Emidio-Silva, C. 1998. A Caça de Subsistência Praticada pelos Índios Parakanã (Sudeste do Pará): Características e Sustentabilidade. Masters dissertation, Universidade Federal do Pará, Belém.

Emmons, L. H., B. M. Whitney and D. L. Ross. 1998. *Sounds of Neotropical Rainforest Mammals: an Audio Field Guide*. Chicago University Press, Chicago.

Ferrari, S. F. 2004. Zoogeography of Amazonian primates. In: *A Primatologia no Brasil – 8*, S. L. Mendes and A. G. Chiarello (eds.), pp.101–122. Sociedade Brasileira de Primatologia, Santa Teresa, Espírito Santo.

Ferrari, S. F., C. Emidio-Silva, M. A. Lopes and U. L. Bobadilla. 1999. Bearded sakis in southeastern Amazonia – back from the brink? *Oryx* 33: 346–351.

Ferrari, S. F., S. Iwanaga, M. R. Messias. E. M. Ramos, P. C. S. Ramos, E. H. Cruz Neto and P. E. G. Coutinho. 2000. Titi monkeys (*Callicebus* spp., Atelidae: Platyrrhini) in the Brazilian state of Rondônia. *Primates* 41: 191–196.

Ferrari, S. F. and M. A. Lopes. 1990. A survey of primates in central Pará. *Bol. Mus. Para. E. Goeldi, Zool.* 6: 169–179.

Ferrari, S. F. and M. A. Lopes. 1996. Primate populations in eastern Amazonia. In: *Adaptive Radiations of Neotropical Primates*, M. A. Norconk, A. L. Rosenberger and P. A. Garber (eds.), pp.53–67. Plenum Press, New York.

Ferrari, S. F., R. Ghilardi Jr., E. M. Lima, A. L. C. B. Pina and S. S. Martins 2002. Mudanças a longo prazo nas populações de mamíferos da área de influência da Usina Hidrelétrica de Tucuruí, Pará. In: *Resumos do XXIV° Congresso Brasileiro de Zoologia*, Sociedade Brasileira de Zoologia, pp.540–541. Editora e Gráfica Berger, Itajaí, SC.

Ferrari, S. F., S. Iwanaga, A. L. Ravetta, F. C. Freitas, B. A. R. Sousa, L. L. Souza, C. G. Costa and P. E. G. Coutinho. 2003. Dynamics of primate communities along the Santarém-Cuiabá highway in southern central Brazilian Amazônia. In: *Primates in Fragments*, L. K. Marsh (ed.), pp.123–144. Kluwer Academic, New York.

Ferrari, S. F. and H. L. Queiroz. 1994. Two new Brazilian primates discovered, endangered. *Oryx* 28: 31–36.

Hershkovitz, P. 1977. *Living New World Monkeys (Platyrrhini), with an Introduction to Primates.* Vol. 1. Chicago University Press, Chicago.

Hershkovitz, P. 1990. Titis, New World monkeys of the genus *Callicebus* (Cebidae, Platyrrhini): a preliminary taxonomic review. *Fieldiana Zool.* 55: 1–109.

Iwanaga, S. and S. F. Ferrari. 2002. Geographic distribution of red howlers, *Alouatta seniculus* (Platyrrhini, Alouattini), in southwestern Brazilian Amazonia, with notes on *Alouatta caraya*. *Int. J. Primatol*. 23: 1245–1256.

Jardim, M. M. A. J. and L. F. Oliveira. 1997. Uso do espaço de *Alouatta belzebul* (Primates, Cebidae) em função da temporalidade de recursos. In: *Caxiuanã*, P. L. B. Lisboa (ed.), pp.417–436. MCT/CNPq, Belém.

Johns, A. D. 1986. Effects of Habitat Disturbance on Rainforest Wildlife in Brazilian Amazonia. Unpublished report to WWF–US, Washington, D. C.

Lisboa, P. L. B. 1997. *Caxiuanã*. MCT/CNPq, Belém.

Lisboa, P. L. B. 2001. *Caxiuanã*, *Populações Tradicionais, Meio Físico e Diversidade Biológica.* MCT/CNPq, Belém.

Lisboa, P. L. B., A. S. Silva and S. S. Almeida. 1997. Florística e estrutura dos ambientes. In: *Caxiuanã*, P. L. B. Lisboa (ed.), pp.163–193. MCT/CNPq, Belém.

Lopes, M. A. and S. F. Ferrari. 2000. Effects of human colonization on the abundance and diversity of mammals in eastern Brazilian Amazonia. *Conserv. Biol.* 14: 1658–1665.

Martins, E. S., J. M. Ayres and M. B. R. do Valle. 1988. On the status of *Ateles belzebuth marginatus* with notes on other primates of the Iriri river basin. *Primate Conserv.* (9): 87–91.

Martins, S. S., J. S. Silva Jr., E. M. Lima and R. R. Santos. 2005. Primatas da Estação Científica Ferreira Penna, Floresta Nacional de Caxiuanã, Pará. *Programa e Livro de Resumos: XI Congresso Brasileiro de Primatologia*, p.124. Pontifícia Unversidade Católica do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul. 13–18 February 2005.

Mascarenhas, B. M. and G. Puorto. 1988. Nonvolant mammals rescued at the Tucuruí dam in the Brazilian Amazon. *Primate Conserv.* (9): 91–93.

Peres, C. A. 1993. Structure and organization of an Amazonian terra firme primate community. *J. Trop. Ecol.* 9: 259–276.

Peres, C. A. 1997a. Primate community structure at twenty western Amazonian flooded and unflooded forests. *J. Trop. Ecol.* 12: 1–25.

Peres, C. A. 1997b. Effects of habitat quality and hunting pressure on arboreal folivore densities in Neotropical forests: a case study of howler monkeys (*Alouatta seniculus*). *Folia Primatol.* 68: 199–222.

Pina, A. L. C. B., L. L. Souza and S. F. Ferrari. 2001. Spacing patterns of *Alouatta belzebul* groups at ECFPn. In: *Caxiuanã, Populações Tradicionais, Meio Físico e Diversidade Biológica*, P. L. B. Lisboa (ed.), pp.687–697. CNPq/MCT, Belém.

Queiroz, H. L. 1992. A new species of capuchin monkey, genus *Cebus*, Exrleben, 1777 (Cebidae: Primates) from eastern Amazonia. *Goeldiana Zool.* 15: 1–13.

Tavares, L. I. and S. F. Ferrari. 2001. Diet of the silvery marmoset (*Callithrix argentata*) at ECFPn: seasonal and longitudinal variation. In: *Caxiuanã*, *Populações Tradicionais, Meio Físico e Diversidade Biológica*, P. L. B. Lisboa (ed.), pp.707–719. CNPq/MCT, Belém.

Terborgh, J. 1983. *Five New World Primates: A Study in Comparative Ecology*. Princeton University Press, Princeton.

Toledo, P. M., H. M. Moraes-Santos and C. C. S. Melo. 1999. Levantamento preliminar de mamíferos não-voadores da Serra dos Carajás: grupos silvestres recentes e zooarqueológicos. *Bol. Mus. Para. Emílio Goeldi, sér. Zool.* 15: 141–157.

Veracini, C. 1997. O Comportamento alimentar de *Callithrix argentata* (Linnaeus 1771) (Primata, Callitrichinae). In: *Caxiuanã*, P.L.B. Lisboa (ed.), pp.437–446. MCT/CNPq, Belém.

Van Roosmalen, M. G. M., T. van Roosmalen, R. A. Mittermeier and A. B. Rylands. 2000. Two new species of marmoset, genus *Callithrix* Erxleben, 1777 (Callitrichidae, Primates) from the Tapajós/Madeira interfluvium, south central Amazonia, Brazil. *Neotrop. Primates* 8: 2–18.

Van Roosmalen, M. G. M., T. van Roosmalen and R. A. Mittermeier. 2002. A taxonomic review of the titi monkeys, genus *Callicebus* Thomas, 1903, with the description of two new species, *Callicebus bernhardi* and *Callicebus stephennashi*, from Brazilian Amazonia. *Neotrop. Primates* 10(suppl.): 1–52.

Wallace, R. B., R. L. E. Painter and A. B. Taber. 1998. Primate diversity, habitat preferences, and population density estimates in Noel Kempff Mercado National Park, Santa Cruz Department, Bolivia. *Am. J. Primatol.* 46: 197–211.

Wallace, R. B., R. L. E. Painter, D. J. Rumiz and A. B. Taber. 2000. Primate diversity, distribution and relative abundances in the Rios Blanco Y Negro Wildlife Reserve, Santa Cruz Department, Bolivia. *Neotrop. Primates* 8: 24–28.

Wallace, R. B., H. Gómez, A. Felton and A. M. Felton. 2006. On a new species of titi monkey, genus *Callicebus* Thomas (Primates, Pitheciidae), from western Bolivia with preliminary notes on distribution and abundance. *Primate Conserv.* (20): 29–39.

Authors' addresses:
Stephen F. Ferrari, Departamento de Biologia, Universidade Federal de Sergipe, 49.100-000 São Cristóvão, Sergipe, Brazil. E-mail: <ferrari@pitheciineactiongroup.org>.
Urbano L. Bobadilla, Departamento de Biologia, Universidade Luterana Brasileira, Canoas, Rio Grande do Sul, Brazil.
Cláudio Emídio-Silva, Programa Parakanã, Tucuruí, Para, Brazil.

Received for publication: October 2007
Revised: October 2007

Primate Conservation 2007 (22): 55–70

Aotus Diversity and the Species Problem

Thomas R. Defler and Marta L. Bueno

Departamento de Biología, Universidad Nacional de Colombia, Bogotá, Colombia

Abstract: Karyotypic variability in *Aotus* suggests at least seven species in the gray-necked group (*A. brumbacki*, *A. griseimembra*, *A. lemurinus*, *A. trivirgatus*, *A. vociferans*, *A. zonalis*, and *Aotus* sp. nov.) based on six known karyomorphs, highly divergent mitochondrial cytochrome c oxidase sequences, different sensitivities to malaria, varied mitogenic and immunological responses to other diseases, and well-defiined geographical distributions, and the likelihood that these species are distinctive enough to possess reproductive barriers. We discuss these karyomorphs and explain why *A. brumbacki* cannot be an *A. lemurinus* subspecies. We briefly describe a karyotype for *Aotus* from Maipures on the Río Orinoco and suggest that this represents *A. brumbacki*, extending our knowledge of that species' distribution to the Orinoco basin. We stress the presence of a new undescribed *Aotus* in Colombia from a completely unknown location, which we name *Aotus jorgehernandezi* in honor of Jorge I. Hernández-Camacho. We discuss the meaning and evolution of chromosome variability, the nature of *Aotus* as a sibling species complex and the use of the phylogenetic versus biological species concepts in primatology.
Key Words: Primates, Aotidae, *Aotus*, night monkeys, *Aotus jorgehernandezi* new species, karyotypes, Colombia

Resúmen: Las variaciones cariológicas encontradas en *Aotus* sugieren la presencia de al menos siete especies dentro del grupo de cuello gris (*A. brumbacki, A. griseimembra, A. lemurinus, A. trivirgatus, A. vociferans, A. zonalis* y *Aotus* sp. nov.), teniendo en cuenta los seis cariomorfos descritos, la alta divergencia en las secuencias del citocromo C oxidasa, las diferencias en las respuestas inmunológicas (a mitogenos, susceptibilidad a malaria y otras enfermedades), el aislamiento geográfico, aspectos que en conjunto sugieren la presencia de barreras reproductivas entre ellas. Basándonos en las diferencias cariológicas, se sostiene que *A. brumbacki* no puede ser una subespecie de *A. lemurinus*. Se describe el cariotipo encontrado en un ejemplar procedente de Maipures, en el Rió Orinoco, con lo cual se sugiere que la distribución de *A. brumbacki* se extiende hasta el Orinoco. Se propone el nombre de *Aotus jorgehernandezi* para una nueva especie con 2N = 50 en honor a Jorge I. Hernández-Camacho. Se discute el uso del concepto de especie filético y especie biológica, la naturaleza de los *Aotus* como un complejo de especies gemelos del género *Aotus* y el significado de la variación cromosómica en la evolución del género.
Pablas Claves: Primates, Aotidae, *Aotus*, micos nocturnos, monos nocturnos, mico de noche, mono de noche, *Aotus jorgehernandezi* especie nueva, cariotipos, Colombia

Introduction

This paper provides evidence suggesting the existence of at least seven gray-necked *Aotus* species, which we believe is well-founded due to known distinctive karyomorphs, different sensitivities to malaria, varied mitogenic and immunological responses to other diseases, and well-defined geographical distributions for most of these species. We also discuss the role of phenotypic evidence in distinguishing taxa and the possible evolutionary implications of chromosome variability in mammals, Neotropical primates, *Aotus*, the meaning of the biological species concept for these *Aotus,* what karyotypes suggest to us about reproductive isolation, and the importance of karyological evidence.

Since the discovery of chromosome variability in *Aotus* it has become clear that there was more than one species in the genus (Ma 1981a, 1981b; Ma *et al*. 1976a, 1976b, 1977, 1978, 1980, 1981a, 1981b; Brumback 1973, 1974, 1976; Brumback and Willenborg 1973; Brumback *et al.* 1971; Hershkovitz 1983; Pieczarka *et al.* 1988, 1992; Defler *et al*. 2001). The first attempt at proposing multi-species nomenclature, based on most of the available morphological and karyological evidence at the time, proposed nine species, consisting of five southern species (*A. azarae, A. miconax, A. nancymai, A. boliviensis*, and *A. nigriceps*) in a "red-necked group", located mostly south of the Río Amazonas-Solimões, and four northern species (*A. brumbacki, A. lemurinus, A. trivirgatus*, and *A. vociferans*) in a "gray-necked group", located north of the Río Amazonas and dividing *A. lemurinus* into two subspecies, *A. lemurinus lemurinus* and *A. lemurinus griseimembra*, and omitting the taxon *A. lemurinus zonalis* (*v.* Hershkovitz, 1983). After consulting with Hershkovitz, Ramírez-C. (1983) included *A. hershkovitzi* as an additional fifth northern species based on an inadequate description and considering particularly its diagnostic diploid number of 58 and fundamental number of 76, the highest known for the genus. Before Hershkovitz published his scheme in 1983, Thorington and Vorek (1976) had criticized the establishment of subspecies for the genus on the grounds that it would complicate the recognition of discrete populations and mosaic evolution, and that there did not seem to be species-wide phenotypes. We discuss this further below.

Giraldo *et al.* (1986) examined 288 Colombian *Aotus*, and found that those from the lower Río San Jorge (Bolívar Department, northern Colombia) with 2n = 52, 2n = 53 and 2n = 54 (*Aotus l. griseimembra*) were a balanced polymorphism with no influence on reproduction among the three karyotypes. Observed frequencies of karyotypes were 13% (2n = 52), 47.6% (2n = 53), and 39% (2n = 54). Night monkeys captured in the middle Río Magdalena valley had no karyotypic differences from those of the north, confirming that this taxon extends right up the Magdalena valley. The author identified the 2n = 58 (*A. hershkovitzi*) karyotype as something quite different from *A. lemurinus* or any other known *Aotus* and assigned it to karyotype X (*sensu* Ma 1981).

Ford (1994) did a morphometric study using data generated by Thorington and Vorek (1976) from 193 *Aotus* skulls and from her own data on pelage characteristics of 105 adult *Aotus* skins. She found mixed phenotypic variation across almost the entire range of *Aotus. Aotus trivirgatus* (all *sensu* Hershkovitz, 1983) was morphologically distinguishable from the other *A. vociferans*, *A. brumbacki*, and *A. lemurinus*, even though no measurable morphometric differences were found amongst the last three from the northern *Aotus* group. Ford's interpretation was that the three indistinguishable (phenotypically) species actually belonged to one clinal species, *Aotus vociferans*, that can be phenotypically distinguished from *A. trivirgatus,* suggesting only two species of gray-necked species north of the Amazon river rather than the four species distinguished by Hershkovitz (1983).

Torres *et al.* (1998) organized the known Colombian gray-necked *Aotus* polymorphs into five karyomorphs (*sensu* Reumer and De Boer 1980), referring to the cytogenetic characterization of five different populations). Thus, different karyomorphs are from different populations and show cytogenetic differences which probably are barriers to reproduction. Karyomorphs were associated with *Aotus lemurinus griseimembra*, *Aotus brumbacki*, *Aotus vociferans*, *Aotus hershkovitzi*, and *Aotus* (Quindío specimen), an animal that they placed in a new karyomorph X, and that Torres *et al.* (1998) had found from a captive animal (in Quindío Department). Torres *et al.* (1988) also included *A. nancymai* as specimens that were obtained from "Leticia", but Defler (2004: pp.91–92, p.274) comments on the probably fallacious inclusion of *Aotus nancymai* as part of the Colombian fauna below.

Rylands *et al.* (2000) and Groves (2001) freshly examined some of the evidence at hand and decided to accept the Hershkovitz (1983) scheme, modifying it by relegating *A. brumbacki* to a subspecies of *A. lemurinus* and accepting both *A. lemurinus zonalis* as discussed by Hernández-Camacho and Cooper (1976) and the subsequently described *Aotus hershkovitzi. A. brumbacki* was included in *A. lemurinus* because its pelage characters "span the gap between the two subspecies" [*A. lemurinus lemurinus* and *A. lemurinus griseimembra sensu* Hershkovitz, 1983] (Groves, 2001: p.164) without consideration of the substantial karyotypic differences.

Defler *et al.* (2001) analyzed the known facts for northern Colombian *Aotus* with the intention of describing *A. hershkovitzi* adequately, including a detailed karyological analysis. From our analysis it became clear that the karyotypes used by Hershkovitz (1983) to represent *Aotus lemurinus lemurinus* were in fact karyotypes for *A. lemurinus zonalis*, a separate lowland taxon, and that the karyotype for *A. hershkovitzi* represented the true authocthonous highland *A. lemurinus lemurinus*. The analysis also brought into question the karyotype published for *A. lemurinus griseimembra*, since the karyotypes analyzed by Ma were (according to Hershkovitz) from lowland populations of *Aotus* from northern Colombia and perhaps west of the Río Magdalena, given that most *Aotus* entered the Baranquilla animal trade from Magangué in the Department of Bolívar in central Colombia (Cooper and Hernández-Camacho 1977; Defler *et al.* 2001: p.41). The type locality of *Aotus lemurinus griseimembra* is the slopes of the Serranía de Santa Marta east of the Río Magdalena at 1,480 ft above sea level; it could very well represent a separate taxon from that of the lowlands (Hershkovitz 1983; Defler *et al.* 2001), and this is suggested by the dark-haired hands and feet of the holotype, which does not concord with the lighter brown hairs of the hands and feet of lowland specimens ascribed to *A. l. griseimembra.*

Further consideration of the karyotypes and of the putative subspecies of *A. lemurinus* led Defler *et al.* (2001) to believe that these were probably good biological species with reproductive barriers, due to chromosomal differences, which seemed to us to be sufficiently distinct to prevent successful pairing of enough alleles to allow development of fertile adult hybrids. This would allow the known gray-necked *Aotus* to be identified as follows: *Aotus brumbacki, A. griseimembra, A. lemurinus, A. trivirgatus, A. vociferans, A. zonalis* and *Aotus* new species (the "Quindío specimen").

Evidence that also contradicts Ford's (1994) reduction of northern *Aotus* to two species is the discovery of highly divergent mitochondrial cytochrome c oxidase (COII) within the genus (Ashley and Vaughn 1995). Unpublished work by Suarez *et al*. (undated) suggests that the taxa *A. griseimembra, A. vociferans, A. azarae, A. nigriceps,* and *A. griseimembra* are distinct from each other and that the *Aotus* radiation dates back at least 4–8 million years.

Many *Aotus* hybrids have been produced in captivity (Cicmanec *et al*. 1977; Rieckman *et al.* undated; Simpson and Jones 1982; Hershkovitz 1983; King 1995: pp.164–168), but most of them are produced from populations having similar chromosomes, especially in polymorphic populations. We deduce from laboratory attempts mentioned in the literature and from normal inferred chromosome pairing that a hybrid will be sterile in the F_1 if there is more than one rearrangement between karyotypes, as they produce sterile hybrids where the meiotic products become arrested in development, as in *Aotus*. For example, the five karyomorphs of African dik-dik antelope (*Madoqua*) produce sterile hybrids (Ryder *et al.* 1989), because the meiotic products become totally arrested in development. Interestingly, dik-diks, like *Aotus*, constitute monogamous breeding pairs which are philopatrically site-specific. Many workers believe that sterility can be induced by chromosome rearrangements which form post-mating isolating mechanisms (King 1995: pp.72–91).

Intra- and Inter-Population Chromosome Variability

Complicating interpretation of chromosome variations is the fact that there are both intra- and inter-populational chromosomal differences. Thus, "considerable confusion has arisen because a large number of different karyotypes have been reported without a clear distinction between intrapopulation and interpopulation variation" (Martin 1990: p.577), there being no selection against heterozygosity in "*griseimembra*" night monkeys with diploid numbers of 54, 53 and 52. A similar situation would appear to be true for "*vociferans*" animals with diploid numbers of 46, 47 and 48 (Descailleaux *et al.* 1990) and perhaps for "*zonalis*" with the polymorphisms 55 and 56 (in this species 2n = 54 is theoretically possible but has not yet been observed). These three taxa appear to maintain their karyological identity with multiple chromosome differences. Nevertheless, a superficial perusal of the range of diploid numbers, their fundamental numbers, and their particular chromosome arrangements suggest that there would probably be no successful interbreeding among the three putative subspecies of *A. lemurinus*, nor between any of them and *A. brumbacki*, nor between *A. vociferans* and populations of *A. brumbacki* or *A. lemurinus*. Karyological differences then would establish interbreeding barriers and thus maintain these populations as species, if we are to maintain a biological species concept. But using all characters, including chromosomes, these species also fall into the phylogenetic species concept, as well (see following discussion).

Are phenotypes diagnostic?

Twenty-five years after the polyspecific nature of *Aotus* was first pointed out via chromosome differences, we are still attempting to classify night monkeys using phenotypic characters alone, often ignoring frequently striking chromosome differences. Several species have been recognized and described only through their karyotypes, since the genus actually forms a sibling species complex (Defler 2003, 2004). Being nocturnal there is very little selection for phenotypic differences, although two influential biologists, Philip Hershkovitz and Jorge Hernández-Camacho, have sustained that all *Aotus* species are phenotypically distinguishable (Hershkovitz 1949, 1983; Hernández-Camacho and Cooper 1976).

The modern generation of taxonomists have problems in distinguishing the various taxa. One analysis even pointed out the overlapping ("clinal") nature of many characteristics in some *Aotus* groups, disqualifying them as capable of distinguishing species (Ford 1994). Species of sibling species groups are by their nature very difficult to tell apart phenotypically, although close analysis usually discovers something helpful (Mayr 1969; Bickham 1983). We are in agreement with Thorington and Vorek (1978), who argued that the subtle differences which do obtain are made up of overlapping mosaics, clines and interpopulation and intergroup variations. Some populations may be distinctive, but it seems questionable to us that all or many will have good diagnostic phenotypic characteristics, even though both Hernández-Camacho and Cooper (1976) and Hershkovitz (1983) argued to the contrary.

Hershkovitz (1983) argued that subspecies of *A. lemurinus* could not be distinguished phenotypically (Hershkovitz 1949, 1983), and his last position seemed to imply that *A. lemurinus lemurinus* (*sensu* Hershkovitz 1983) and *Aotus l. griseimembra* could only be reliably recognized from their karyotype. Hershkovitz (1983: p.209) did believe, however, that *full* species of *Aotus* were distinguishable by both phenotype and karyotype; for example, his experience allowed him to identify photos and a preserved head, previously thought to be from the Río Paraguay, as having come from Villavicencio in Colombia. He also identified photos of animals which Ma had karyotyped, as exhibiting the "*griseimembra*" phenotype or "B" phenotype (northern Colombia type, Hershkovitz 1983). He published phenotypic descriptions of *A. nancymai* and *A. brumbacki*, and reiterated Humboldt´s phenotypic description of *A. trivirgatus.* He added information on pelage growth fields in terms of crests and whorls which had not been pointed out by others (Hershkovitz 1977, 1983), although Ford (1994) subsequently denied their usefulness. Hernández-Camacho and Cooper (1976) likewise included detailed phenotypic descriptions of various northern Colombian taxa, including *A. l. zonalis* that they felt were diagnostic, and they pointed out the variability of *A. lemurinus* (*sensu* Hernández-Camacho and Cooper 1976).

Methods

We examined and compared all karyological evidence available for gray-necked northern *Aotus,* including an unpublished description of the chromosomes of an *Aotus* sp. from the left bank of the Río Orinoco, 2 km from the site of the Maipures (Maypures) village. We also tested published phenotypic descriptions of *Aotus* using museum specimens from the two major Colombian collections and attempted to place the specimens into their respective taxa using published descriptions from Hershkovitz (1949, 1983) and Hernandez and Cooper (1976).

Taxonomy of the Gray-necked *Aotus*

We list six karyomorphs in Table 1 and comparative karyological characteristics in Table 2 that correspond to six gray-necked species of *Aotus* (*A. zonalis*, *A. griseimembra, A. lemurinus*, *A. brumbacki*, *A. vociferans*, and *Aotus* sp. nov.). We add to these *A. trivirgatus* which has not been characterized karyologically. This gives a total of seven gray-necked species.

Aotus brumbacki as a subspecies of *A. lemurinus?*

Groves (2001) and Rylands *et al.* (2001) classified *A. brumbacki* as a subspecies of *A. lemurinus*. Groves' (2001: p.164) argument was as follows: "In pelage characters, she [Ford 1994] found it to span the gap between the two subspecies of *A. lemurinus*, which are otherwise more distinctive than hitherto recognized. In this light, it does seem likely that, as she indicated it should be placed as a subspecies of *A. lemurinus*, and that […] the characters of the (now three) subspecies are somewhat mosaic." This seems misguided to us in view of the considerable karyological differences between these two taxa. Karyological information clearly demonstrates that *A. brumbacki* (2n = 50) and *A. lemurinus* (2n = 58) are different species, highlighting difficulties in using a phylogenetic species concept if it is based on purely phenotypic characters (see discussion below). Groves (2005) continued to list *A. brumbacki* as a subspecies of *A. lemurinus*, but he has since agreed with us, that in fact *A. brumbacki* is a separate species (C. P. Groves pers. comm. to Defler, 2006).

Aotus brumbacki and the Maipures specimen

A specimen collected live by one of us (TRD) near Maipures, Vichada, along the Orinoco River (IvH 4105) had a karyotype very similar to *A. brumbacki* ("*A. t. trivirgatus*" of Yunis *et al.* [1977]) (Table 2). One of the two Maipures specimens was karyotyped by V. Monsalve, and her interpretation was reviewed by P. Hershkovitz (letter to María Victoria Monsalve, May 9, 1989). Although there were problems resolving two of the chromosomes, Monsalve *et al.* (1989) identified 4 metacentric pairs, 7 submetacentric pairs and 11 acrocentric pairs. We have examined the poorly reproduced copy of the fotomicrograph and believe that the two poorly resolved chromosomes could be submetacentric, in which case the chromosome morphology would agree with the Yunis *et al.* (1977) description (= *A. brumbacki* of Hershkovitz (1983: p.217). It should be taken into account that none of the 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. *Aotus brumbacki* should thus be re-studied for chromosome morphology. Nevertheless, the Maipures karyotype is actually closer to the morphology of the karyotype published by Yunis *et al*. (1977) than are the other two published karyotypes, suggesting to us that *A. brumbacki* extends throughout the Llanos Orientales to the Río Orinoco.

Is the Maipures specimen *A. trivirgatus*?

When Hershkovitz examined color slides of the Maipures specimens he stated that he believed they were *A. trivirgatus* and that, therefore, *A. trivirgatus* had 2n = 50 (P. Hershkovitz, letter to María Victoria Monsalve, 9 May 1989). Jorge I. Hernández Camacho did not agree with this interpretation, believing that the Maipures specimen was *A. brumbacki* or a new species (Hernández-Camacho pers. comm. to TRD). We ourselves have difficulty seeing the Maipures specimen (I.v.H. no. 4105, 4164) phenotypically as either *A. brumbacki* or *A. trivirgatus*, although it is important to note that the preserved specimens are considerably altered in color, due to the length of time they had been in captivity in Bogotá. Santos-

Table 1. Northern (gray-necked) *Aotus* karyotypes (diploid numbers) and fundamental numbers (FN).

Species	2n	FN	Reference
A. vociferans	46, 47, 48	70	Ma *et al.* (1976), Descailleaux *et al.* (1990)
A. brumbacki	50	70	Brumback (1971), Yunis *et al.* (1977)
Aotus (Quindío)[1]	50		Torres *et al.* (1998)
Aotus (Maipures)	50		Monsalve *et al,* (unpubl.)
A. griseimembra[2]	52, 53, 54 13%, 46%, 41% n = 620	72	Ma *et al.* (1976), Giraldo *et al.* (1986)
A. zonalis	55, 56	72	Ma *et al.* (1976)
A. lemurinus	58	76	Ramírez-C. (1983), Giraldo *et al*. (1986), Defler *et al*. (2001), Torres *et al*. (1998)
A. trivirgatus	—	—	—

[1] Is there any way this can be related to the Maipures specimen, which is 2n = 50 as well? Maybe this is *A. trivirgatus*.

[2] Remains a problem whether this karyotype actually relates to *A. griseimembra* or to another lowland taxon.

Mello and Thiago de Mello (1985) published an abstract of a talk given at the 10th Congress of the Brazilian Primatological Society where they describe a karyomorph 2n = 51 for males and 2n = 52 for females, determined from "*Aotus* collected around Manaus" and this, according to the authors, is the true karyotype for *A. trivirgatus.* We believe that it is likely that there may be differences in karyomorphs from each side of Rio Negro, because of its size as a barrier. Karyotypes of night monkeys immediately west of the Rio Negro have yet to be described.

The so-called "Quindío" specimen as a new species: *Aotus jorgehernandezi*

Torres *et al*. (1998) karyotyped another *Aotus* specimen which proved to have 2n = 50, possessing nine pairs of metacentric, three pairs of metacentric and 12 pairs of acrocentric chromosomes (Fig. 1). Unfortunately the preserved specimen ICN14023 could not be located, so the only phenotypic information that we could find must be taken from Figure 2, p.261 in their publication (Fig. 2). However, the karyotype illustrated in their Figure 2 must be considered diagnostic for this new species and to serve as part of the holotypic description.

The specimen was found in captivity in the Department of Quindío, Colombia, although Defler *et al.* (2001) discounted the possibility that the specimen was actually from Quindío Department itself. Chromosome morphological differences would make it very difficult for *A. brumbacki* and the Quindío *Aotus* to pair in genetic recombination, and any hybrid would

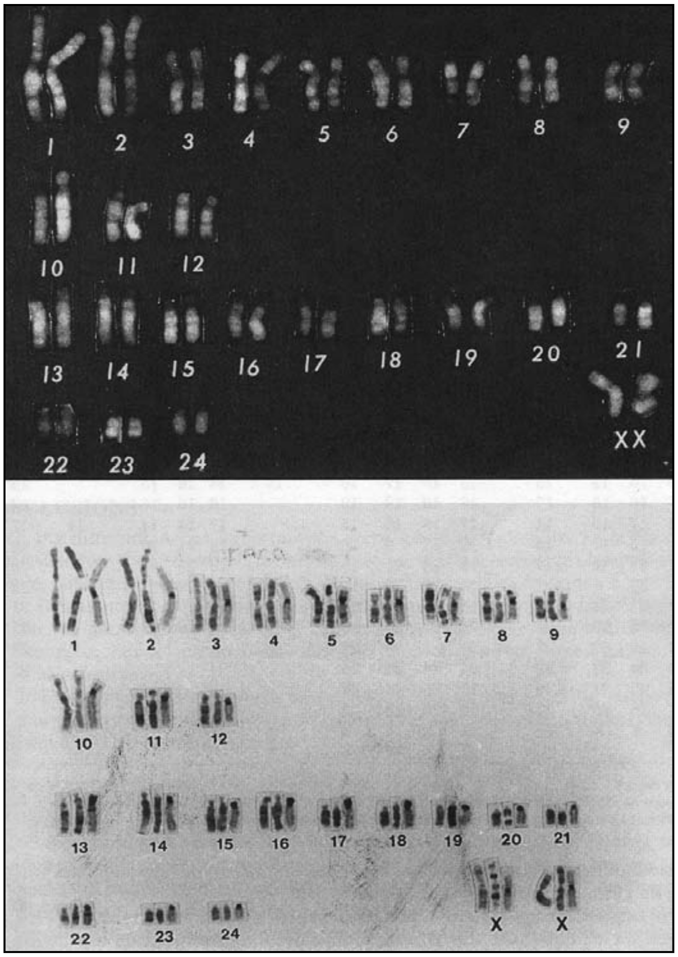


Figure 1. Karyomorph of *Aotus jorgehernandezi* (reprinted from Torres *et al*. 1998). With permission from Wiley-Liss Inc.

Table 2. Determined chromosome structure of recognized gray-necked *Aotus* karyomorphs. Revised from Torres *et al.* (1998); according to Defler *et al*. 2001 and Monsalve *et al*. (unpublished).

Species	2n[a]	Karyotype	Karyomorph	Karyomorph	Pairs of Autosomes			Chromosomes			Reference
		Ma (1981)	DeBoers and Reumer (1978)	Torres *et al*. (1998)	M[b] 1–1.9[c]	S[b] 2–4.9[c]	A[b] >5[c]	X	Y	RL	
A. vociferans	46 47 48	V	7	7	7	5	10	M[b]	ND	-	Ma *et al.* (1976) Torres *et al*. (1998)
A. brumbacki	50		6	6	5	5(or 6?)	14(or 13)	M	M	0.9	Torres *et al.* (1998)
A. brumbacki	50		6	6	4	9	11	M			Yunis *et al.* (1977)
A. brumbacki	50		6	6	5(or 4?)	7(or 6?)	12(or 14)	M	Very small terminal		Brumback (1974)
A. (Quindío)	50			9	9	3	12	M	M	-	Torres *et al.* (1998)
A. (Maipures)	50			?	4	9	11	M	-	-	Monsalve *et al*. (unpubl.)
A. griseimembra	52 53 54	II III IV	2	2	5 6	5 5	16 14	M	M	0.8	Torres *et al.* (1998)
A. griseimembra	52 53 54	II III IV	2	2	5 4 4	7 7 7	14 13 15				Ma *et al.* (1976) Yunis *et al.* (1977)
A. griseimembra	52 53 54	II III IV	2	2	5 6	10 10	11 11	M M	Very small terminal		Brumback *et al.* (1971) Brumback (1973, 1974)
A. zonalis	55 56	VIII IX	1		4/4.5 4	4/4.5 4	21/23 23	M	-	-	Ma *et al.* (1976)
A. lemurinus	58				4	4	20	M	M	1.4	Defler *et al*. (2002)
A. lemurinus	58	X		8	4	5(or 6?)	18				Giraldo *et al.* (1986) Torres *et al.* (1998)

2n[a] = diploid number. [b]Chromosome morphology: M, metacentric; S, submetacentric; A, acrocentric. [c]Range of arm ratio (q/p). X = total X chromosome containing haploid complement length; Y = total Y chromosome; ND = not determined; RL = relative length expressed as % of Total Chromosome Length (TCL).

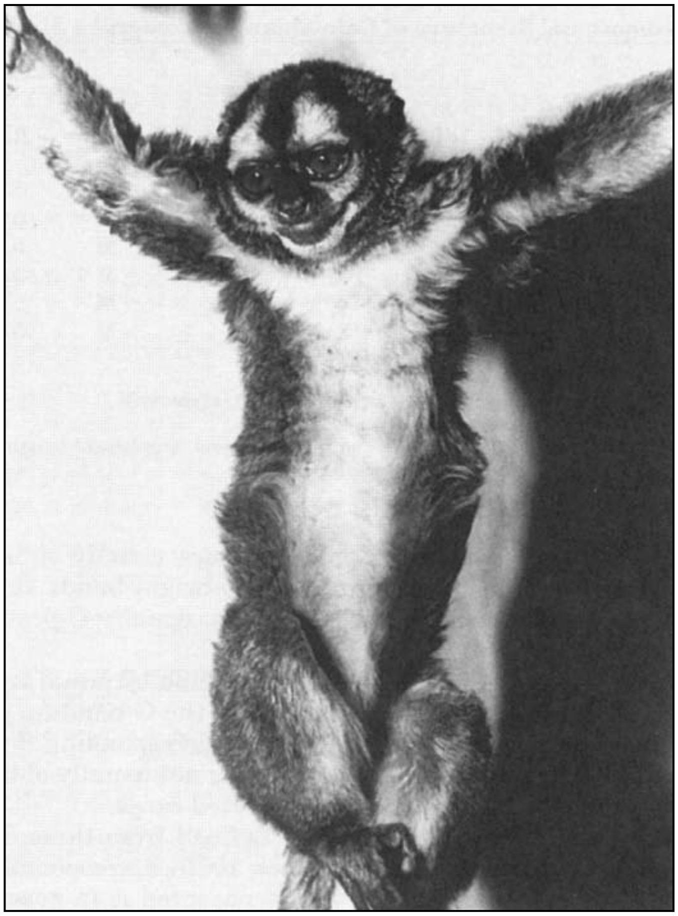


Figure 2. Live *Aotus jorgehernandezi* (reprinted from Torres *et al*. 1998). With permission from Wiley-Liss Inc.

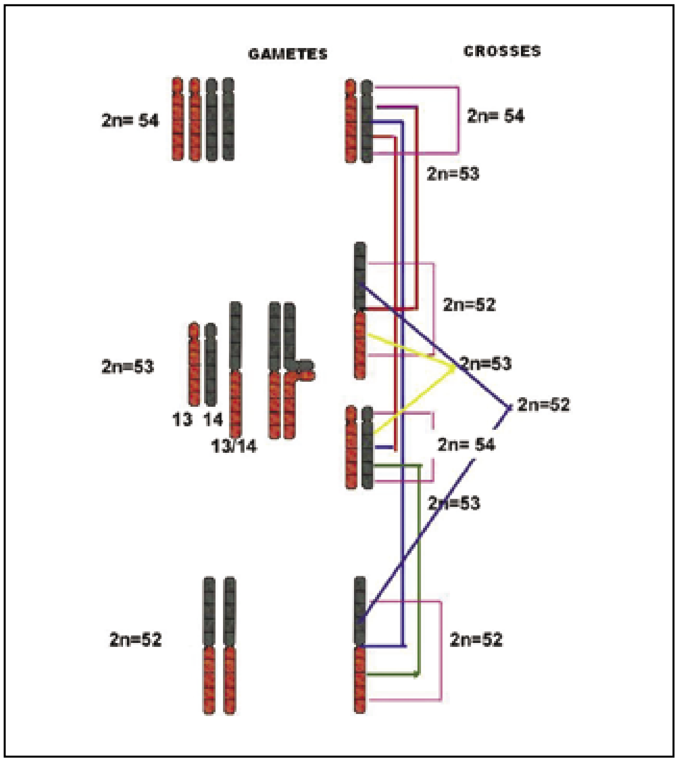


Figure 3. Hardy-Weinberg equilibrium relation between karyotypes found in *Aotus griseimembra* indicating how chromosome pairing takes place among the three different karyotypes, resulting in viable offspring rather than infertility.

certainly be sterile. Martin (1990: p.550) pointed out the superior importance of the fundamental number (i.e., the total number of chromosome arms) to the diploid number in indicating phylogenetic relationships, since the fundamental number tends to remain stable due to the inter-chromosomal rearrangements of reciprocal converson of acrocentric and metacentric chromosomes (Matthey 1949; Bender and Metler 1958; Chu and Bender 1961; Bender and Chu 1963; White 1973; Martin 1978). We thus concur with Torres *et al*. (1998: p.270) that this karyomorph represents a new, undescribed species of *Aotus,* the exact type locality of which is unknown at this time.

Aotus jorgehernandezi new species

Type specimen: Specimen ICN 14023, a female (Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá – not located in the collection); pictured in this article (Fig. 2) and in Torres *et al*. (1998: p.261, Fig. 2).

Type locality: Uncertain. Found in captivity in Quindío Department, Colombia, but said to be from the Parque de los Nevados on the border between Quindío and Riseralda.

Diagnosis: "The previously undescribed karyomorph exhibits a diploid number of 50 chromosomes, with a chromosome constitution different from all published *Aotus* karyotypes. It was observed in a female specimen from Quindío, *Aotus* [nov. sp.]. [Figure 1] shows a QFQ karyotype, which has nine pairs of metacentric chromosomes, as well as three pairs of submetacentric and 12 pairs of acrocentric ones. Intense fluorescent terminal bands were present in the 8p, 10p, 11p, 12p, 13p, 14p, and 15p chromosomes. For chromosomes 8, 13, 14, and 15, these bands correspond to C-positive constitutive heterochromatin. [Figure 1] shows a composite karyotype representing the haploid set with G, R, and C banding. As in other karyomorphs, the X chromosome was identified by its late replication and band pattern. Chromosomes 13q and 22q show interstitial C bands, proximal to the centromere, while chromosomes 13–18 show heteromorphic whole heterochromatic short arms. The centromeric heterochromatic band of chromosome 5p is also heteromorphic." (Torres *et al.* 1998: p.271, Fig. 9).

Description: This is a gray-necked specimen whose face shows two discrete supraocular white patches separated by a broad black frontal stripe. Sub-ocular white bands of fur are separated by a thin black malar stripe on each side of the head. The ventral part of the arms from the wrists running up into the chest and belly are of thick white fur (Fig. 2).

Comparisons: The other gray-necked *Aotus* with 2n = 50, *Aotus brumbacki* has 4 or 5 metacentric chromosomes (instead of the 9 in the new species), has 5 o 6 submetacentrics (according to Torres *et al.* 1998), 6 or 7 submetacentrics (according to Brumback 1974) or 12 or 14 submetacentrics (according to Yunis *et al.* 1977) instead of the 3 pairs of submetacentric chromosomes reported for this new species. Finally, *A. brumbacki* is reported to have 14 pairs of acrocentrics (according to Torres *et al*. 1998), 11 acrocentrics (according to Yunis *et al.*

1977), and 12 acrocentrics (according to Brumback 1974) as compared with the 12 acrocentric chromosomes reported by Torres *et al.* (1998).

Etymology: It seems appropriate to us to name this species *Aotus jorgehernandezi* in honor of our friend and colleague, the late Jorge I. Hernández-Camacho, a person who has influenced much of Colombian organismic biology and was instrumental in influencing our latest examination of the taxonomy of *Aotus.*

Aotus vociferans

Descailleaux *et al.* (1990) have indicated that *A. vociferans* has at least three diploid numbers (46, 47 and 48), and that the karyotypes 46 and 48 appear in the population with the same frequency, 47 being very rare. This suggests strong positive selective pressure for 2n = 46 and 2n = 48 with strong negative selection for 2n = 47. In their study of 68 *A. vociferans* they found a total homology of all chromosomes, except for a large metacentric chromosome in 2n = 46, which corresponded exactly with two acrocentric chromosomes of the 2n = 48. The only individual having 2n = 47 was a female, apparently a hybrid between the other two most common karyotypes. While the authors write that the karyotypes were all from the same "population" (Descailleaux *et al.* 1990: p.573), we assume they are not using the term in a natural demographic sense but rather to refer to the sum of their gray-necked animals, which from other publications of this research group we learn had been collected from a wide area north of the Río Marañon (Aquino and Encarnación 1988: pp.377–378). Nevertheless, Aquino and Encarnación (1988: p.377) found 2n = 46 and 2n = 48 to be "syntopic". One interpretation of these frequencies could be that this is an actual speciation event. Further studies of this phenomenon seem warranted.

Aotus griseimembra

The karyology of *Aotus griseimembra* has been studied much more than other karyomorphs of *Aotus* (Ma *et al.* 1976, 1978; Yunis *et al.* 1977; Miller *et al*. 1977; Giraldo *et al.* 1986). Martin (1978, 1990) and Defler and Bueno (2003) have described the behavior of the three polymorphic chromosome sets described for the taxon, and repeated calculations equaling more than 700 karyotypes have consistently shown similar values respecting the Hardy-Weinberg equilibrium, resulting in rearrangements that have neutral or mildly negative heterotic effects (Fig. 3). In this species, individuals with 2n = 53 have 3 unpaired elements, chromosome 1 formed by a simple Robertsonian fusion of chromosomes 13 and 14 and two elements with no homologues on chromosomes 13 and 14. Karyotype 2n = 52 has a double Robertsonian fusion on pair #1, and there are no unpaired chromosomes in this karyotype. Pairs #13 and #14 are free. The rest of the complements are the same in all three karyotypes.

Aotus zonalis

The karyology of *A. zonalis* (previously called *A. lemurinus* by Hershkovitz 1983) shows four pairs of metacentric, 4 pairs of metacentric and submetacentric, and 23 pairs of subtelo- and acrocentric autosomes in the 2n = 56 karyotype. The 2n = 55 has 4.5 pairs of metacentric and submetacentrics and 21 pairs of subtelo- and acrocentric, and two unpaired acrocentric autosomes with the sex chromosomes identical to those of the 2n = 56. The 2n = 55 has identical matching elements with the complement of 3n = 56 except for three unpaired chromosomes. Actually, because this karyomorph shares 24 pairs of identical chromosomes with *A. lemurinus*, we can say that *A. zonalis* is more closely related to *A. lemurinus* than it is to other Colombian *Aotus*, including *A. griseimembra. Aotus zonalis* and *A. griseimembra* differ in two distinct translocations of one chromosome (Ma *et al.* 1978).

The Meaning of Chromosome Variability and its Evolution

The prevalence of a high degree of chromosome variability in *Aotus*, *Callicebus*, *Alouatta* and other genera, and in general in the Platyrrhini, requires explanation, although presently we only have hypotheses. The first question might be whether chromosome variability has some selective value or not? Does a high degree of genetic shuffling within a genus mean a "high" rate of evolution? Could high variability in *Aotus* reflect the advantages of an unfilled primate niche where the only competition is from some nocturnal non-primate mammals, and then how could such high variability be explained in diurnal genera such as *Callicebus* and *Alouatta*? Is each karyotype an adaptive block or is chromosome variability unconnected with adaptation?

The most obvious value of a high diploid number might be the increased capacity for genetic recombination (Martin 1990: p.579), and in this light it is interesting that the highest number recognized for *Aotus* (2n = 58; *A. lemurinus*) is a species found above 1,500 m in the Cordillera de los Andes, where much more variable habitat extremes are found than those of the lowlands. The small size of *Aotus* and the fact that other primates of this size or less drop out of the primate community at elevations above 500–600 m suggest that physiological adaptations have played a part in the success of this primate occurring up to altitudes of 3,200 m (Hernández-Camacho and Defler 1985).

Aotus has highly variable chromosomes throughout many populations, and chromosome mutation in different evolving populations has produced a series of diploid numbers varying from 2n = 46 to 2n = 58 with FN's 54–78. In general, primates have one of the highest mammalian speciation rates, surpassed only by the horses (Bush *et al.* 1977). The average mammalian genus has been calculated at about 6.5 million years and the average primate genus at 3.8 million years (Bush *et al.* 1977); if the fossil "*Aotus" didensis* is correctly placed in the genus *Aotus*, we have a primate genus at least 12–13 million years old (Sertoguchi and Rosenberger, 1987).

Perhaps this explains in part the high chromosome variability of this genus? However, the genus *Equus* (the modern horses) seems to have an age that is somewhat less than the average mammalian genus; that is 3.5 million years (since *Equus* first appears in the fossil record in the late Pliocene) and *Equus* is also karyologically highly variable (Bush *et al*. 1977: p.3944). Genus age does not seem to explain the extreme chromosome polymorphism. What do *Aotus* and *Equus* have in common, if anything?

Bush (1975), Bush *et al.* (1977), Lande (1979), Wilson *et al.* (1975), Marks (1987), Ridley (1996: pp.457–458) and others have developed the idea that high rates of karyotypic evolution may be due to certain social structures and breeding systems, which might give a higher chance of survival of chromosomal changes, so that these changes may become fixed in a population. These social structures would have to cause a subdivision of populations into small, inbred demes, giving a chance for chromosome mutation to become fixed in the homozygous state. Galbreath (1983: pp.248–249) explicitly evoked genetic drift in small *effective* populations as the mechanism most responsible for *Aotus* chromosome variability. Others go on to identify characteristics such as limited adult vagility and juvenile dispersal, patchy distribution and strong individual territoriality as characteristics of such populations subject to high chromosome evolution. Martin (1990) criticized the evocation of fixation of chromosome changes in small demes, suggesting that mammals in general do not form small inbred population units, rather one sex usually continues reproductive interchange with other social units, and that localized inbreeding is not a consistent mammalian feature. Bickham (1981) and Robbins *et al.* (1983) sustain that chromosome change is more likely to proceed to adaptive change in evolution and not to fixation in small demes. The characteristics of reproduction in the populations of many are, however, unknown and there are many potential barriers to panmictic reproduction, including social systems, population structure and habitat characteristics (Wilson *et al*. 1989).

Few details are known about *Aotus* social structure. It is known that monogamous breeders defend a territory, but the process of outbreeding is completely unknown at the present. Some comments about *Callicebus,* may be helpful here, since they also have very high chromosome variability and, like *Aotus*, are monogamous territory holders. Some species of *Callicebus* (*C. torquatus*, *C. ornatus* and certainly others) live in monogamous units and vigorously defend a territory. After the second year the territory holders' young disperse, and search for a member of the opposite sex so that they can establish a territory of their own. This is probably not easy and so at least two tactics seem to be available.

Using the first strategy, lone *C. torquatus* have been observed far from their natal groups, crossing patches of grassy savannah in northern Colombia or attempting to cross the seasonally mostly dry portion of the lake bed of an oxbow lake on the lower Río Apaporis of eastern Colombia. In all likelihood these dispersals of a small, diurnal *Callicebus* have a high degree of failure, since most successful territories are occupied, unless one of a breeding pair happens to die. This means that philopatry is a viable option, since there are usually only patches of a few *Callicebus* pairs spread throughout the forest in a metapopulation structure. *Callicebus* densities are not high and there are large expanses of forest where titis are absent, judging by the absence of their vocalizations (Defler 2003, 2004). Dispersal in *Aotus* is even less well-known, but any long-distance dispersal is likely to be fraught with danger and the likelihood of failure is high; even more so for titis that do not have the cover of night.

A second strategy may involve unpaired *Callicebus* adults attaching themselves to a resident pair for a period of time. These adult "floaters" appear to be known to the generally aggressive territory holders; they are thus probably mature offspring that have not dispersed far and may even be enjoying the benefits of the territory where they grew up (Defler 2003, 2004). Breeding pairs vigorously defend their territory, usually via loud duetting, and occasionally with chases and same sex-attacks. We have noticed that, while displaying, *Callicebus torquatus* are visibly more aggressive towards some neighboring pairs than towards others. Neighboring territory holders that receive comparatively less aggression (cursory shout displays, then silence, as opposed to continued loud screaming with one pair finally retiring into the center of their territory or actual chases at the edges of the two territories) may include one offspring. Our interpretation is that a young animal electing to remain near its parents' territory may have resolved its breeding challenge by mating with a nearby animal that might have recently lost its mate, or it may have paired with another "floater", with both in the process of attempting to establish a new territory nearby. If this can be confirmed, this may lend support to the possibility of the fixation of a homozygous new karyomorph.

The most likely vicariant mechanism that could facilitate fixation of a new karyomorph (i.e., a population of a particular karyotype) could be the cutting off of the neck of a meandering river bend, resulting in the isolation for a time of a small, isolated population enclave until such time as the filling in of the isolated meander would allow long-distance dispersal of group members from one bank of the cut-off river bend to the other (Hershkovitz 1983). Until it was possible to cross such a barrier the isolated population could become inbred and subject to chromosome changes becoming dominant in that population. One such formerly isolated population of *C. torquatus lugens* and of *Aotus vocierans* is known from the lower Río Apaporis in eastern Colombia, but, because of filled-in vegetation and seasonal levels in the cut-off river meander, individuals are now able to pass freely from one side to the other of what were opposite river banks (Defler pers. obs.). An *A. nancymai* enclave on the left bank of the Río Marañon is known to be surrounded by *A. vociferans* as described in Hershkovitz (1983: p.236), the two species being at least partly sympatric (Aquino and Encarnación 1986). If a cut off population had no competition on the other side of a river, then any new chromosome mutation that had become fixed in the small population would be then spread and be diagnostic for the new population.

Observations of *Callicebus torquatus* in the Caparú Biological Station in eastern Colombia are very suggestive that not all animals disperse permanently — and if in *Callicebus,* why not in *Aotus*, which has a similar type of social structure? More detailed observations are needed on the two genera to confirm these ideas. DNA comparisons of individual animals to determine relatedness are now possible from the field, and we hope that future research might attempt using fecal material to obtain genealogical information for these species (Morin and Goldberg 2004; Woodruff 2004).

In the case of *Alouatta*, a much larger primate, the hypothesis about the causal factors leading to highly variable chromosomes would have to be modified, since the members of this genus are not monogamous. But, one male and one female are a basic social unit for at least the red howler, *A. seniculus*, and an isolated group could become inbred, and fixation of a new chromosome mutation could occur theoretically. However, a cut-off meander of a river would not be an adequate vicariant mechanism, since these animals are strong swimmers, nor do *Alouatta* balk at walking long distances over treeless expanses (Defler 2003, 2004). So of four genera with highly variable chromosome numbers and morphology, *Aotus, Alouatta, Callicebus* and *Hylobates*, three are monogamous and one is age-graded, perhaps requiring different explanations for this variability (Rylands and Brandon-Jones 1998).

Other Differences in *Aotus* Populations

Taylor and Siddiqui (1978a, 1978b, 1979) found significant mitogene differences (PHA with A and PWM) in lymphocyte cultures of *Aotus* from Panama (*A. zonalis*), Colombia (*A. griseimembra*), and Peru (*A. azarae*), and these differences were also reflected in experimental infections with *Plasmodium falciparum.* This differential sensitivity to *falciparum* infection was also studied by Espinal *et al*. (1984). Blood serum differences between populations were also pointed out by Brumback and Willenborg (1973).

Described *Aotus* Phenotypes

Most primatologists have considerable difficulties in distinguishing *Aotus* species phenotypically. Hershkovitz (1983) maintained that each species of *Aotus is* distinguishable phenotypically, karyotypically, and via serum proteins. His descriptions of color and hair patterns allow us to test his assertion (Hershkovitz 1949, 1983). Additional information provided by Hernández-Camacho and Cooper (1976) provide ample morphological descriptions for gray-necked *Aotus*. However, because *Aotus* is made up of a complex of sibling species, these phenotypes are not easy for the non-expert to apply.

Phenotypically it is of course easy to separate the "red-necked" southern species from the "gray-necked" northern species and this basic separation comes with an identifiable genetic difference as well — in the gray-necked group the chromosome pairs 6 and 7 are discrete, while in the red-necked group the chromosomes 6 and 7 have a reciprocal translocation of arms (Hershkovitz 1983: p.211). Like Hershkovitz (1949, 1983), Hernández-Camacho and Cooper (1976) in general lumped the three northern species *A. zonalis*, *A. griseimembra*, and *A. lemurinus* phenotypically into the so-called "B-phenotype"; they distinguished *A. l. griseimembra* as having short adpressed (densely compacted) pelage and light brownish hands and feet (in actuality the holotype had blackish hands and feet), as opposed to *A. l. zonalis* with blackish hands and feet; all other characteristics being similar to *A. l. griseimembra.* They also distinguished *A. l. lemurinus* as being "only from the Cordillera de los Andes "from about 1,000–1,500 m upward to the tree line (3,000–3,500 m)" (p. 47). Hernández-Camacho and Cooper (1976) characterized *A. t. lemurinus* as follows: "It is a rather variable subspecies, appearing quite often in two color phases, which can both be found in the same family group. One is decidedly grayish-brown, and the other is a richer, more reddish-brown in the upper parts. However, a range of intermediate coloration can be found. The underparts are always a rather dull yellow, indistinguishable from *A. t. griseimembra* and *A. t. zonalis.* The hair coat is extremely long and soft and is the most valuable distinguishing characteristic." However, pelage length is often pointed out as a poor diagnostic character, and being above about 1,500 m probably universally produces long-furred fluffy *A. lemurinus.*

Aotus are variable in color, sometimes even in the same family group and in individual specimens, but there seems to be a trend from the western Cordillera to the Eastern, although this trend should be examined in the future to confirm it. In all three species there are as well two color phases, a light overall grayish phase and a darker, reddish-brown phase with variations in between. These both are liable to appear in the same family group and there may be no trend or cline (Hernández-Camacho and Cooper 1976). The authors continue "The hands and feet of this species are remarkable in their color variation and lack of full correlation, even in individual specimens. Specimens examined from the western Andes (around Cali) and most of the specimens from the central Andes have black-tipped hairs on the hands and feet (at least reaching the distal carpus and tarsus). A few specimens from the western Andes and a number of those from the central Andes appear variably grizzled in color on the metatarsal and metacarpal regions due to reduced extent of the dark tips, thus allowing exposure of the lighter hair bases. In the eastern Andes a full range of individual variation occurs with regard to this character, i.e., from extensive black hair tips to the very reduced tips typical of *A. t. griseimembra.* Some variation has also been observed between the hands and feet of the same individuals with regard to this characteristic" (Hernández-Camacho and Cooper 1976: p.47). The most important phenotypic differences between these taxa then are the almost universal blackish hands and feet and short pelage of *A. zonalis*, the almost universal brownish feet and hands and short pelage of *A. griseimembra*, and the black or brown hands and feet and very long pelage of *A. lemurinus.*

Identifying *A. brumbacki* was no problem for Hershkovitz (1983), he identified a preserved head, which was said to be from the Río Paraguay, as in fact coming from the Villavicencio area. Hershkovitz (1983) then went on to describe *A. brumbacki* as a new species, basing his opinion especially on the karyotype (2n = 50), described by Brumback (1974) and Yunis *et al.* (1983). This species is also short-haired, with two temporal stripes which continue as shadowy stripes, appearing to merge into a generally dark blotch on top of and behind the crown. The body is usually some shade of grayish-buffy and there is no mid-dorsal stripe; a pale band between buffy supraorbital and suborbital patches is interrupted by an extension of the blackish temporal stripe to the outer corner of the eye; a blackish malar stripe is present. Hershkovitz (1983: p.216, p.219) distinguished *A. brumbacki* from the *A. lemurinus* complex and from *A. trivirgatus*, because *A. brumbacki* has an interscapular whorl or crest not present in the others. These characters are of questionable diagnostic value, as Ford (1994: p.26) found, since there are many exceptions, and even Hershkovitz (1983: p.216) explaining their use, noted many problems.

According to Hershkovitz (1983: p.216), *A. vociferans* has an interscapular whorl with centrifugal and a more or less circular gular gland, the surrounding hairs radiating from the center as a whorl. One helpful characteristic pointed out by Ford (1994: p.25) in this species is that the head stripes nearly always converge posteriorly.

Ford's (1994: p.25) analysis argued that *A. trivirgatus* is the most divergent and best-defined of the group of northern gray-necked *Aotus.* There are no whorls, crests or tufts and the head stripes do not unite posteriorly, this being a strongly reliable character of the species. The dorsum is usually grayish, sometimes with buffy agouti and with a narrow and strongly contrasting orange middorsal band. Morphometrically this species is easily distinguishable from the rest of the northern *Aotus* as well, with a canonical variate from cranial measurements separating *A. trivirgatus* completely from the other northern species (Ford 1994: pp.11–17).

An interpretation of Ford´s (1994) discovery that *A. trivirgatus* (*sensu* Hershkovitz 1983) was morphometrically clearly distinguishable from the complex *A. vociferans–A. brumbacki–A. lemurinus* (*sensu* Hershkovitz 1983) might be that *A. trivirgatus* was the first to separate from the others of the *Aotus* species complex, allowing for the development of the more accentuated morphological differences (Mayr and Ashlock 1991: p.92). If there is no strong selection pressure on visible phenotype, easily understandable for pelage markings, and if these are fairly new species, there may not have been enough time for such phenotypical differences to become evident, although closer analysis may yet find some sharp phenological differences, as is usual after increased study of most sibling species (Mayr 1969: pp.33–58). The most fecund analyses might be made in vocalizations or pheromone cues, since these are the phenotypic characteristics that are most important to a nocturnal animal (Mayr 1969: pp.33–58).

Many problems arose when we actually studied collection skins, because of strong similarities among these species. Perhaps *Aotus* species are so similar because they are nocturnal, and selection for coat patterns may be very weak. It may be that blocks of balanced adaptations maintain themselves in an essentially homogeneous habitat throughout the range of the genus, and that the "*Aotus* adaptation" for nocturnal forest living is reflected via similar phenotypes. Patton and Smith (1980) described genetic and morphological divergence among pocket gopher species, where two species (operationally defined as clearly maintaining two genetically different populations through reproductive isolation maintained by a sterile F_1 hybrid zone) have no distinguishable morphological difference except for size and that also show no substantive degree of genetic differentiation (as measured by electrophoresis). Other gopher species of this complex (*Thomomys*) show considerable genetic differences. Morphological differentiation appears to have occurred much more slowly than genetic differentiation in the sibling species complex, and may be due mostly to genetic drift in color and skull characteristic rather than any selective force.

Thorington and Vorek (1976) make some interesting observations on variation in coat color in *Aotus*. They felt that Hershkovitz' designations of the subspecies *A. lemurinus lemurinus* and *A. l. griseimembra* would only complicate a real appreciation of the variability in *Aotus* populations. Van Roosmalen *et al.* (2002) believe that the use of the subspecies category has "minimal value" when describing Neotropical primate diversity. Although Hershkovitz (1949, 1983) and Hernández-Camacho and Cooper (1976) confidently identified and described various *Aotus* populations in their publications; we find the task to be much more difficult, especially because different characters vary independently across the species' range and many characters do not seem to exhibit regular variations. It is possible Hershkovitz and Hernández-Camacho had special abilities that come from many years of study of *Aotus*.

The fact that Ford´s (1994) work defined one phenetic unit made up of *A. vociferans, A. brumbacki,* and *A. lemurinus* (*sensu* Hershkovitz, 1983) is not surprising, given the nature of sibling species complexes. But it is important to realize that a phenetic unit (or a phenetic "species") is not the same as a biological species. Biological species require reproductive barriers and these are strongly suggested by the karyotypic differences. Although differences in karyotype do not inevitably mean reproductive barriers, as evidenced by the balanced polymorphism of *A. griseimembra*, the level of karyotypic differences found in *A. lemurinus, A. zonalis* and *A. brumbackii* would most probably result in pre-zygotic barriers due to problems of chromosome pairing, resulting in sterility at the F_1 or F_2 generation or drastically reduced fertility (Torres *et al.* 1998; Defler *et al.* 2001).

Similarities and lack of truly cogent differences in *Aotus* phenotypes may be due to the fixation of chromosome differences in small, isolated populations. If *Aotus* has an established phenotype adapted to a nocturnal feeding niche, there would be little pressure for new feeding adaptations, which are often the basis for many morphological differences, especially in teeth. A speciation event, due to a pre-zygotic mechanism such as a chromosome change, very possibly would allow the two sister clades to continue to exist parapatricly in a very similar niche. If the new species was successful enough to quickly expand its population, only gene drift would define differences between the populations, not new adaptations. If the genus (as seems likely) was well-adapted to its nocturnal existence, balanced co-adapted gene clusters could maintain themselves even in reproductively isolated populations, as has been discussed in the pocket gopher species complex, where many morphologically very similar or identical species exist (Patterson and Smith 1989). Many mosaic characters of *Aotus* such as pelage coloration may be the results of genetic drift (Thorington and Vorek 1976; Ridley 1996).

Despite the difficulties of determining the various phenotypes, we include here a key (Table 3) that has been constructed based on the comments of Hernández-Camacho and Cooper (1976), Hershkovitz (1983) and Ford (1994), in their efforts at recognizing appropriate phenotypes for some of the gray-neck species that we recognize. Although these authors in several cases do not agree with each other (for example, Ford lumps all species together except for *A. trivirgatus*), it seems helpful to us to organize this information in such a way that it can be used by other workers.

It should be appreciated that from the first time that a second species was distinguished from *A. trivirgatus*, the division was appreciated because of karyotypic differences not phenotypic. Further species have been identified, each time because of their karyotype, not because of phenotype.

Aotus Origin and Evolution

Aotus may have had its origin in central Colombia, if "*Aotus dindensis*" described from 12–13 million-year-old deposits of the La Venta formation near the Río Magdalena in Colombia (Setoguchi and Rosenberger 1987) truly belongs to this genus. This was well before the appearance of the Cordillera de los Andes about 5 millon years ago. Two other lines of evidence suggest a northern origin. First, following the theory of metachromism (Hershkovitz 1977, 1983), the red-necked *Aotus* species had to have derived from the gray-necked species in the north. According to the model, these pigment changes are one-way and always proceed from the loss of eumelanin.

Secondly, the *Aotus* karyotype appears to have evolved generally through fusion, as the highest diploid numbers are among the gray-necked northern group, the lowest numbers among the animals to the south. Ma (1981) and Galbreath (1983) had posited an ancestral *Aotus* of 2n = 54, before a published description of the karyomorph 2n = 58 (Defler *et al.* 2001; Torres *et al.* 1998; Giraldo *et al.* 1986). Our analysis

Table 3. Phenetic key to species of gray-necked *Aotus* (according to Hernández-Camacho and Cooper 1976; Hershkovitz 1983; Ford 1994).

1.1	Part or entire side of neck including area behind and below ear, and not less than medial portion and posterior half of throat orange or buff like chest. ......**Red neck species group** (south of Río Amazonas)
1.2	Entire side of neck including area behind and below ear, grayish agouti or brownish agouti like flank or outer side or arm; throat from entirely grayish or brownish agouti to entirely orange or buff. ......**Gray-neck species group** (north of Río Amazonas)
	Gray-neck species group
2.1	Inner side of limbs entirely grayish agouti like outer side or with orange or buffy of chest and belly extending to or slightly beyond midarm or midleg rarely to ankle; pelage of dorsum short and adpressed to long and lax; coloration of upper parts of body variable; middorsal band, if present, broad, blackish, brown or orange and not well defined, temporal stripes separate or united behind (Hershkovitz [1983] added that the interscapular whorl or crest is absent in all specimens of this group; Ford [1994] found that this is unreliable). **3**
2.2	Interscapular whorl or crest present with raised hairs directed backward and laterally; gular gland long (5 cm), thin, the surrounding hairs extending outward from sides (according to Hershkovitz (1983). Ford (1994) rejected this and distinguished ***A. brumbacki*** as belonging phenotypically to 4.1 and 4.2; Hernández-Camacho and Cooper (1976) identified ***A. brumbacki*** as ***A. trivirgatus***, and described the taxon as "short-to-medium hair coat usually of a rather pure gray color with comparatively light-colored hands and feet due to rather short, dark, apical hair tips slightly more apparent than those of ***A. t. griseimembra***". **5**
3.1	Long fluffy hair (long and lax), feet may or may not have black hairs. ......***Aotus lemurinus***
3.2	Hair of dorsum short and adpressed. **4**
4.1	Feet with black hairs (Hernández-Camacho and Cooper 1976). ......***Aotus zonalis***
4.2	Feet with light brown hairs (Hernández-Camacho and Cooper 1976). ......***Aotus griseimembra***
5.1	With raised hairs directed backward and laterally; gular gland long (5 cm), thin, the surrounding hairs extending outward from sides (according to Hershkovitz [1983], but Ford [1994] rejected this). ......***Aotus brumbacki***
5.2	Temporal stripes nearly always united behind (Hershkovitz [1983] and Ford [1994] both agreed that this is an important diagnostic character for this species); Hershkovitz (1983 also wrote "malar stripe well defined to absent; pedal digital tufts thin, not extending beyond ungues; size smaller, tail length 340(308-363)38 N. ......***Aotus vociferans***

suggests that in fact the ancestral *Aotus* was probably 2n = 58, due to the acrocentric chromosome that is involved in two different rearrangements, in *A. brumbacki* and *A. griseimembra* (Defler *et al.* 2001: p.48, Fig. 8).

During the late Miocene, the paleo-Amazon River emptied into the Pacific Ocean, creating a historic barrier to the south. Later, perhaps due to the rising Cordillera, *Aotus* was able to extend south of the great river and, in the process, bleaching of the blackish-brown eumelanin and the acquisition of the reddish pheomelanic hairs of its ventrum and neck took place, thus producing the "red-necked" group, which become isolated south of the great river with the continuing rise of the Cordillera.

Chromosome evolution takes place not by addition or subtraction so much as rearrangement of genetic material, so that animals with large karyotypic differences still retain their phylogenetic inheritance somewhere upon the chromosome arms (Martin 1990: 548). If the chromosome arms are rearranged, difficulties start to arise because of pericentric inversions, centric rearrangements or fission or fusion (perhaps via Robertsonian translocations) in attempts at meiotic synapsis, and it becomes impossible for genetic recombination to occur.

Some interpopulational (inter-karyomorphic) polymorphs, which surmount problems of chromosome differences (though the known polymorphic karyomorphs are only present in a one-step series of three karyotypes, not in wide differences, as exist between many karyomorphs), are able to maintain a polymorphic condition within the karyomorph. Examples of these are *Aotus vociferans* (2n = 46, 47, 48), *Aotus griseimembra* (2n = 54, 55, 56), and *Aotus zonalis* (2n = 52, 53, although one expects that 54 will be discovered in the future), but most crosses between different species should cause problems of infertility or reduced fertility in F_1 or F_2 generations. Each of these polymorphisms seems to maintain itself and population samples from each have contained each of these karyotypes (Giraldo *et al.* 1986). These chromosome differences then become species isolating mechanisms which then work to maintain the integrity of the species and its karyomorph. It is probable that other pre-mating isolating mechanisms have evolved, most likely in the form of such as displays, vocalizations, and pheromones — anything that would be effective at night to allow two animals to recognize each other as the same species.

It seems doubtful that extensive chromosome variation in *Aotus* is a reflection of active phenotypic evolution, since morphological differences in *Aotus* are quite difficult to determine. Many authors have taken the view that chromosomal rearrangements do not have special adaptive significance and only contribute to reproductive isolation (White 1973, 1978; Martin 1990), although it has been justly pointed out that there have been many linked clusters of genes recognized in mammals, and this suggests that the order that is found of genes upon the chromosome could have selective differences (Bodmer 1975, 1981). Chromosome number should be adaptive in as much as it affects the level of recombination that can occur, so that large diploid numbers have greater capacities for genetic recombination than small diploid numbers (Martin 1990). Possible recombinations vary exponentially with an increase in haploid number, so that even an increase in diploid number from 56 (lowland *Aotus*) to 58 means a vast increase in possibilities for recombination (Dutrillaux 1986; Martin 1990). It is, then, significant that the autochthonous *Aotus lemurinus* with a karyomorph of 2n = 58 (the highest known diploid number in the genus) inhabits the Cordillera de los Andes above 1,500 m to 3,200 m, where it must be adapted to many different habitat types, while lower diploid numbers are found in karyomorphs from lowland and more homogeneous habitat.

Species Concepts

Recently Groves (2001: pp.30–31) has suggested that primatologists should accommodate to the "phylogenetic species concept (PSC)" as defined by Cracraft (1983), replacing entirely the "biological species concept (BSC)", because of various criticisms of the older view of species that include: the indeterminate status of geographic isolates, the over-reliance on reproductive barriers to define species, and difficulties in demonstrating reproductive isolation, hybridization between putative species, the difficulties in highlighting discrete variation. Cracraft (1983) defined his species concept as "the smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent", and argued that "Species possess, therefore, only unique combinations of primitive and derived characteristics, that is, they simply must be diagnosable from all other species. This does not mean, however, that such a definition is predicated on reproductive disjunction as is the BSC, but only on an acknowledgment that all species definitions must have some notion of reproductive cohesion within some definable cluster of individual organisms." Cracraft (1983: p.170). He criticized the BSC especially on the basis of a recognized conflict of taxonomic practices with systematic analysis and his belief that "the pattern of reproductive disjunction among taxa does not necessarily correlate with the history of their differentiation", thus making any speciation analysis incomplete (Cracraft 1983: p.160).

We believe that it is true that modern biology has not developed adequate tools for the analysis and description of phylogenetic history. Molecular analysis is, after all, very recent, and classificatory criteria are still being considered and taxonomies often ignore karyological, and other, information. Thus, real evolutionary variation is often not reflected in the taxonomic scheme that is in use; but, we do not think that a PSC model will solve these problems, especially if it ignores reproductive barriers.

A taxonomist who was just "conscientious and spread the net as widely as possible, taking osteodental, soft anatomy, external, ethological, karyological, and molecular features into account *to the extent that they are available* [our emphasis]" (Groves 2001: p.31), would be describing a taxon that might accord with a biological species. But such taxonomies are few and far between. Instead we have "species" on the basis of differences in hand color, black or white (*v. Callicebus medemi*), or other "species" (for example of the *C. torquatus* complex) that have been described as subspecies first, then just bumped up (revision of Van Roosmalen *et al.* 2002). Species are often described on the basis of some sharply distinct feature. This is the argument of the separation of *Lagothrix lugens* and *L. lagothricha*, (even though they actually have much phenotypic overlap and *L. l. lugens, sensu* Fooden [1963], actually contains at least 2–3 distinctive phenotypes of which we are aware [Groves 2001: pp.176–177, pp.190–192]). To upgrade all subspecies to species because "we increasingly find the concept of subspecies to be of minimal value in describing the diversity of Neotropical primates", we see as only moving the problem up one level, and obscures the reality of a real evolutionary unit, the biological species, without actually solving the problem of the description of diversity (Van Roosmalen *et al.* 2002). If separate lineages are identified using all possible criteria, including karyological and molecular, many such "species" will be identical to a biological species. However, ignoring karyological evidence in favor of phenotypic and the use of small pelage differences alone only takes us back to the typological species concept of 150 years ago. The biological species concept should not be ignored just because it is not easily translated into an operational definition. The "subspecies" concept is useful to classify phenotypic diversity within a polytypic species, but the fact that we now recognize so many other levels of diversity, especially genetic polymorphism, only points to the need to find new methods of classifying the diversity within a species, and these methods are only now being formulated.

Possible Future Research

More *Aotus* karyotypes must be collected from individuals of known provenance to better understand their geographic distribution. This need not result in the death of the individuals which could be photographed and released at the capture site. High altitude *Aotus* karyotypes from the Cordillera de los Andes are needed to confirm the karyotype of *A. lemurinus*, and in the Sierra Nevada to confirm the karyotype of *Aotus griseimembra.* More *A. zonalis* karyotypes are needed which we predict will result in the discovery of individuals with a diploid number of 54. It would be of great interest to locate any hybrids in *Aotus* colonies between *A. zonalis* and *A. griseimembra* and to identify whether they are sterile or fertile. The poorly-understood distributions of *A. brumbacki* and other night monkeys east of the Colombian Andes need to be plotted using karyotypes of individuals. New Maipures karyotypes need to be analyzed to be certain of the phylogeny of the populations there. *Aotus* in eastern Colombia need to be studied for karyotype, especially since phenotypes seem to be related to *A. trivirgatus*, and the true karyotype for *A. trivirgatus* needs to be established. The distribution of *Aotus jorgehernandezi* needs to be determined.

In Memoriam

We dedicate this paper to the memory of our colleague and friend, Professor Jorge Ignacio Hernández-Camacho, who passed away on 15 September 2001. Jorge was an inspiration to us both and showed us many paths that needed to be trod, one of them being detailed consideration of the northern *Aotus.* He accompanied us along this path for part of the way (see Defler *et al.* 2001). Jorge's dedication to the Colombian biota and to the unfinished journey provoked us to extend the arguments in our previous paper, which we present here.

Acknowledgments

We are grateful to Colin P. Groves and Anthony Rylands for reading previous drafts of this article and for their many helpful and thoughtful comments on the text. In some instances we differ from Groves' interpretations, but his contribution has been invaluable and it has greatly improved the article.

Literature Cited

Aquino, R. and F. Encarnación. 1988. Population densities and geographic distribution of night monkeys (*Aotus nancymai* and *Aotus vociferans*) (Cebidae: Primates) in northeastern Peru. *Am. J. Primatol.* 14(4): 375–381.

Ashley, M. V. and J. L. Vaughn. 1995. Owl monkeys (*Aotus*) are highly divergent in mitochondrial cytochrome c oxidase (COII) sequences. *Int. J. Primatol.* 16(5): 793–806.

Bender, M. A. and E. H. Y. Chu. 1963. The chromosomes of primates. In: *Evolutionary and Genetic Biology of Primates*, J. Buettner-Janusch (ed.), pp.261–310. Academic Press, New York.

Bender, M. A. and L. E. Metler. 1958. Chromosome studies in primates. *Science* 128: 186–190.

Bickham, J. W. 1981. Two-hundred-year-old chromosomes: deceleration of the rate of karyotypic evolution in turtles. *Science* 212: 1291–1293.

Bickham, J. W. 1983. Sibling species. In: *Genetics and Conservation*, C. M. Schönewald-Cox, S. Chambers, B. MacBryde and W. Thomas (eds.), pp.96–106. The Benjamin/Cummings Publishing Company, Inc., Menlo Park, California.

Bodmer, W. F. 1975. Analysis of linkage by somatic cell hybridization and its conservation by evolution. *Symp. Soc. Stud. Hum. Biol.* 14: 53–61.

Bodmer, W. F. 1981. Gene clusters, genomic organization, and complex phenotypes. When the sequence is known, what will it mean? *Am. J. Hum. Genet.* 33: 664–682.

Brumback, R. A. 1973. Two distinctive types of owl monkeys (*Aotus*). *J. Med. Primatol.* 2: 284–289.

Brumback, R. A. 1974. A third species of the owl monkey (*Aotus*). *J. Hered.* 65: 321–323.

Brumback, R. A. 1976. Taxonomy of the owl monkey (*Aotus*). *Lab. Prim. Newsl.* 15(1): 1–2.

Brumback, R. A. and D. O. Willenborg. 1973. Serotaxonomy of *Aotus,* a preliminary study. *Folia Primatol.* 20: 106–111.

Brumback, R. A., R. D. Staton, S. A. Benjamin and C. M. Land. 1971. The chromosomes of *Aotus trivirgatus* Humboldt, 1812. *Folia Primatol.* 15: 264–273.

Bush, G. L. 1975. Modes of animal speciation. *Ann. Rev. Ecol. Syst.* 6: 339–364.

Bush, G. L., S. M. Case, A. C. Wilson and J. L. Patton. 1977. Rapid speciation and chromosomal evolution in mammals. *Proc. Natl. Acad. Sci. USA* 74: 3942–3946.

Chu, E. H. Y. and M. A. Bender 1961. Chromosome cytology and evolution in primates. *Science* 133: 1399–1405.

Cicmanec. J. C. and A. K. Campbell. 1977. Breeding the owl monkey (*Aotus trivirgatus*) in a laboratory environment. *Lab. Anim. Newsl.* 27: 512–517.

Cooper, R. W. and J. I. Hernández-Camacho. 1977. A current appraisal of Colombia's primate resources. In: *Primate Utilization and Conservation*, G. Bermant and D. G. Lindburg (eds.), pp.37–66. John Wiley & Sons, New York.

Cracraft, J. 1983. Species concepts and speciation analysis. In: *Current Ornithology*, R. F. Johnston (ed.), pp.159–187. Plenum Press, New York.

Cracraft, J. 1990. Species concepts in theoretical and applied biology: A systematic debate with consequences. In: *Species Concepts and Phylogenetic Theory*, Q. D. Wheeler and R. Meier (eds.), pp.3–16. Columbia University Press, New York.

de Boer, L. E. M. and J. W. F. Reumer. 1979. Reinvestigation of the chromosomes of a male owl monkey (*Aotus trivirgatus*) and its hybrid son. *J. Hum. Evol.* 8: 479–489.

Datta, M. 1979. Evolutionary significance of the chromosome numbers in the mammals: A point of view. In: *Comparative Karyology of Primates*, B. Chiarelli, A. L. Koen and G. Ardito (eds.), pp.73–81. Mouton Publishers, The Hague.

Defler, T. R. 2003. *Primates de Colombia.* Conservación Internacional Colombia, Bogotá.

Defler, T. R. 2004. *Primates of Colombia.* Conservación Internacional Colombia, Bogotá.

Defler, T. R. and M. L. Bueno. 2003. Karyological guidelines for *Aotus* taxonomy. *Am. J. Primatol.* 60:Suppl. 1: 134–135. Abstract.

Defler, T. R., M. L. Bueno and J. I. Hernández-Camacho. 2001. Taxonomic status of *Aotus hershkovitzi*: its relationship to *Aotus lemurinus lemurinus. Neotrop. Primates* 9(2): 37–52.

Descailleaux, J., R. Fujita, L. A. Rodríguez, R. Aquino and F. Encarnación. 1990. Rearreglos cromosómicos y variabilidad cariotípica del género *Aotus* (Cebidae: Platyrrhini). In: *La Primatología en el Perú*. Invetigaciones Primatológicas (1973–1985), Proyecto Peruano de Primatologia "Manuel Moro Sommo" (ed.), pp.572–577. Lima.

Dixson, A. F., R. D. Martin, R. C. Bonney and D. Fleming. 1980. Reproductive biology of the owl monkey. In: *Non-human Primate Models for Study of Human Reproduction*, A. Kumar (ed.), pp.61–68. Karger, Basel.

Dutrillaux, B. 1986. Le role des chromosomes dan l´évolution: une nouvelle interpretation. *Ann. Génét.* 29: 69–75.

Dutrillaux, B. and J. Courturier. 1981. The ancestral karyotype of platyrrhine monkeys. *Cytogenet. Cell Genet.* 30: 232–242.

Dutrillaux, B., J. Couturier, E. Viégas-Pequignot and M. Muleris. 1982. Cytogenetic aspects of primate evolution. In: *Human Genetics. Part A. The Unfolding Genome*, B. Bonne-Tamir and T. Cohen (eds.), pp. 183–184. Alan R. Liss, New York.

Dutrillaux, B., J. Couturier, M. Muleris, Y. Rumpler and E. Viégas-Pequignot. 1986. Relations chromosomiques entre sous-ordres et infra-ordres et schéma évolutif général des primates. *Mammalia* 50: 108–121.

Espinal, C., E. Moreno, J. Umaña, J. Ramírez and M. Montilla. 1984. Susceptibility of different populations of Colombian *Aotus* monkeys to the FCB-1 strain of *Plasmodium falciparum. Am. Soc. Trop. Med. Hyg*. 33(5): 777–782.

Ford, S. M. 1994. Taxonomy and distribution of the owl monkey. In: *Aotus: The Owl Monkey*, J. F. Baer, R. E. Seller and I. Kakoma (eds.), pp.1–57. Academic Press, New York.

Galbreath, G. J. 1983. Karyotypic evolution in *Aotus. Am. J. Primatol.* 4: 245–251.

Giraldo, A., M. L. Bueno, E. Silva, J. Ramírez, J. Umaña and C. Espinal. 1986. Estudio citogenético de 288 *Aotus* colombianos. *Biomédica* 61(1–2): 5–13.

Groves, C. P. 2001. *Primate Taxonomy.* Smithsonian Institution Press, Washington, DC.

Groves, C. P. 2005. Order Primates. In: *Mammal Species of the World: A Taxonomic and Geographic Reference*, 3rd Edition, Volume 1, D. E. Wilson and D. M. Reeder (eds.), pp.111–184. Johns Hopkins University Press, Baltimore.

Hernández-Camacho, J. and R. W. Cooper. 1976. The non-human primates of Colombia. In: *Neotropical Primates: Field Studies and Conservation*, R. W. Thorington and P. G. Heltne (eds.), pp.35–69. National Academy of Sciences, Washington, DC.

Hernández-Camacho, J. and T. R. Defler. 1989. Algunos aspectos de la conservación de primates no-humanos en Colombia. In: *La Primatología en Latinoamérica*, C. J. Saavedra, R. A. Mittermeier and I. B. Santos (eds.), pp. 67–100. WWF-US, Washington, DC.

Hershkovitz, P. 1949. Mammals of northern Colombia: Preliminary report No. 4: Monkeys (Primates), with taxonomic revisions of some forms. *Proc. U. S. Natl. Mus.* 98(3232): 323–427.

Hershkovitz, P. 1977. *Living New World Monkeys (Platyrrhini): With an Introduction to the Primates,* Vol. 1. The University of Chicago Press, Chicago.

Hershkovitz, P. 1983. Two new species of night monkeys, genus *Aotus* (Cebidae, Platyrrhini): a preliminary report on *Aotus* taxonomy. *Am. J. Primatol.* 4: 209–243.

Hershkovitz, P. 1989. *In litt.* to María Victoria Monsalve, 9 May 1989.

Horovitz, I. 1999. A phylogenetic study of living and fossil platyrrhines. *Am. Mus. Nov.* (3269): 40pp.

Howard, D. J. 1993. Small populations, inbreeding, and speciation. In: *Hybrid Zones and the Evolutionary Process*, R. G. Harrison (ed.), pp.46–69. Oxford University Press, New York.

John, B. 1981. Chromosome change and evolutionary change: a critique. In *Evolution and Speciation: Essays in Honor of M. J. D. White*, W. R. Atchley and D. S. Woodruff (eds.), pp.23–51. Cambridge University Press, Cambridge.

King, M. 1995. *Species Evolution: The Role of Chromosomal Change.* Cambridge University Press, New York.

Koiffman, C. P. and P. H. Saldanha. 1974. Cytogenetics of Brazilian monkeys. *J. Hum. Evol.* 3: 275–282.

Kumamoto, A. T. and M. L. Houick. 2001. Cytogenetic identification of a hybrid owl monkey, *Aotus nancymaae* × *Aotus lemurinus griseimembra. J. Zoo Wild. Med.* 32(1): 130–133.

Lande, R. 1979. Effective deme sizes during long-term evolution estimated from rates of chromosomal rearrangement. *Evolution* 33: 234–251.

Lande, R. 1985. The fixation of chromosomal rearrangements in a subdivided population with local extinction and recolonization. *Heredity* 54: 323–332.

Ma, N. S. F. 1981a. Chromosome evolution in the owl monkey. *Am. J. Phys. Anthropol.* 54: 294–304.

Ma, N. S. F. 1981b. Errata. Chromosome evolution in the owl monkey *Aotus*. *Am. J. Phys. Anthropol.* 54: 326.

Ma, N. S. F., T. C. Jones, A. Miller, L. Morgan and E. Adams. 1976a. Chromosome polymorphism and banding patterns in the owl monkey (*Aotus*). *Lab. Anim. Sci.* 26: 1022–1036.

Ma, N. S. F., M. W. Elliott, L. M. Morgan, A. C. Miller and T. C. Jones. 1976b. Translocation of Y chromosome to an autosome in the Bolivian owl monkey, *Aotus*. *Am. J. Phys. Anthropol.* 45(2): 191–202.

Ma, N. S. F., T. C. Jones, M. T. Bedard, A. C. Miller, L. M. Morgan and E. A. Adams. 1977. The chromosome complement of an *Aotus* hybrid. *J. Heredity* 68: 409–412.

Ma, N. S. F., R. N. Rossan, S. T. Kelley, J. S. Harper, M. T. Bedard and T. C. Jones. 1978. Banding patterns of the chromosomes of two new karyotypes of the owl monkey, *Aotus*, captured in Panama. *J. Med. Primatol.* 7: 146–155.

Ma, N. S. F., D. M. Renquist, R. Hall, P. K. Sehgal, T. Simeone and T. C. Jones. 1980. XX/“XO” sex determination system in a population of Peruvian owl monkeys, *Aotus*. *J. Heredity* 71(5): 336–342.

Ma, N. S. F., T. Simeone, J. McLean and P. Parham. 1982. Chromosome localization and gene synteny of the major histocompatibility complex in the owl monkey *Aotus*. *Immunogenetics* 15(1):1–16.

Marks, J. 1987. Social and ecological aspects of primate cytogenetics. In: *Primate Models: The Evolution of Human Behavior*, W. G. Kinzey (ed.), pp.139–151. State University of New York Press, Albany, New York.

Martin, R. D. 1978. Major features of prosimian evolution: a discussion in the light of chromosomal evidence. In *Recent Advances in Primatology, Vol. 3: Evolution*, D. J. Chivers and K. A. Joysey (eds.), pp.3–26. Academic Press, London.

Martin, R. D. 1990. *Primate Origins and Evolution.* Princeton University Press, Princeton, New Jersey.

Mayr, E. 1967. Cladistic analysis or cladistic classification? *Z. Zool. Syst. Evol. Forsch.* 12: 94–128.

Mayr, E. 1969. *Animal Species and Evolution.* 2nd edition. Belknap Press, Harvard University Press, Cambridge, Massachusetts.

Mayr, E. 1990a. The biological species concept. In: *Species Concepts and Phylogenetic Theory*, Q. D. Wheeler and R. Meier (eds.), pp.17–29. Columbia University Press, New York.

Mayr, E. 1990b. A critique from the Biological Species Concept Perspective: What is a species, and what is not? In: *Species Concepts and Phylogenetic Theory*, Q. D. Wheeler and R. Meier (eds.), pp. 93–100. Columbia University Press, New York.

Mayr, E. and P. D. Ashlock. 1991. *Principles of Systematic Zoology.* 2nd Edition. McGraw-Hill, Inc., New York.

Miller, C. K., D. A. Miller, O. J. Miller, R. Tantravahi and R. T. Reese. 1977. Banded chromosomes of the owl monkey, *Aotus trivirgatus. Cytogenet. Cell Genet.* 19: 215–266.

Monsalve, M. V., R. Olivares and T. Defler. Undated. Evidence of the *Aotus brumbacki* subspecies by karyotype study. Unpublished manuscript.

Morin, P. A. and T. L. Goldberg. 2004. Determination of genealogical relationships from genetic data: A review of methods and applications. In: *Kinship and Behavior in Primates*, B. Chapais and C. M. Berman (eds.), pp.15–45. Oxford University Press, Oxford.

Patton, J. L. and M. F. Smith. 1989. Population structure and the genetic and morphologic divergence among pocket gopher species (genus *Thomomys*). In: *Speciation and Its Consequences*, D. Otte and J. A. Endler (eds.), pp.284–304. Sinauer Associates, Inc., Sunderland, Massachusetts.

Pieczarka, J. C. and C. Y. Nagamachi. 1988. Cytogenetic studies of *Aotus* from eastern Amazonia Y-autosome rearrangement. *Am. J. Primatol.* 14(3): 255–264.

Pieczarka, J. C., M. D. S. Barros-R., C. Nagamachi, R. Rodríguez and A. Espinel. 1992. *Aotus vociferans* × *Aotus nancymai* sympatry without chromosomal hybridization. *Primates* 33(2): 239–245.

Ramírez-C., J. 1983. Reporte de una nueva especie de primate del género *Aotus* de Colombia. *Resúmenes de las Comunicaciones Científicas del IX Congreso Latinoamericano de Zoología*, Arequipa, Perú, 9–15 de Octubre, 1983, p.146.

Reardon, M. J., R. D. Hall, and C. E. Davidson. 1979. Serum electrophoretic patterns of karyotypically defined owl monkeys (*Aotus trivirgatus*). *Lab. Anim. Sci.* 29(5): 617–620.

Reumer, J. W. F. and L. E. M. de Boer 1980. Standardization of *Aotus* chromosome nomenclature with description of the 2n = 49–50 karyotype and that of a new hybrid. *J. Hum. Evol.* 9: 461–482.

Ridley, M. 1996. *Evolution.* 2nd edition. Blackwell Science, Cambridge, Massachussets.

Rieckman, K. H., J. E. K. Mrema, P. H. Marshall and D. M. Hafner. Undated. Breeding of *Aotus* monkeys for human malaria research. Unpublished manuscript.

Ryder, O. A., A. T. Kumamoto, B. S. Durraand and K. Benirschke. 1989. Chromosomal divergence and reproductive isolation in dik-diks. In: *Speciation and Its Consequences.* D. Otte and J. A. Endler (eds.), pp.208–225. Sinauer Associates, Inc., Sunderland, Massachusetts.

Rylands, A. B. and D. Brandon-Jones. 1998. Scientific nomenclature of the red howlers from the northeastern Amazon in Brazil, Venezuela, and the Guianas. *Int. J. Primatol.* 19(5): 879–905.

Rylands, A. B., H. Schneider, A. Langguth, R. A. Mittermeier and C. P. Groves. 2000. An assessment of the diversity of New World primates. *Neotrop. Primates* 8(2): 61–93.

Santos-Mello, R. and M. T. de Mello. 1986. Cariótipo de *Aotus trivirgatus* (macaco-da-noite) das proximidades de Manaus, Amazonas. Nota preliminar. In: *A Primatologia no Brasil – 2*, M. T. de Mello (ed.), p.388. Sociedade Brasileira de Primatología, Brasília.

Setoguchi, R. and A. L. Rosenberger. 1987. A fossil owl monkey from La Venta, Colombia. *Nature, Lond.* 326: 692–694.

Simpson, J. S. and A. C. Jones. 1982. Hybrid production in owl monkeys (*Aotus trivirgatus*). *Lab. Anim.* 16: 71–72.

Taylor, D. W. and W. A. Siddiqui. 1978a. Comparative mitogen responses of lymphocytes. *Lab. Anim. Sci*. 28(5): 567–574.

Taylor, D. W. and W. A. Siddiqui. 1978b. The effect of *falciparum* malaria infection on *in vitro* mitogen response of spleen and periferical blook lymphocytes from the owl monkey. *Am. J. Trop. Hyg.* 27: 738–742.

Taylor, D. W. and W. A. Siddiqui. 1979. Susceptibility of owl monkeys to *Plasmodium falciparum* infection in relation to location of origin, phenotype and karyotype. *J. Parisitol.* 65(2): 267–271.

Thorington, R. W., Jr. and R. E. Vorek. 1976. Observations on the geographic variation and skeletal development of *Aotus. Lab. Anim. Sci.* 26(6): 1006–1021.

Torres, O. M., S. Enciso, F. Ruiz, E. Silva and I. Yunis. 1998. Chromosome diversity of the genus *Aotus* from Colombia. *Am. J. Primatol.* 44(4): 255–275.

Van Roosmalen, M. G. M., T. van Roosmalen and R. A. Mittermeier. 2002. A taxonomic review of the titi monkeys, genus *Callicebus* Thomas, 1903, with the description of two new species, *Callicebus bernhardi* and *Callicebus stephennashi* from Brazilian Amazonia. *Neotrop. Primates* 19(suppl.): 1–52.

White, M. J. D. 1973. *Animal Cytology and Evolution* (3rd edition). Cambridge University Press: Cambridge.

White, M. J. D. 1978. *Modes of Speciation.* W. H. Freeman, San Francisco.

Wilson, A. C., G. L. Bush, S. M. Case and M. -C. King. 1975. Social structuring of mammalian populations and rate of choromosomal evolution. *Proc. Natl. Acad. Sci. U.S.A.* 72: 5061–5065.

Woodruff, D. S. 2004. Noninvasive genotyping and field studies of free-ranging nonhuman primates. In: *Kinship and Behavior in Primates*, B. Chapais and C. M. Berman (eds.), pp.46–68. Oxford University Press, Oxford.

Wright, S. 1969–1978. *Evolution and Genetics of Populations*. 4 vols. The University of Chicago Press, Chicago.

Yunis, E., O. M. Torres de Caballero and C. Ramírez 1977. Genus *Aotus* Q-and G-band karyotypes and natural hybrids. *Folia Primatol.* 27: 165–177.

Authors' addresses:

Thomas R. Defler, Departamento de Biología, Universidad Nacional de Colombia, Bogotá, Colombia. E-mail: <thomasdefler@gmail.com>.

Marta L. Bueno, Departamento de Biología, Universidad Nacional de Colombia, Bogotá, Colombia. E-mail: <mlbuenoa@unal.edu.co>.

Received for publication: October 2004
Revised: September 2007

Primate Conservation 2007 (22): 71–77

The Status of Lemur Species at Antserananomby: An Update

Elizabeth A. Kelley[1], Robert W. Sussman[1], Kathleen M. Muldoon[2]

[1] Department of Anthropology, Washington University, St. Louis, MO, USA
[2] Department of Anatomy, Dartmouth Medical School, Hanover, NH, USA

Abstract: Antserananomby Forest was once a refuge of the rare deciduous flora of western Madagascar. Through primate studies that were conducted in the late 1960s and early 1970s, it was discovered that the primate density and diversity in this forest was greater than any other known in western Madagascar. Although research at Antserananomby ceased in the 1980s, satellite images from 2000 indicated that the forests were still intact. In August 2004, we returned to Antserananomby to determine whether this site could feasibly become a location for long-term primate research and to assess whether efforts should be initiated to establish Antserananomby Forest as a national reserve. In addition to general assessments, we conducted diurnal primate surveys using the line transect sampling method. We found that the 8.6 ha of Antserananomby Forest have since been cleared. Due to recent demographic and attitudinal changes in the local human population, the surrounding forests are regularly burned, and at least some of the lemur species are hunted with lemur traps, dogs, and sling shots. In addition, the population densities of especially *Eulemur fulvus rufus* and *Lemur catta*, but also of *Propithecus verreauxi verreauxi, Phaner furcifer*, and *Lepilemur ruficaudatus*, have declined appreciably. We conclude that although all of the primate fauna appear to be present, the current rate of deforestation at Antserananomby is unsustainable. If no action is taken to conserve what is left and restore what has been lost, then the forests in this region and their inhabitants are likely to soon disappear.

Key Words: Madagascar; deforestation; sacred forests; critically endangered ecoregion

Introduction

The region of Antserananomby is 12 km north of the Mangoky River, 21.7°S, 44.1°E, in the Toliara province of Madagascar (Fig. 1). In the 1970s, one of the forests, Antserananomby, was the site of a comparative primate ecology study and several primate surveys (Petter *et al*. 1971; Sussman 1972; Richard 1978). Antserananomby was an alluvial forest of dense, mainly deciduous vegetation with trees reaching a height of 25 to 30 m. The dominant tree was *Tamarindus indica*, but species such as *Acacia rovumae*, *Ficus soroceoides*, *Terminalia mantaly*, *Quivisianthe papinae*, and *Vitex beraviensis* were also relatively common (Sussman 1972).

Within the last thirty years, there has been very little contact between the villagers of Antserananomby and researchers. In addition to Sussman, the villagers remember Otto Appert, a Swiss missionary and naturalist who lived close to the area for many years. Appert produced multiple publications on bird species in the region (for example, Appert 1968, 1970a, 1970b, 1980), and one broad diurnal primate survey (Appert 1966). One of the main reasons so few other researchers have conducted studies in this area is that the entire region north of the Mangoky River becomes an island throughout the austral summer, when the Mangoky and Morondava rivers swell from the rains. In addition, the ability to reach Antserananomby has become increasingly problematic with the region's continuous decline in infrastructure (Sussman *et al*. 2003).

Despite its inaccessibility, Antserananomby has long been perceived as a site of great ecological importance. Specific to the primate fauna, Antserananomby has been the only forest found to contain all of the lemur species known to exist in this region of western Madagascar [Sussman, unpubl. data]. Moreover, the densities of these populations have been reported as exceptionally high. When A. Schilling and Sussman conducted surveys on *Lepilemur ruficaudatus* (red-tailed sportive lemurs) and *Phaner furcifer* (western fork-marked lemur) in the late 1960s, they found densities of 260 individuals/km² and at least 550 individuals/km² respectively (Petter *et al*. 1971). Similarly, Sussman (1972, 1974) observed that *Lemur catta* lived in densities of 214 individuals/km² and that *Eulemur* *fulvus rufus* lived in densities of 1,120 individuals / km^2. Both densities are the highest ever recorded for any unprovisioned *L. catta* and *E. f. rufus* populations (Sussman 1972; Gerson 1999; Overdorff *et al.* 1999; Sussman *et al*. 2006). Last, in 1974, A. Richard accompanied Sussman to Antserananomby Forest and identified 86 *Propithecus verreauxi verreauxi* in mean group sizes of 7.8 (Richard 1978), with a conservative density estimate of 860 individuals/km^2. These numbers are the highest mean group size and density numbers recorded for these taxa (Table 1).

At the time of these studies, it was not only the researchers who recognized the value of Antserananomby Forest. The people of this region were also aware of Antserananomby Forest's richness and would mention this forest whenever they were asked about local plants or animals. Hunting was forbidden within its boundaries by the inhabitants of the neighboring village (Antserananomby) because it was perceived as a sacred site (Sussman 1972).

Figure 1. Location of Antserananomby.

In an effort to conserve the area's unique flora and fauna, Sussman and colleagues Ian Tattersall and Joelisoa Ratsirarson recently planned to begin the process to establish Antserananomby Forest and the surrounding forests as a national reserve. These plans were encouraged by satellite images from 2000, which indicated that the forests of Antserananomby, including Antserananomby Forest, were still intact (Sussman *et al.* 2003). In 2001 and 2004, surveys ware conducted to ground truth the information conveyed by the satellite images. During our surveys, however, we found that conditions in the region had changed radically since the 1970s – 1980s. A number of major socio-economic changes had transformed the region, including the immigration of people who did not respect the taboos (*fadys*) of the previous local inhabitants and the introduction of new crops. In this paper, we present a vivid example of how drastic changes can occur within a very short period of time, forever eliminating unique ecological communities and habitats. Many of the extremely rich but small, mainly undisturbed, natural habitats are not perpetuated as recognized protected reserves but, instead, by the beliefs and practices of the local people (Smith 1997; Clark *et al.* 1998; Golding and Folke 2000; Harpet *et al*. 2000; Casse *et al*. 2004; Bodin *et al*. 2006; Green *et al*. unpubl. ms.). A greater attempt must be made to protect these areas. As stated by Smith (1997: pp.438 & 440) "It is evident that in Madagascar, as in many countries, reserves have been primarily located in areas unsuitable — or least suitable — for alternative use and development. This strategy is likely to have caused the extinction of many species and the loss of some of the best examples of Western dry forest."

Methods

Earlier censuses were conducted at Antserananomby by Sussman and colleagues in 1970 and 1974. In 1970, all groups of *L. catta* and *E. f. rufus* living within the 9 – 10 ha gallery forest at Antserananomby were censused weekly or biweekly between July and September. There were 12 groups of red-fronted lemur with a total of approximately 112 animals, and 1 group of ringtailed lemurs containing 19 individuals (Sussman 1972). In 1974, all groups of *P. v. verreauxi* inhabiting the same forest were identified and then censused repeatedly by A. Richard and R. W. Sussman during the month

Table 1. Density estimates of *Propithecus v. verreauxi* and *Eulemur fulvus rufus* in the surrounding forests of the former site of Antserananomby.

	No. of inds. observed	No. of inds. analyzed	Transect width m	Mean group size	95% CI of mean group size range	Mean ind. per km^2	95% CI of inds. per km^2	Pop. densities from previous studies in SW Madagascar[1]
P. v. verreauxi	134	89	59	3.6	3.2 – 4.1	49.0	36.0 – 66.7	80 – 550 [2]
E. f. rufus	58	47	25	2.7	2.2 – 3.4	24.0	15.4 – 37.0	90 – 1120 [3]

[1] Previous estimates of ringtailed lemur density in undisturbed forest are 75 – 300 individuals per km^2 (Sussman *et al.* 2006).
[2] Richard (1978), Jolly *et al.* (1982), Richard *et al.* (1997).
[3] Smith (1991), Sussman (2003).

of July. There were 10 groups with a total of 58 individuals (Richard 1978). The forest was in a circumscribed area with a relatively low continuous canopy with exceptional visibility, and groups were easily observed and censused.

In August 2004, Kelley and Muldoon revisited Antserananomby to 1) determine whether this site could feasibly become a location for long-term ecological research and to 2) assess whether efforts to establish Antserananomby Forest as a national reserve should continue. In addition, we conducted a diurnal primate survey using Buckland *et al.*'s (2001) line-transect sampling method (see also Burnham and Anderson 1976; Burnham *et al.* 1980). This method was chosen over other methods, such as point transects, because line transect surveys are ideal for animals such as primates that 1) typically occur in low densities, 2) have large home ranges, and 3) are difficult to detect unless disturbed (Whitesides *et al.* 1988; Buckland *et al.* 2001; Ross and Reeve 2003). Since the gallery forest at Antserananomby no longer existed, the methods used in earlier years were no longer feasible. Permission to conduct this study was granted through the University of Antananarivo. The data collection methods are in compliance with the legal requirements for ecological research in Madagascar. Here we report on the census data collected on the diurnal lemur species in 2004.

Data collection

Data collection for the line-transect surveys took place from 8 August 2004 to 27 August 2004. A total of 122 hours were spent collecting line transect data within a total area of 5.9 km². The hours of data collection coincided with the diurnal/cathemeral lemurs' peak activity (Sussman 1972; Ganzhorn 1995; Müller *et al.* 2000). Morning data were collected from 06:30 to 12:30. At 1500, we would survey a different forest fragment because it minimized the risk that the same group would be counted twice in the same day (Ross and Reeve 2003). We collected afternoon data until approximately 18:00 hr. For each lemur sighting, we collected the following data: a) the time of sighting, b) Geographic Positioning System (GPS) readings (latitude, longitude, elevation, accuracy), c) the distance between us and the individual or central member in the group of lemurs, d) the number of observed adults and subadults, e) the initial canopy height of the lemurs, f) the compass direction the team was traveling when the lemur(s) were spotted, g) the compass direction of the lemur(s) in relation to the field team, and h) the compass direction the lemur(s) were traveling if they were moving when seen. Notes on general behavior were also recorded *ad libitum.* Only actual sightings were counted (Ganzhorn 1995; Müller *et al.* 2000). If we suspected that a group or individual had already been counted, we did not record that sighting.

Data analysis

GPS data on lemur sightings were plotted on a LANDSAT 7 ETM + image to indicate where these groups were found relative to: 1) the Ianandranto River, the only water source, 2) villages, and 3) other landmarks. Measurement errors were corrected by referring to notes on landscape features that fell within the accuracy ranges measured by the GPS.

Density estimates for *P. v. verreauxi* and *E. f. rufus* were analyzed using Distance 5.0 Beta 5 (Thomas *et al.* 2005). The sample size of *L. catta* was too low for this analysis (Buckland et al. 2001). Prior to density analyses, sightings distance data were visualized in box plots and histograms using SPSS 11.5. Based on these results, the observation width for *P. v. verreauxi* was truncated to 59 m, and the observation width for *E. f. rufus* was truncated to 25 m. Density estimates were obtained using the uniform + cosine (Fourier series) estimator (Crain *et al.* 1979; Burnham *et al.* 1980; Buckland *et al.* 2001). Group size and density estimates were the same regardless of whether group size estimates were obtained using mean cluster size or the size-regression method.

Results

Upon arrival at Antserananomby, it immediately became apparent that a great deal of change had occurred in the region since the 1970s (Fig. 2). First, the site of the old Antserananomby village is now barren savanna. Second, Antserananomby Forest is gone. Third, lemur traps, of which we observed four, were found within the remaining fragmented forests.

Seven of the eight lemur species that were known to inhabit Antserananomby Forest were observed during the survey, however: *E. f. rufus*, *L. catta*, *L. r. ruficaudatus*, *Microcebus murinus*, *Mirza coquereli, P. furcifer*, and *P. v. verreauxi.* The only species that was not sighted, *Cheirogaleus medius,* hibernates during the austral winter (Sussman 1972; Hladik *et al.*, 1980).

Since surveys were conducted only during the day, density estimates were not obtained for the nocturnal species. Among the three diurnal/cathemeral species, *P. v. verreauxi* was the most frequently sighted and widely dispersed. Over half of the 202 group sightings (which sometimes consisted of a single individual) were of Verreaux's sifaka (n = 134), and four sifaka females were observed with infants. While the mean observed group size for this species was 3.6 (Table 1), one group contained 12 individuals. This species could be observed as far as 250 m away in the hillier areas of the region. In addition, *P. v. verreauxi* was the only species to be observed in groups of three or more within 500 m of Antserananomby village. As of 2004, we estimate the population density of Verreaux's sifaka at Antserananomby to be 49 individuals/km². The second most frequently sighted of the three species was *E. f. rufus* (n = 58). These sightings often consisted of a lone individual or a pair, although the average group size was slightly higher (Table 1). The population density of this species was estimated to be 23.9 individuals/km². *Lemur catta* was only observed 10 times. With the exception of a troop that we sighted almost 125 m away, the species reacted to our presence every time. Consequently, half of the *L. catta* sightings were of a single individual (n = 5).

Most notable during the surveys were the observations of two mixed species groups. In this context, we have defined

Figure 2. Comparison of the general Antserananomby area. Figure 2a was taken on the dried Beangily river bed and is an image of Antserananomby Forest in 1970. Figure 2b is a view of the same general area in 2004 as it looked from the bank of the Beangily River. Notice the fire smoldering across the remaining forest fragments in the 2004 photograph.

mixed-species groups as groups with individuals of two species that travel, feed, and/or rest together as would one with individuals of a single species. Both groups that met this definition were seen together more than once over a 24-hour time period. The first group, of five Verreaux's sifakas and three red-fronted lemurs, was observed in a continuous canopy forest fragment just five minutes from camp. This forest fragment was near a burning forest patch, and parts of the forest near the camp were also smoldering. One of the two *E. f. rufus* infants that were sighted during the survey was observed in this group. The second mixed group was of seven red-fronted lemurs and eight ringtailed lemurs. It was seen traveling and feeding near the Ianadranto River, the only running water in the region during the austral winter. This mixed-species group had the largest number of *E. f. rufus* found near this river, and the only young ringtailed lemur seen throughout the study. Last, it is of interest to note that the second time the second group was observed, it was seen traveling through the exact same location with the same number of individuals, but with a single Verreaux's sifaka tailing the group.

Discussion

Primate survey

Based on six years of observations, Appert (1966) wrote that the most widespread and frequently sighted of the diurnal primate species in the Mangoky/Antserananomby region was Verreaux's sifaka, and the least frequently sighted was the red-fronted lemur. Although it does not appear that Appert surveyed our area, our results are relatively consistent. Since in western Madagascar red-fronted lemurs are restricted largely to the dense middle canopies of deciduous and gallery forests (Sussman 2003; Müller *et al*. 2000), habitat type may be an important reason why the red-fronted lemur had a high local density at Antserananomby Forest but not elsewhere.

However, the results of our survey clearly indicated that the overall densities of red-fronted lemurs and ringtailed lemurs have declined appreciably within the last few decades. Even Verreaux's sifaka, which appeared to be faring somewhat better relative to the other two species in this region, was found at a much lower density than is typical for this species (49 individuals/km² compared with 80–550 individuals/km², Table 1), when approximately 30 years earlier it had the highest recorded density for sifakas (Sussman 2003). Similarly, although we did not systematically conduct nocturnal surveys, due to the complete loss of rich gallery forest habitat where the high density of these species was observed in earlier surveys, there is no doubt that the *L. ruficaudatus* and *P. furcifer* populations have also declined markedly. These two species are largely restricted to undisturbed primary canopy forests in this region (Smith *et al*. 1997, Sussman pers. obs.).

Last, we believe that the mixed species groups are the residual results of crowding (Hagan *et al*. 1996). In the example of the sifaka and red-fronted lemur group, fires were burning in the surrounding forest fragments. It is likely that what was observed was a demographic "concussion" in which individuals from both species were forced to reside within the same fragmented forest patch (Hagan *et al*. 1996). This is the only group of red-fronted lemurs that was found near camp. Similarly, since running drinking water is very important for red-fronted lemurs (Scholz and Kappeler 2004); it is of note that the mixed species group that inhabited the fragment by the river had the largest number of *E. f. rufus*. It is possible that cohabitation with *L. catta* was the best opportunity these red-fronted lemurs had for gaining access to the water.

Causes of the recent changes at Antserananomby

Appert (1966) noted unsustainable rates of deforestation within the Mangoky/Antserananomby region as early as the 1960s. Antserananomby Forest was always an exception, however, because it was protected by the local villagers (Sussman, 1972). There is evidence that the causes for the forest's recent demise are human migration and the introduction of maize.

In the late 1970s, many of the original inhabitants of Antserananomby Village died from an epidemic disease, and the village was abandoned (Sussman unpubl. data), and the town of Vondrove, which used to be the closest center of economic activity to Antserananomby, also started to decline (Sussman *et al*. 2003). Today, all that remains of Vondrove is a small village. The Antserananomby area, which has been sparsely inhabited for many years, has recently been resettled by immigrants who lack the restrictions on clearing the forest and hunting the lemurs that were maintained by earlier inhabitants (R. W. and L. K. Sussman, unpubl. data). Given this, it is interesting to note that Verreaux's sifaka, the largest and most visible species at this site, is also the only species that could readily be found resting there, and at ease in close proximity to the village.

In addition, maize is a new crop to Antserananomby that was not present during the 1970s research (R. W. and L. K. Sussman, unpubl. data). Unlike crops such as cassava and sweet potatoes, maize requires *hatsaka* (Horning 2000; Horning 2003; Sussman *et al.* 2003). *Hatsaka* is a type of slash-and-burn agriculture in which forests are cut in one to six ha patches and burned (Ferguson 2002; Sussman *et al*. 2003; Casse *et al*. 2004). As this agricultural practice is technically illegal in Madagascar, *hatsaka* is more commonly practiced in isolated areas (Jarosz 1993; Casse *et al.* 2004]. Economists who have studied the effects of maize cropping south of the Antserananomby region have found that *hatsaka* is the primary reason for forest clearance [Casse *et al*. 2004]. During our 2004 survey, *hatsaka* was the major crop in the area surrounding Antserananomby. Although maize was not yet being grown on the plot that was once the Antserananomby gallery forest, future maize cropping is undoubtedly the reason for its recent clearance (Bernard Tsiefatao pers. comm.).

Conclusions

In the volume accompanying the vegetation map published in 1965, Humbert and Cours Darne described the type of forest represented by Antserananomby Forest as almost totally destroyed with only rare vestiges still remaining (Humbert, 1965, p.70). Moreover, deciduous dry forests in Madagascar have declined from 12.5% of the original cover in 1950 to only 2.8% in 1990 (Smith, 1997, p.426). Since Antserananomby Forest and some of the remaining forests were likely included in the 1990 percentage, its recent disappearance suggests that current estimates of remaining dry forests in Madagascar are even smaller.

Since forest regeneration in southwest Madagascar is slow to non-existent once large portions of a forest have been cleared (Sussman *et al*. 2003; Casse *et al*. 2004), future conservation efforts at Antserananomby could serve as a case study for whether an environment that has rapidly degenerated in recent years can be repaired. In the best case scenario, future research with applied conservation efforts at Antserananomby could result in environmentally sustainable sustenance alternatives for the local human population, the protection of lemur species, and the initiation of collaborative interests among the local community, the Malagasy government, and the scientific community. Yet achieving these aims will be a major challenge. Logistically, this area is often inaccessible for nine months of the year and a follow-up attempt to visit this site in 2005 failed, partly because of its remoteness. In addition, it is possible that the densities of some of the primate species, most notably red-fronted lemurs and ringtailed lemurs are already too low for successful recovery. Yet if the remaining forests in the region of Antserananomby disappear, then the region's villagers will likely have to move to forested areas with fertile land, if any still exist, where the destructive processes that are occurring at Antserananomby will be perpetuated. Conserving what is left of the region's biodiversity will not only benefit the immediate area, it will also benefit three of the world's most unique and critically endangered ecosystems — the spiny and succulent xerophytic forests of southern Madagascar, the rapidly disappearing deciduous forests of the northwest, and especially the extremely rare, lush forests of the small transition area that contains the unique flora and fauna between the two.

The loss of the gallery forest of Antserananomby offers another example of the importance of local beliefs and practices, and of "sacred forest" in the preservation of small but extremely rich and unique ecological communities and habitats throughout Madagascar and elsewhere. In the region between the Morondava and Mongoky rivers, we are observing a rich and unique habitat disappear before our eyes. The question is whether anything can, or will, be done to prevent this irreversible tragedy.

Acknowledgments

Transportation, letter of intent, and permission to conduct this research was provided by the University of Antananarivo's School of Agronomy, notably by Prof. Joelisoa Ratsirarson. We warmly thank him for his support and assistance. Ony Andrianasolondraibe played an integral role at the field site as translator, and her assistance in collecting the data is greatly appreciated. We also thank Brad Kelley and two anonymous reviewers who gave us very useful suggestions. This project was supported in part by the Washington University Anthropology Summer Travel Grant [EAK]. We wish to thank Washington University's Graduate School of Arts and Sciences for providing this funding. This project adhered to the research protocols of Madagascar.

Literature Cited

Appert, O. 1966. La distribution geographique des lemuriens diurnes de la region du Mangoky au sud-ouest de Madagascar. *Bull. l'Académie Malgache* 44: 43 – 45.

Appert, O. 1968. Neues zur lebensweise und verbreitung des kurols, *Leptosomus discolour* (Hermann). *J. Ornitologie* 109: 116 –126.

Appert, O. 1970a. Zur biologie der Vangawürger (Vangidae) südwest-Madagaskars. *Der Ornithologische Beobachter* 67: 101–133.

Appert, O. 1970b. Zur biologie einiger kua-arten Madaskars. *Zoologische Jahrbu¨cher. Abteilung für System* 97: 424–453.

Appert, O. 1980. Erste farbaufnahmen der rachenzeichnung junger kuas von Madagaskar (Cuculi, Couinae). *Der Ornithologische Beobachter* 77: 85–101.

Bodin, Ö, M. Tengö, A. Norman, J. Lundberg and T. Elmqvist. 2006. The value of small size: Loss of forest patches and ecological thresholds in southern Madagascar. *Ecol. Applications* 16: 440–451.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers and L. Thomas. 2001. *Introduction to Distance Sampling*. Oxford University Press, Oxford.

Burnham, K. P. and D. R. Anderson. 1976. Mathematical models for nonparametric inferences from line transect data. *Biometrics* 32: 325–336.

Burnham, K. P., D. R. Anderson and J. L. Laake. 1980. Estimation of density from line transect sampling of biological population. *Wildl. Monog*. 72: 1–202.

Casse, T., A. MilhØj, S. Ranaivoson and J. R. Randriamanarivo. 2004. Causes of deforestation in southwestern Madagascar: What do we know? *For. Policy. Econ*. 6: 33–48.

Clark, C. D., S. M. Garrod and M. Parker Pearson. 1998. Landscape archaeology and remote sensing in southern Madagascar. *Int. J. Remote Sensing* 19: 1461–1477.

Crain, B. R., K. P. Burnham, D. R. Anderson and J. L. Laake. 1979. Nonparametric estimation of population density for line transect sampling using Fourier series. *Biom. J.* 21: 731–748.

Ferguson, B. 2002. *Opportunities for Community Based Conservation in the Androy Region of Madagascar's Southern Spiny Forest*. The Tandroy Conservation Trust, Ifotaka, Androy, Madagascar. 25pp.

Ganzhorn, J. U. 1995. Low-level forest disturbance effects on primary production, leaf chemistry, and lemur populations. *Ecology* 76: 2084–2096.

Gerson, J. S. 1999. Social relationships in wild red-fronted lemurs (*Eulemur fulvus rufus*). Doctoral dissertation, Duke University, Durham, NC.

Golding, J. and C. Folke. 2000. The taboo system: lessons about informal institutions for nature management. *The Georgetown International Law Review* 12: 413–445.

Green, G. M., R. W. Sussman and S. P. Sweeney. Undated. Stability in a convolving mosaic of land-cover change episodes: conservation by sacred forests in southwestern and southern Madagascar. Unpublished manuscript.

Hagan, J. M., W. M. V. Haegen and P. S. McKinley. 1996. The early development of forest fragmentation effects on birds. *Conserv. Biol.* 10: 188–202.

Harpet, C., J. Vololoniaina and C. M. Hladik. 2000. Sacred lemur sites in the Sakalava region of north-west Madagascar; updated data and implications for sustained development and conservation. *Rev. d'Ecol., La Terre et la Vie* 55: 291–295.

Hladik, C. M., P. Charles-Dominique and J. J. Petter. 1980. Feeding strategies of five nocturnal prosimians in the dry forest of the west coast of Madagascar. In: *Nocturnal Malagasy Primates: Ecology, Physiology, and Behavior*, P. Charles-Dominique, H. M. Cooper, A. Hladik, C. M. Hladik, E. Pages, G. F. Pariente, A. Petter-Rousseaux, J. J. Petter (eds.), pp.41–73. Academic Press, New York.

Horning, N. R. 2000. Explaining compliance with rules governing common-pool forest resource use and conservation: dynamics in Bara country, southwestern Madagascar. *Meetings paper for the International Association for the Study of Common Property*, Bloomington, Indiana 31 May – 4 June 2000. 29pp. Available at: <http://dlc.dlib.indiana.edu/archive/00000569/00/horningn052300.pdf>. Accessed 26 January 2007.

Horning, N. R. 2003. How rules affect conservation outcomes. In: The Natural History of Madagascar, S. M. Goodman and J. P. Benstead (eds.), pp.146–153. The University of Chicago Press, Chicago, IL.

Humbert, H. 1965. Description des types de végétation. In: *Notice de la Carte Madagascar*, H. Humbert and G. Cours Darne (eds.), pp.46–78. L'Institut Francais de Pondichery, Pondichery.

Jarosz, L. 1993. Defining and explaining tropical deforestation: shifting cultivation and population growth in colonial Madagascar (1896–1940). *Econ. Geogr*. 69: 366–379.

Jolly, A., H. Gustafson, W. L. R. Oliver and S. M. O'Connor. 1982. *Propithecus verreauxi* population and ranging at Berenty, Madagascar. 1975 and 1980. *Folia Primatol.* 39: 124–144.

Müller, P, A. Velo, E. O. Raheliarisoa, A. Zaramody and D. J. Curtis. 2000. Surveys of sympatric lemurs at Anjamena, north-west Madagascar. *Afr. J. Ecol*. 38: 248–257.

Overdorff, D. J., P. T. Merenlender, A. Telo and Z. A. Forward. 1999. Life history of *Eulemur fulvus rufus* from 1988–1998 in southeastern Madagascar. *Am. J. Phys. Anthropol.* 108: 295–310.

Petter, J. J., A. Schilling and G. Pariente. 1971. Observations eco-ethologiques sur deux lemuriens Malgaches nocturnes: *Phaner furcifer* et *Microcebus coquereli. Extrait de la Terre et la Vie* 3: 287–327.

Richard, A. F. 1978. *Behavioral Variation: Case Study of a Malagasy Lemur*. Associated University Presses, Inc., Cranbury, NJ.

Richard, A. F., P. Rakotomanga and M. Schwartz. 1993. Dispersal by *Propithecus verreauxi* at Beza Mahafaly, Madagascar. *Am. J. Primatol*. 30: 1–20.

Ross, C. and N. Reeve. 2003. Survey and census methods. In: *Field and Laboratory Methods in Primatology*, J. M. Setchell and D. J. Curtis (eds.), pp.90–109. Cambridge University Press, Cambridge, UK.

Scholz, F. and P. M. Kappeler. 2004.Effects of seasonal water scarcity on the ranging behavior of *Eulemur fulvus rufus. Int. J. Primatol.* 25: 599–613.

Smith, A. P. 1997. Deforestation, fragmentation, and reserve design in western Madagascar. In: *Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities*, W. F. Lawrence and R. O. Bierregaard Jr. (eds.), pp.415–441. The University of Chicago Press, Chicago, IL.

Smith, A. P., N. Horning and Moore, D. 1997. Regional biodiversity planning and lemur conservation with GIS in western Madagascar. *Conserv. Biol.* 11: 498–512.

Sussman, R. W. 1972. An ecological study of two Madagascan primates: *Lemur fulvus rufus* (Audebert) and *Lemur catta* (Linnaeus). Doctoral dissertation, Duke University Durham, NC.

Sussman, R. W. 1974. Ecological distinctions in sympatric species of *Lemur*. In: *Prosimian Biology*, R. D. Martin, G. A. Doyle, A. C. Walker (eds.), pp.75–108. Duckworth, London.

Sussman, R. W. 2003. *Primate Ecology and Social Structure*, Vol. 1. Pearson Custom Publishing, Needham Heights, MA.

Sussman, R. W., G. M. Green, I. Porton, O. L. Andrianasolondraibe and J. Ratsirarson. 2003. A survey of the habitat of *Lemur catta* in southwestern and southern Madagascar. *Primate Conserv.* (19): 32–57.

Sussman, R. W., S. Sweeney S, G. M. Green, I. Porton, O. L. Andrianasolondraibe and J. Ratsirarson. 2006. A preliminary estimate of *Lemur catta* population density using satellite imagery. In: *Ring-tailed Lemur Biology*, A. Jolly, R. W. Sussman, N. Koyama, and H. R. Rasamimanana (eds.), pp.16–31. Springer, New York.

Thomas, L., J. L. Laake, S. Strindberg, F. F. C. Marques, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. L. Hedley, J. H. Pollard, J. R. B. Bishop and T. A. Marques. 2005. Distance 5.0. Release Beta 5. Research Unit for Wildlife Population Assessment, University of St. Andrews, St. Andrews, UK: Available at: <http://www.ruwpa.st-and.ac.uk/distance/>. Accessed 14 February 2007.

Whitesides, G. H., J. F. Oates, S. M. Green and R. P. Kluberdanz. 1988. Estimating primate densities from transects in a West African rain forest: A comparison of techniques. *J. Anim. Ecol*. 57: 345–367.

Authors' addresses:
Elizabeth A. Kelley and Robert W. Sussman, Department of Anthropology, Campus Box 1114, 112 McMillan Hall, Washington University, One Brookings Drive, St. Louis, MO, 63130-4899, USA. E-mail:<eakelley@artsci.wustl.edu>.
Kathleen M. Muldoon, Department of Anatomy, Dartmouth Medical School, Hanover, New Hampshire 03755, USA.

Received for publication: 12 March 2007
Revised: 29 June 2007

Primate Conservation 2007 (22): 79–87

Habitat Utilization of Blue-eyed Black Lemurs, *Eulemur macaco flavifrons* (Gray, 1867), in Primary and Altered Forest Fragments

Nora Schwitzer[1], Guy H. Randriatahina[2], Werner Kaumanns[1], Dirk Hoffmeister[3]
and Christoph Schwitzer[4]

[1] *WG Primatology, Zoologischer Garten Koeln, Koeln, Germany*
[2] *Département de Biologie Animale, Faculté des Sciences, Université d'Antananarivo, Antananarivo, Madagascar*
[3] *Department of Geography, University of Cologne, Koeln, Germany*
[4] *Bristol Zoo Gardens, Clifton, Bristol, UK*

Abstract: Lemurs of the genus *Eulemur*, including *Eulemur macaco*, are usually considered to be generalized, opportunistic frugivore-folivores, with a high degree of ecological flexibility. They are thus regarded as being able to adapt to a range of habitat types, and therefore less affected by the loss of primary forest habitat. In this study we assessed the suitability of altered forest habitat for the blue-eyed black lemur (*Eulemur macaco flavifrons*) on the Sahamalaza Peninsula (northwest Madagascar). Our aims were to identify structural vegetation characteristics that are important for the taxon, and to compare their availability in a primary and a secondary forest fragment. Home range size and habitat use of four groups of *E. m. flavifrons*, the availability of food resources and sleeping trees, as well as plant biodiversity and plant communities were investigated. The forest fragments harboring *E. m. flavifrons* groups differed in a number of structural variables. The density of food and resting trees was higher in primary forest. Home range size of blue-eyed black lemurs was larger in secondary forest. The lemurs used both habitat types differently. In the primary forest fragment the number of plant families and trees used for feeding or resting was higher. The results indicate that although *E. m. flavifrons* seems to be an edge-tolerant subspecies, the taxon nevertheless shows some degree of habitat specialization. The lower density of blue-eyed black lemurs in the secondary forest fragment indicates that this type of habitat is only of limited value to *E. m. flavifrons*.

Key words: Madagascar, *Eulemur macaco flavifrons*, primary forest, secondary forest, habitat generalist, habitat specialist

Introduction

The genus *Eulemur* is medium-sized, with a weight of 1.0–2.5 kg, and occurs in almost all forested areas of Madagascar (Glander *et al.* 1992; Terranova and Coffman 1997). These lemurs are often considered to be generalist, opportunistic frugivore-folivores (for example, Overdorff [1988] for *E. rubriventer*; Vasey [1997] for *E. albifrons*; Mittermeier *et al.* 2006). It is commonly suggested that these species show a high degree of ecological flexibility and can adapt well to different habitat types, including secondary forest and plantations (for example, Sussman and Tattersall [1976] for *E. mongoz*; Mittermeier *et al.* 2006). Some species, such as *E. sanfordi*, even appear to favor secondary forests (Freed 1996). Such behavioral and ecological flexibility is also reported for some other lemur genera, for example by Irwin and Raharison (2006) for *Propithecus diadema*, and by Feistner and Mutschler (2000) for *Hapalemur occidentalis*. Despite these findings, however, there are still very few data on how different lemur species respond to habitat degradation and on whether different species can use regenerating or replanted forests (Ganzhorn 1987; Ganzhorn and Abraham 1991; Ganzhorn *et al.* 1997; Andrianasolo *et al.* 2006). This is because the resources which represent essential or limiting factors for different lemurs are poorly understood (Andrianasolo *et al.* 2006). Knowledge of these issues can have significant implications for conservation and natural resource management decisions. If a primate species shows a high degree of ecological flexibility, it will probably be less affected by the loss of its original habitat than one that relies on certain structural vegetation characteristics present only in certain forest types. Rendigs *et al.* (2003) emphasized the importance of microhabitat analyses for lemur conservation. Secondary forest is often of limited value to mouse lemurs (*Microcebus murinus*) as buffer zones or even corridors (Ganzhorn and Schmid 1998). According to Andrianasolo *et al.* (2006), more specialized lemurs may require specific habitat structures. Such habitat specialists select patches of usable habitat and there are higher population densities if suitable microhabitats are available. Habitat generalists, on the other hand, are not expected to differ in population density as a consequence of habitat structure and should not co-vary with the structure of different forest types.

The size of home ranges in the frugivorous and folivorous Lemuridae is generally highly variable and appears to depend on habitat type (Curtis and Zaramody 1998). Home ranges seem to be large in eastern rain forest habitats and in the southern xerophytic zone of Madagascar, whereas they appear to be smaller in the seasonal forests of western Madagascar (although group sizes of *Eulemur* taxa are similar in both habitats). According to Curtis and Zaramody (1998), this could imply a more abundant and perhaps uniform distribution of the main food resources in seasonal western forests throughout the year.

Home range size is frequently cited as influencing a species' ability to live and survive in a fragment (Lovejoy *et al*. 1986; Estrada and Coates-Estrada 1996; Chapman *et al*. 2003). Primate groups and densities appear to be smaller in secondary than in primary forests (for example, Estrada and Coates-Estrada 1995; McCann *et al*. 2003; Rodríguez-Toledo *et al*. 2003), which in turn suggests that a larger home range is necessary to sustain the same number of individuals in a secondary forest.

Blue-eyed black lemurs, *Eulemur macaco flavifrons* (Gray 1867), are found only in the semi-deciduous forests on, and just east of, the Sahamalaza Peninsula (Sofia region, northwest Madagascar). This is a transition zone between the Sambirano region in the north and the western dry deciduous forest region in the south. The forests in this area contain plant species typically found in dry forest as well as those from the wetter Sambirano domain (for example, various *Dyospyros* species, *Garcinia pauciflora*, *Plagioscyphus jumellei*, *Prociopsis hildebrandtii*, *Strychnos madagascariensis*, and *Trilepsium madagascariensis*; Birkinshaw [2004]). Today, *E. m. flavifrons* is only found in a few remaining and already highly fragmented stretches of primary and secondary forest in an area of about 2,700 km² south of the Andranomalaza, north of the Maevarano, and west of the Sandrakota rivers (Meyers *et al*. 1989; Rabarivola *et al*. 1991; Meier *et al*. 1996; Mittermeier *et al*. 2006). Schwitzer *et al*. (2005) estimated the *E. m. flavifrons* population of the Sahamalaza Peninsula to be between 2,780 and 6,950 individuals. Rakotondratsima (1999) stated that the population has shown a decline of 35.3% between 1996 and 1999, probably mainly due to habitat destruction (see also Andriamanandratra 1996). The underlying threat to *E. m. flavifrons* is the increasing pressure from human population expansion in Madagascar (Harcourt and Thornback 1990; Burney *et al*. 1997; Richard and O'Connor 1997; Andrianjakarivelo 2004), with an annual human population growth of 2.7% (Population Reference Bureau 2006, <http//:www.prb.org>).

The blue-eyed black lemur was classified as Critically Endangered (A2cd) by the IUCN in 1993 and again in 2005. To date, the ecology and behavior of the blue-eyed black lemur has neither been studied extensively in the wild nor in captivity, and the existing knowledge is thus either fragmented or anecdotal (Schwitzer and Kaumanns 2005).

Comparative studies of *E. m. flavifrons* living in habitats that differ in their degree of degradation might help to explain the ecological and behavioral flexibility of blue-eyed black lemurs. If *E. m. flavifrons* is a habitat generalist, as would be expected from studies of other *Eulemur* species, the lemurs should use primary and secondary forest similarly. If it is a habitat specialist, however, parameters such as population density and habitat use should differ in primary and secondary forests, and depending on varying degrees of human exploitation. Larger home ranges should be necessary for lemurs to find sufficient food resources in secondary, less suitable habitat if one assumes that home range size correlates with the distribution of food resources (Clutton-Brock and Harvey 1979; Robbins *et al.* 2006). In this study we describe differences in structural vegetation characteristics of a primary and a secondary forest fragment inhabited by different blue-eyed black lemur groups. We also compare the size and utilization of the groups' home ranges, as well as the use of vertical forest strata. The results are extrapolated to compare the availability and diversity of potential feeding and sleeping trees for *E. m. flavifrons* within these fragments, and thus to assess the suitability of altered habitat for the species.

Methods

Study site

The study was conducted in the Ankarafa Forest, in the UN Biosphere Reserve and National Park on the Sahamalaza Peninsula, and part of the Province Autonome de Mahajanga, NW Madagascar. It extends between 13°52'S and 14°27'S and 45°38'E and 47°46'E (WCS/DEC 2002). The Ankarafa Forest includes primary and secondary forest fragments, which are believed to accommodate one of the largest connected populations of blue-eyed black lemurs (Schwitzer *et al.* 2005). There are no larger connected areas of intact primary forest left on the Sahamalaza Peninsula, and even the remaining fragments of primary forest all show some degree of anthropogenic disturbance and/or edge effects.

The climate is strongly seasonal, with a cool, dry season from May to October and a hot, rainy season from November to April. Mean annual precipitation is 1,600 mm, with the highest rainfall in January and February. Temperature fluctuates around 28.0°C throughout the year, with a maximum average temperature of 32.0°C (November) and a minimum average of 20.6°C (August).

Habitat structure and forest characteristics

The point-centered quarter method was used to describe the habitats used by four different groups of blue-eyed black lemurs living in a primary and a secondary forest fragment, respectively (Ganzhorn *et al.* 1997; Ganzhorn 2002, 2003).

The primary forest fragment measured 0.13 km², and the secondary forest fragment 0.48 km². The fragments were separated from each other by a stretch of less than 1 km of grass savannah and shrub. They were considered to be representative of the forest structure in general. Sixty sample points were taken in each of two forest fragments on parallel perpendicular lines located at intervals of 15 m on a 105-m transect line. Distances between sample points along the perpendicular lines were chosen randomly. Each sample point represented the centre of four compass directions that divided the sample plot into four quarters. In each quarter the distance from the centre to the nearest tree ≥ 3.1 cm DBH (diameter at breast height) was measured. Trees < 3.1 cm DBH were not considered as being used by the lemurs and were therefore not measured. Altogether, 480 trees were sampled. Tree density per unit area ($A = 10{,}000$ m²) was then calculated as A/d^2, where d is the mean distance between the trees and the centre of the associated sample point.

Medians and upper and lower quartiles were calculated for DBH, tree height, crown diameter and height of the first branch in both forest fragments. We estimated the percentage of closure of the overstorey for each sample point by assigning the covered area on a photo taken from the ground to one of the following five categories: full closure, ¾ closure, ½ closure, ¼ closure, fully open. Because trees with lianas may be preferred as sleeping sites by lemurs (Rendigs *et al.* 2003), we also estimated the proportion of trees without lianas, with a single, or with several lianas growing up to the tree crown. As a measure of recent anthropogenic disturbance of the forest fragments, we noted the number of tree stumps visible from each sample point.

To compare the availability of larger food and resting trees (that could support an entire group of lemurs at the same time) in the primary and secondary forest fragments, we determined the minimum DBH of trees used for feeding and resting. Food and resting trees were defined as such trees supporting ≥ 3 lemurs at the same time for at least 10 consecutive minutes, and were recorded regularly throughout the year. The minimum DBH for food or resting trees across both forest fragments was ≥ 22.47 cm.

For further classification of the forest fragments, we collected herbarium specimens from each of the 480 trees sampled with the point-centered quarter method. The specimens were taken simultaneously with the measurements. In addition to the trees ≥ 3.1 cm DBH, specimens from trees < 3.1 cm DBH were also taken in order to obtain a comprehensive picture of forest composition. A total 960 specimens were collected in the two forest fragments. They were identified with the help of the botanical department of the Parc Botanique et Zoologique de Tsimbazaza, Antananarivo.

Habitat use

Four groups of *E. m. flavifrons* in two different fragments of the Ankarafa Forest (see above) were each followed for 24 hour/month during eight months between July 2004 and July 2005, combined resulting in 600 h of observation spanning the dry and the rainy seasons. The two fragments consisted mainly of primary and secondary vegetation respectively.

Activity data and data on home range use were collected by recording the activity and position that all or most members of the respective group were engaged in at two-minute intervals (Altmann 1974; Mann 1999, 2000). To determine the vertical position of the lemurs, the forest was classified into four different vertical levels: ground; subcanopy (trees or shrubs which extend between the ground and the lowest areas of the canopy); understorey (trees representing the lower part of the canopy); and overstorey (trees representing the upper part of the canopy and emergents).

Forest cover and home range size

Primary and secondary forest fragments were divided by an area which is only covered with grass savannah, bushes and shrubs. The secondary forest within the study area was considered to be at least 35 years old, based on aerial and satellite images and GIS data obtained from Conservation International. Limits of the forest fragments were recorded via GPS, and included forest as well as shrubs.

To determine the horizontal position of the animals, all food and resting trees used by a lemur group were marked and recorded via GPS (for definition of food and resting trees see above). We then superimposed 10 × 10 m squares on a map around the marked trees to take their crown diameters into account. Home range size was calculated using the minimum convex-polygon method (Hayne 1949), connecting the outer edges of the extremity squares and measuring the total area enclosed. GPS data were analyzed with ArcGIS 9® and ArcView® (ESRI 2005). To allow for analysis of seasonal changes in home range size we lumped the data for the two lemur groups in each forest fragment, respectively.

Statistics

The units of statistical analysis used to test for differences in habitat structure and forest characteristics between the primary and the secondary forest fragment were either the total number of trees and shrubs sampled ($n = 480$ trees + 480 shrubs) or the number of point-centered plots ($n = 120$). The nonparametric Mann-Whitney ‘U’ test and the Chi-Square test were applied to these data. For analyzing differences in plant composition between both types of forest, we used the total number of all trees that could be identified to species level ($n = 832$) as statistical units, and applied a ‘G’ test. To analyze the use of plant families by the lemurs in primary and secondary forest, we used data on trees that were used by the animals and that could be identified to species level as statistical units ($n = 58$), and applied a ‘G’ test. To test for differences in the use of feeding and resting trees, we applied a ‘G’ test to the total number of regularly used trees ($n = 134$). Data were analyzed using the software SPSS 14.0 (Statsoft, 2005) and SSS 1.1m (Rubisoft, 2002).

Results

Habitat structure and forest characteristics

The structural comparison of the two habitat types revealed differences in structural variables (Table 1) as well as in plant diversity and plant communities. Differences were significant for trees ≥3.1 cm DBH (Mann-Whitney ‘U’ test: $p \leq 0.01$; two-tailed; $Z = -6,457$), which occurred in higher densities in the secondary forest fragment and for potential food or resting trees, usable for a whole group of lemurs (≥22.47 cm DBH), which were more abundant in the primary forest fragment (primary forest = 39 trees; secondary forest = 12 trees; Chi-Square test: $n = 480$; $p \leq 0.01$). Median DBH of measured trees and the number of trees with lianas were significantly greater in the primary than in the secondary forest fragment (Median DBH: Mann-Whitney ‘U’ test: $p \leq 0.01$; two-tailed; $Z = -12,311$ and number of trees with lianas: Mann-Whitney ‘U’ test: $p \leq 0.01$; two-tailed; $Z = -4,956$).

Table 2 shows the plant composition and the proportion of different plant families in the two forest fragments. Twenty-two plant families occurred in both the primary and secondary forests, 20 occurred only in the primary, and 12 only in the secondary forest. The number of different plant families was significantly higher in primary forest (42 versus 34; ‘G’ test: $p \leq 0.05$). The two fragments also differed considerably with regard to their plant communities (Table 2).

Habitat use

The lemurs in the primary forest fragment spent most of their time in the highest forest strata, but in the secondary forest fragment the overstorey was less used than the understorey (Fig. 1). All levels, except for the ground, varied in their degree of use by the lemurs over the course of the year. However, the distribution of forest level use over the year appears to be more even in primary than in secondary forest habitat. This becomes evident by looking at the more frequent use of the lower forest strata in secondary forest during the dry season (Figs. 2a and 2b).

The forest floor was only irregularly used and, if used at all, the lemurs normally only stayed on the ground for seconds at a time (twice in October, once in November and once in December). During the dry season, in June, an infant male was observed on the ground for several minutes, drinking from a puddle.

Use of plant families

Thirty-five of 97 regularly-used trees, belonging to 17 plant families, were individually identified in primary forest, and 23 out of 37 regularly used trees, belonging to six plant families, in secondary forest. The family-level diversity was thus higher in trees used by the lemurs in primary forest than in trees used in secondary forest (‘G’ test: $p \leq 0.01$). In

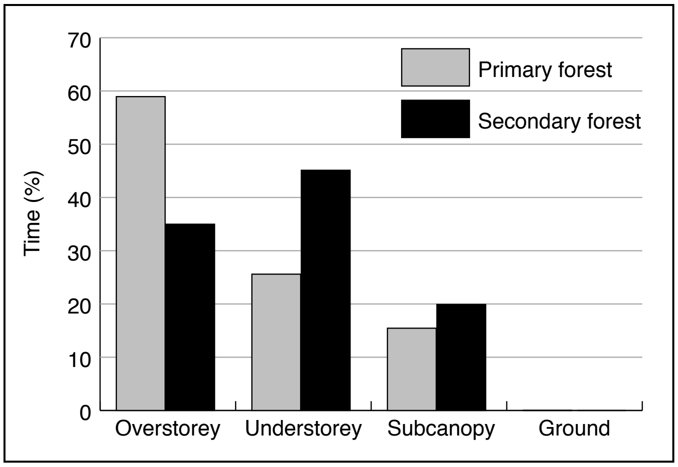


Figure 1. Forest level use by *Eulemur m. flavifrons* in primary and secondary forest during the study period (% of observation time). Levels: ground; subcanopy, extending between the ground and the lowest areas of the canopy; understorey, representing the lower part of the canopy; overstorey, representing the upper part of the canopy and emergents.

Table 1. Variables characterizing habitat structure within the two different forest fragments. Values are medians and quartiles. *N* is the number of trees or plots sampled. Mann-Whitney ‘U’ test/ Chi-Square test: *P≤0.05; ** P≤0.01.

Variable	Primary forest (N =240)	Secondary forest (N =240)
Trees ≥ 3.1 cm DBH		
Distance of trees (m)	2.30 (1.20;4.00)	1.50** (1.00;2.20)
DBH of trees (cm)	7.00** (4.42;14.96)	6.68 (4.45;11.61)
Height of trees (m)	7.10 (4.50;14.00)	7.50 (5.50;10.25)
Crown diameter (m)	2.80 (1.60;4.50)	3.00 (1.80;4.40)
Height of first branch (m)	3.50 (1.90;7.05)	3.80 (2.20;6.20)
Trees with one liana [%]	20.38**	0.00
Trees with more than one liana [%]	22.08	13.75
Useable trees [%] (range of DBH within food and resting trees)	16.25**	5.00
Shrubs < 3.1 cm DBH		
Distance of shrubs (m)	1.30*(0.64;1.81)	0.92(0.50;1.20)
Plots (N =60)		
Estimated canopy coverage [%] > 50%	55.00	63.30
Estimated canopy coverage [%] < 50%	23.33	31.66
No canopy coverage [%]	21.00*	5.00
Stumps (absolute)	12.00	6.00
Stumps [%]	20.00	10.00

Table 2. Plant community composition in the two forest fragments.

Trees	**Primary forest [%] N=240**	**Secondary forest [%] N=240**
Anacardiaceae	11.25	11.82
Annonaceae	2.05	4.77
Aphloiaceae**	0.00	1.36
Apocynaceae	1.28	7.73
Araliaceae	0.26	0.68
Arecaceae**	0.00	0.23
Asteraceae	0.26	0.91
Bignoniaceae	0.51	0.91
Burseraceae	0.26	0.45
Canellaceae*	0.77	0.00
Capparidaceae*	0.26	0.00
Celastraceae	1.28	0.45
Chrysobalanaceae	3.84	14.77
Clusiaceae	6.39	7.50
Combretaceae**	0.00	0.23
Connaraceae*	0.26	0.00
Dichapetalaceae*	0.26	0.00
Ebenaceae	7.93	1.82
Erythroxylaceae**	0.00	0.86
Euphorbiaceae	3.32	4.55
Fabaceae	1.53	6.14
Kiggelariaceae*	1.02	0.00
Lauraceae*	0.26	0.00
Leeaceae*	0.26	0.00
Loganiaceae*	0.26	0.00
Loganiaceae**	0.00	1.82
Marantaceae*	0.26	0.00
Melastomataceae**	0.00	0.23
Meliaceae*	3.07	0.00
Menispermaceae**	0.00	0.68
Monimiaceae*	3.84	0.00
Moraceae	17.14	5.45
Myrsinaceae*	1.28	0.00
Myrtaceae*	2.05	0.00
Ochnaceae**	0.00	1.36
Oleaceae	0.26	0.91
Physenaceae*	1.79	0.00
Pittosporaceae**	0.00	0.23
Rhamnaceae*	0.26	0.00
Rhizophoraceae*	0.77	0.00
Rhizophoraceae**	0.00	1.82
Rubiaceae	5.37	11.82
Rutaceae*	0.51	0.00
Saliaceae**	0.00	2.27
Salicaceae	1.28	5.00
Sapindaceae**	0.00	1.36
Sapinoaceae*	7.93	0.00
Sapotaceae	4.09	0.23
Sorindeia	0.26	0.23
Strecoliaceae*	1.02	0.00
Tiliaceae	0.26	0.91
Verbenaceae	0.26	0.45
Viglaceae*	0.26	0.00
Violaceae	4.35	0.45

*Only in primary forest; **only in secondary forest.

primary forest Salicaceae was the most frequently used family (20% of observation time), whereas in secondary forest Anacardiaceae accounted for more than half of the observations.

Use of trees for feeding and resting

In each type of forest, some trees were used by the lemurs exclusively for resting and others for both, feeding and resting. In the primary forest fragment, *E. m. flavifrons* used significantly more trees coevally for feeding and resting ('G' test: n = 134; $p \leq 0.05$) than in secondary forest (Fig. 3).

Forest cover and home range size

The total home ranges of the four study groups differed greatly in size and covered between 3.8 ha (primary forest) and 19.6 ha (secondary forest). Home ranges of neighboring groups overlapped in both types of forest (Fig. 4). Home range size changed during the dry and the rainy season in both types of forest. They were smaller during the dry season. In secondary forest the animals decreased the size of their home range to 1.4 ha (9.7% of the original home range size), and in primary forest to 5.7 ha (77.4% of the original home range size) during the dry season (Fig. 5).

Discussion

In this study we examined the use of two different forest fragments by *Eulemur macaco flavifrons*, one of which was predominantly primary forest, and the other secondary. The latter was in the process of regeneration after significant human disturbance of the original forest vegetation over an extended period in the past. It displayed major differences in forest structure and canopy species composition as compared to the nearby primary forest. All conditions for the definition of secondary forest given by Chokkalingam and de Jong (2001) were met in this study fragment.

The two fragments differed considerably in a number of variables. The primary forest fragment had more trees with lianas, which provided additional cover for the lemurs and were thus potential sleeping trees (Rendigs *et al.* 2003). It also had more large trees (DBH ≥22.47 cm). Also, overall plant biodiversity was higher in the primary than in the secondary forest fragment. Moreover, plant communities were different in the two fragments. Nevertheless, human pressure was higher and canopy cover altogether less dense in the primary forest fragment (Table 1), which means that at the time of our study, it was showing some degree of disturbance. Despite this, our results clearly demonstrate differences in habitat use of *E. m. flavifrons* in the primary and secondary forest fragment. While the animals in primary forest spent most of their time in the highest forest strata in all months of the year, in secondary forest the patchily distributed overstorey was almost unused during the stormy dry season. During June, July and August, a strong wind from the south-east to the north-west (*Varatraza*) dominates the weather in the study area. At this time, blue-eyed black lemurs decreased their activity (Schwitzer *et al.* submitted) and spent most of the day in the largest

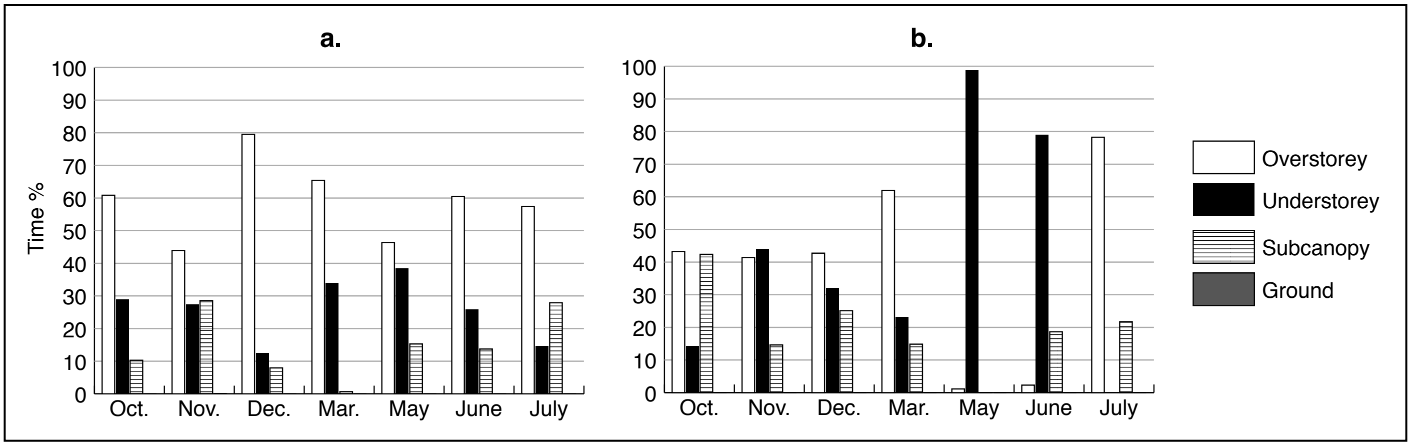


Figure 2. Seasonal variation in forest level use by *Eulemur m. flavifrons* in primary forest (a) and secondary forest (b). For description of levels see Figure 1.

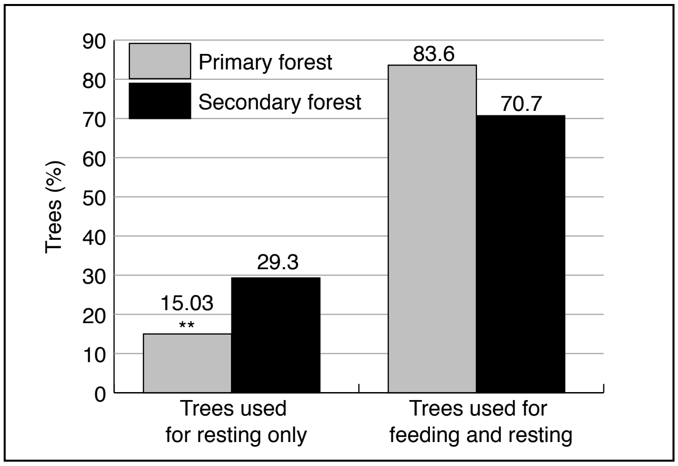


Figure 3. Proportion of trees regularly-used by *Eulemur m. flavifrons* in primary and secondary forest that is used for feeding and resting or exclusively for resting. ** P≤0.05.

trees, hiding on branches near the trunk. Groups of massive trees seem to be necessary for providing sufficient protection for the lemurs on the Sahamalaza Peninsula during the *Varatraza* months. The overstorey of the secondary forest may provide insufficient cover from aerial predators in the dry season, when some of the trees do not have leaves. In addition to large trees, the primary forest fragment had a greater diversity of families of trees, and more trees that served as food and resting trees, allowing for shorter travel distances for the animals. The combination of these factors might be responsible for our finding that the home range size of *E. m. flavifrons* was smaller in primary forest. Moreover, the density of blue-eyed black lemurs was higher in primary forest than in secondary forest (Schwitzer *et al.* 2005).

This is consistent with the findings of Wilson *et al.* (1989), who sighted *Eulemur coronatus* in primary forest much more frequently, and in greater numbers, than in edge or degraded forest. Overdorff (1992) related that *Eulemur rufus* and *Eulemur rubriventer* preferred the highest forest strata, and Ganzhorn and Schmidt (1998) found that *Microcebus murinus* reached lower population densities in secondary than in primary forest (see also Ganzhorn *et al.* 1996; Smith *et al.* 1997). Studies on South American howler monkeys (genus *Alouatta*) in Nicaragua demonstrated a marked preference for primary forest habitats, presumably due to a higher density of food species (McCann *et al.*, 2003). Group size and density of howler monkeys appeared to be smaller where there was a higher degree of human-modified habitat (McCann *et al.* 2003; Rodríguez-Toledo *et al.* 2003). Estrada and Coates-Estrada (1995) found a greater primate presence in undisturbed forest fragments where vegetation was taller than in fragments where the canopy height was lower than 10 m.

The blue-eyed black lemurs were expected to be habitat generalists with a broad habitat tolerance, probably because they were previously classified as frugivorous and adaptable (Andriamanandratra 1996; Rakotondratsima 1999). Nevertheless, our study indicates that they show some degree of habitat selectivity. The lack of large trees and lianas as well as the lower number of different plant families may have lead to a decrease in the density of blue-eyed black lemurs in secondary forest fragments, as reported by Schwitzer *et al.* (2005). This indicates that secondary forests might be of only limited value in providing a suitable habitat for the species, even though it is there that they can exploit food trees such as mango, *Mangifera indica*. Long-term studies in secondary forest are needed in order to see if blue-eyed black lemurs populations are viable in areas entirely lacking primary forest.

Eulemur m. flavifrons was classified as Critically Endangered (CR A2cd) in the most recent IUCN Red List assessment on the basis of a habitat loss of 80% during the last 25 years. Its remaining habitat is already substantially fragmented (Schwitzer *et al.* 2005). The main goal for future conservation plans in Sahamalaza should therefore be the protection of the remaining patches of primary forest, using secondary forest as buffer zones and corridors between primary forest blocks.

Conclusions

Blue-eyed black lemur groups are able to adapt to different types of habitat. Home range size and use differ between primary and secondary forest fragments. *Eulemur m. flavifrons*

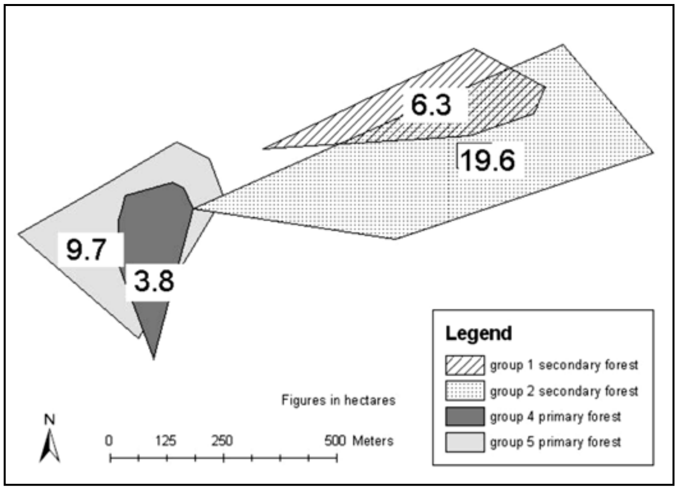


Figure 4. Home ranges (in ha) of the four study groups of *Eulemur m. flavifrons* in primary and secondary forest throughout the study period.

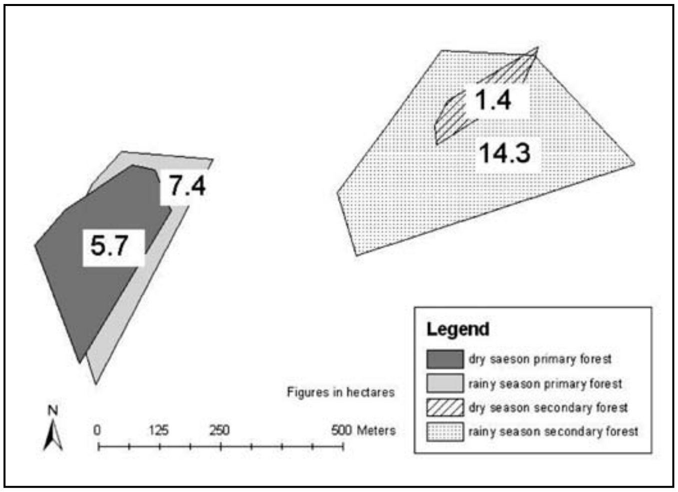


Figure 5. Seasonal changes in home range size (in ha) of *Eulemur m. flavifrons* groups in primary and secondary forest. Data for the two study groups in each forest fragment were lumped for analysis.

groups have larger home ranges and lower densities in secondary forest compared to primary forest, suggesting that the former is less suitable. Different forest types evidently differ in their suitability for *Eulemur macaco flavifrons*, which, as such, cannot be classified as a habitat generalist. Long-term studies in isolated secondary forest and forest-agricultural mosaic fragments need to be carried out to reveal whether or not blue-eyed black lemurs can survive without access to primary forest.

Acknowledgments

We are grateful to the Direction Générale des Eaux et Forêts and the Malagasy national parks authority ANGAP for granting a research permit, as well as to Clément Rabarivola from the University of Mahajanga and Gunther Nogge from Cologne Zoo for their assistance. Our thanks to Jörg Ganzhorn and Felicia Ruperti, who provided very helpful comments on the manuscript. We also thank Irina Massmann and David White, as well as our field assistants Yvess Claudias Jaomamory, Augustin "Richard" Randrianasara, Jean-Charles "Zafihita" Milson and Tombomisy Jean-Ede, without whose help the work would not have been possible. This study was supported by AEECL, the Margot Marsh Biodiversity Foundation and Conservation International's Primate Action Fund. Equipment was sponsored by Thrane & Thrane, Lyngby, Denmark, ESRI ArcView9.1 Student Edition, and Bushnell, Cologne, Germany.

Literature Cited

Altmann, J. 1974. Observational study of behaviour: sampling methods. *Behaviour* 49: 227–65.

Andriamanandratra A. N. 1996. Proposition pour un nouveau parc national dans la région du Nord-Ouest de Madagascar: Un commencement intégratif, AEECL. Report to AEECL Mulhouse, Zoo de Mulhouse. 51pp.

Andrianasolo T. H., T. L. Andrianjazalahatra, S. J. Rakotondranary, R. E. A. F. Ramarokoto, G. Randria, N. Ruedel, J. Schueller and J. U. Ganzhorn. 2006. Habitat utilisation of nocturnal lemurs in evergreen littoral forests of different degrees of degradation. In: *German-Malagasy Research Cooperation in Life and Earth Sciences*, C. Schwitzer, S. Brandt, O. Ramilijaona, M. Rakotomala Razanahoera, D. Ackermand, T. Razakamana and J. U. Ganzhorn (eds.), pp.151–159. Concept Verlag, Berlin.

Andrianjakarivelo V. 2004. Exploration de la zone en dehors de la peninsule Sahamalaza pour l'évaluation rapide de la population d'*E. m. flavifrons*. Report, Wildlife Conservation Society (WCS) Madagascar, Antananarivo. 31pp.

Birkinshaw, C. R. 2004. Priority areas for plant conservation. *Ravintsara* 2(1): 14–15.

Burney, D. A., H. F. James, F. V. Grady, J. G. Rafamantanantsoa Ramilisonina, H. T. Wright and J. B. Cowart. 1997. Environmental change, extinction and human activity: evidence from caves in NW Madagascar. *J. Biogeog.* 24(6): 755–767.

Chapman, C.A., M. J. Lawes, L. Naughton-Treves and T. Gillespie. 2003. Primate survival in community-owned forest fragments: Are metapopulation models useful amidst intensive use? In: *Primates in Fragments: Ecology and Conservation*, L. K. Marsh (eds.), pp.63–78. Kluwer Academic/Plenum, New York.

Chokkalingam, U. and W. de Jong. 2001. Secondary forest: a working definition and typology. *Int. Forest Rev.* 3 (1): 19–26.

Clutton-Brock, T. H. and P. H. Harvey. 1979. Home range size, population density and phylogeny in primates. In: *Primate Ecology and Human Origins: Ecological Influences on Social Organisation*, I. S. Bernstein and E. O. Smith (eds.), pp.201–214. Garland Press, New York.

Curtis, D. J. and A. Zaramody. 1998. Group size, home range use, and seasonal variation in the ecology of *Eulemur mongoz*. *Int. J. Primatol.* 19(5): 811–835.

Estrada, A. and R. Coates-Estrada. 1995. *Las Selvas Tropicales Humedas de Mexico: Recurso Poderoso, Pero Vulnerable*. La Ciencia desde Mexico, Mexico City.

Estrada, A. and R. Coates-Estrada. 1996. Tropical rain forests fragmentation and wild populations of primates at Los Tuxtlas, Mexico. *Int. J. Primatol.* 17(5): 759–783.

Feistner, A. T. C. and T. Mutschler. 2000. Feeding fussy folivores: Nutrition of gentle lemurs. In: *Zoo Animal Nutrition*, J. Nijboer, J. M. Hatt, W. Kaumanns, A. Beijnen and U. Ganslosser (eds.), pp.107–117. Filander Verlag, Fuerth.

Freed, B. Z. 1996. Co-occurrence among Crowned Lemurs (*Lemur coronatus*) and Sanford's Lemurs (*Lemur fulvus sanfordi*) of Madagascar. PhD thesis, Washington University, St. Louis, Missouri.

Ganzhorn, J. U. 1987. A possible role of plantations for primate conservation in Madagascar. *Am. J. Primatol.* 12(2): 205–215.

Ganzhorn, J. U. 2002. Distribution of a folivorous lemur in relation to seasonally varying food resources: integrating quantitative and qualitative aspects of food characteristics. *Oecologia* 131(3): 427–435.

Ganzhorn, J. U. 2003. Habitat description and phenology. In: *Field and Laboratory Methods in Primatology. A Practical Guide*, J. M. Setchell and D. J. Curtis (eds.), pp.40–56. Cambridge University Press, Cambridge, UK.

Ganzhorn, J. U. and J. P. Abraham. 1991. Possible role of plantations for lemur conservation in Madagascar: Food for folivorous species. *Folia Primatol.* 56(3): 171–176.

Ganzhorn, J. U., O. Langrand, P. C. Wright, S. O'Connor, B. Rakotosamimanana*,* A. T. C. Feistner and Y. Rumpler. 1996. The state of lemur conservation in Madagascar. *Primate Conserv.* (17): 70–86.

Ganzhorn, J. U., S. Malcomber, O. Andrianantoanina and S. M. Goodman. 1997. Habitat characteristics and lemur species richness in Madagascar. *Biotropica* 29(3): 331–343.

Ganzhorn, J. U. and J. Schmid. 1998. Different population dynamics of *Microcebus murinus* in primary and secondary deciduous dry forests of Madagascar. *Int. J. Primatol.* 19(5): 785–796.

Glander, K. E., P. C. Wright, P. C. Daniels and A. M. Merenlender. 1992. Morphometrics and testical size of rain forest lemur species from southeastern Madagascar. *J. Hum. Evol.* 22 (1):1–17.

Harcourt, C. and J. Thornback. 1990. *Lemurs of Madagascar and the Comoros. The IUCN Red Data Book*. IUCN, Gland, Switzerland.

Hayne, D. W. 1949. Calculation of size of home range. *J. Mammal.* 30: 1–17.

Irwin, M. T. and J. Raharison. 2006. Dietary and behavioural flexibility facilitates survival of diademed sifakas (*Propithecus diadema*) in forest fragments—at least in the short term. *Int. J. Primatol.* 27 (suppl.1): 502.

Lovejoy, T. E., R. O. Bierregaard Jr., A. B. Rylands, J. R. Malcolm, C. E. Quintela, L. H. Harper, K. S. Brown, A. H. Powell, G. V. N. Powell, H. O. R. Schubart and M. B. Hays. 1986. Edge and other effects of isolation on Amazon forest fragments. In: *Conservation Biology: The Science of Scarcity and Diversity*, M. E. Soulé (ed.), pp.257–285. Sinauer Associates, Sunderland, Massachusetts.

Mann, J. 1999. Behavioral sampling methods for cetaceans: a review and critique. *Marine Mammal Sci.* 15: 102–122.

Mann, J. 2000. Unravelling the dynamics of social life: long-term studies and observational methods. In: *Cetacean Societies: Field Studies of Dolphins and Whales,* J. Mann *et al.* (eds.), pp.45–64. Univesity of Chicago Press, Chicago.

McCann, C., K. Williams-Guillen, F. Koontz, A. A. R. Espinoza, J. C. Martinez Sanches and C. Koontz. 2003. Shade coffee plantations as wildlife refuge for mantled howler monkeys (*Alouatta palliata*) in Nicaragua. In: *Primates in Fragments: Ecology and Conservation,* L. K. Marsh (ed.), pp.321–341. Kluwer Academic/Plenum, New York.

Meier, B., A. Lonina and T. Hahn. 1996. Summer 1995 expedition report on the creation of a new national park in Madagascar. *Zeit. Koelner Zoo* 39(2): 61–72.

Meyers, D. M., C. Rabarivola and Y. Rumpler. 1989. Distribution and conservation of Sclater's lemur: Implications of a morphological cline. *Primate Conserv.* (10): 77–81.

Mittermeier, R. A., W. R. Konstant, F. Hawkins, E. E. Louis, O. Langrand, J. Ratsimbazafy, R. Rasoloarison, J. U. Ganzhorn, S. Rajaobelina, I. Tattersall and A. D. Meyers. 2006. *Lemurs of Madagascar*. Conservation International, Washington, DC.

Overdorff, D. J. 1988. Preliminary report on the activity cycle and diet of the red-bellied lemur (*Lemur rubriventer*) in Madagascar. *Am. J. Primatol.* 16(2): 143–153.

Overdorff, D. J. 1992. Differential patterns in flower feeding by *Eulemur fulvus rufus* and *Eulemur rubriventer* in Madagascar. *Am. J. Primatol.* 28(3): 191–203.

Populations Reference Bureau. 2006. *2006 World Population Datasheet: USA*. August Website: <http//;www.prb.org>. Accessed 10 December 2006.

Rabarivola, C., D. Meyers and Y. Rumpler. 1991. Distribution and morphological characters of intermediate forms between the black lemur (*Eulemur macaco macaco*) and the Sclater's lemur (*E. m. flavifrons*). *Primates* 32(1): 269–273.

Rakotondratsima, M. 1999. Etude quantitative de *Eulemur macaco flavifrons* dans la presqu'île Radama. In: *Wildlife Conservation Society Madagascar Country Program: Evaluation de l'état de l'environnement naturel terrestre de la presqu'île Radama*. Antananarivo, WCS: 15–29.

Rendigs, A., U. Radespiel, D. Wrogemann and E. Zimmermann. 2003. Relationship between microhabitat structure and distribution of mouse lemurs (*Microcebus* spp.) in northwestern Madagascar. *Int. J. Primatol.* 24(1): 47–64.

Richard, A. and S. O'Connor. 1997. Degradation, transformation, and conservation. In: *The Past, Present and Possible Future of Madagascar's Environment,* S. Goodman and B. Patterson (eds.), pp.406–418. Smithsonian Institution Press, Washington, DC.

Robbins, M. M., J. Bosco Nkurunungi and A. McNeilage. 2006. Variability of the feeding ecology of eastern gorillas. In: *Feeding Ecology in Apes and Other Primates. Ecological, Physical and Behavioural Aspects*, G. Hohmann, M. M. Robbins and C. Boesch (eds.), pp.25–47. Cambridge University Press, Cambridge, UK.

Rodríguez-Toledo E. M., S. Mandujano and F. Garcia-Orduña. 2003. Relationships between forest fragments and howler monkeys (*Alouatta palliata mexicana*) in southern Veracruz, Mexico. In: *Primates in Fragments: Ecology and Conservation*, L. K. Marsh (ed.), pp.79–97. Kluwer Academic/Plenum, New York.

Schwitzer, C. and W. Kaumanns 2005. Blue-eyed black lemur (*Eulemur macaco flavifrons* Gray, 1867)—Perspectives for *in situ* and *ex situ* research and conservation activities. In: *Proceedings of the EAZA Conference 2004, Kolmarden*, B. Hiddinga. (ed.), pp.116–127. EAZA Executive Office, Amsterdam.

Schwitzer, C., N. Schwitzer, G. H. Randriatahina, C. Rabarivola and W. Kaumanns. 2005. Inventory of the *Eulemur macaco flavifrons* population in the Sahamalaza protected area, northwest Madagascar, with notes on an unusual colour variant of *E. macaco*. *Primate Rep.* Special Issue 72–1: 39–40.

Smith, A. P., N. Horning and D. Moore. 1997. Regional biodiversity planning and lemur conservation with GIS in Western Madagascar. *Conserv. Biology* 11(2): 498–512.

Sussman, R. W. and I. Tattersall. 1976. Cycles of activity, group composition, and diet of *Lemur mongoz* Linnaeus 1766 in Madagscar. *Folia Primatol.* 26: 270–283.

Terranova, C. J. and B. S. Coffman. 1997. Body weights of wild and captive lemurs. *Zoo Biol.* 16: 17–30.

Vasey, N. 1997. Community Ecology and Behaviour of *Varecia variegata rubra* and *Lemur fulvus albifrons* on the Masoala Peninsula, Madagascar. Ph.D. thesis, Washington University, St. Louis, Washington.

WCS/DEC. 2002. *Etude de faisabilité de la création d'APMC et plan de développement pour le site de la RBM Sahamalaza – Nosy Radama.* Wildlife Conservation Society/ Development Environment Consult, Antananarivo, WCS/ DEC. 138pp.

Wilson, J. M., P. D. Stewart, G. S. Ramangason, A. M. Denning and M. S. Hutchings. 1989. Ecology and conservation of the crowned lemur, *Lemur coronatus*, at Ankarana, N. Madagascar. With notes on Sanford's lemur, other sympatric and subfossil lemurs. *Folia Primatol.* 52(1–2): 1–26.

Authors' addresses:
Nora Schwitzer, WG Primatology, Zoologischer Garten Koeln, Riehler Str. 173, 50735 Koeln, Germany.
Guy H. Randriatahina, Département de Biologie Animale, Faculté des Sciences, Université d'Antananarivo, Antananarivo 101, Madagascar.
Werner Kaumanns, WG Primatology, Zoologischer Garten Koeln, Riehler Str. 173, 50735 Koeln, Germany.
Dirk Hoffmeister, Department of Geography, University of Cologne, Albertus-Magnus-Platz, 50923 Koeln, Germany.
Christoph Schwitzer, Bristol Zoo Gardens, Clifton, Bristol BS8 3HA, UK. Corresponding author: <cschwitzer@bristolzoo.org.uk>.

Received for publication: January 2007
Revised: September 2007

Primate Conservation 2007 (22): 89–95

Habitat and Distribution of the Ruffed Lemur, *Varecia*, North of the Bay of Antongil in Northeastern Madagascar

Evon R. Hekkala[1], Marius Rakotondratsima[2], and Natalie Vasey[3]

[1]*Department of Biology, University of Nevada, Reno, Nevada, USA*
[2]*Peregrine Fund Madagascar Project, Antananarivo, Madagascar*
[3]*Department of Anthropology, Portland State University, Portland, Oregon, USA*

Abstract: Here we present information on the conservation status of ruffed lemurs (*Varecia*) north of the Bay of Antongil in northeastern Madagascar. Two contiguous protected areas were recently established that traverse this region via blocks of forest connected by narrow forest corridors: the Masoala National Park, which expands further to the east, and the Makira Protected Area, which expands further to the west and northwest. The two extant ruffed lemurs, *Varecia variegata* and *V. rubra*, overlapped in this region historically and, on rare occasions, hybridized. As such, land north of the Bay of Antongil is a critical part of the ruffed lemur's northern geographic range. Habitat surveys and interviews with local informants were carried out in this region to determine the extent of suitable habitat for *Varecia* populations, to assess the extent of human exploitation of this genus, and to obtain data on the western and northern range limits of *V. rubra*. Interviews indicated that there are populations of *V. rubra* as far northwest as the confluence of the Antainambalana and Sahantaha Rivers. Surveys and interviews revealed extensive habitat degradation and lemur hunting in the three major river drainages north of the Bay of Antongil. The recent establishment of protected forest blocks and forest corridors in the region was critical, as these links will provide the only connections between *Varecia* populations that would otherwise be entirely isolated in forest patches surrounded by agricultural land. The geo-referenced habitat survey and the summary of interview results provided here can be used as comparators for future population and habitat assessments following the establishment of the protected areas. A primary direction for future work should be to examine how *Varecia* populations are adapting to conditions in and near forest corridors.

Key Words: Black-and-white ruffed lemur, *Varecia variegata*, red ruffed lemur, *Varecia rubra*, population and habitat survey, hybrids, hunting

Introduction

The red ruffed lemur, *Varecia rubra,* and the black-and-white ruffed lemur, *Varecia variegata*, inhabit the eastern rain forests of Madagascar. The most recent IUCN assessment treated them as subspecies, with the former categorized as Critically Endangered and the latter as Endangered (IUCN 2006), but they have recently been reclassified from subspecies to full species (Groves 2001, 2005; Vasey and Tattersall 2002). The two taxa currently exhibit a parapatric distribution, with the Antainambalana River in northeastern Madagascar considered the primary geographic boundary between them (Fig. 1; Petter *et al*. 1977; Tattersall 1982). *Varecia variegata* has a range extending from south of the Mananara River in southeastern Madagascar to the Antainambalana River, northwest of the Bay of Antongil (Petter *et al*. 1977; Tattersall 1977). *Varecia rubra* has a smaller geographic range occurring only in northeastern Madagascar. While it is known to occur on the Masoala Peninsula to the exclusion of *V. variegata*, there is little data on the western or northern boundaries of its range (Tattersall 1977).

A recent review of a wide variety of data, including historical documents and museum collections, has revealed several localities in northeastern Madagascar where more than one species of *Varecia* was collected in the late 19th and early 20th centuries (Vasey and Tattersall 2002). These localities span the three major river drainages north of the Bay of Antongil: from east to west, they are the Mahalevona, the Andranofotsy, and the Antainambalana Rivers (Fig. 1). Despite this area of historical overlap, hybridization appears to have been rare in the wild, although it evidently spanned all three river drainages. Only a handful of wild hybrids are known from northeastern Madagascar. All were collected in the late 19th and early 20th centuries, and diagnosed on the basis of their

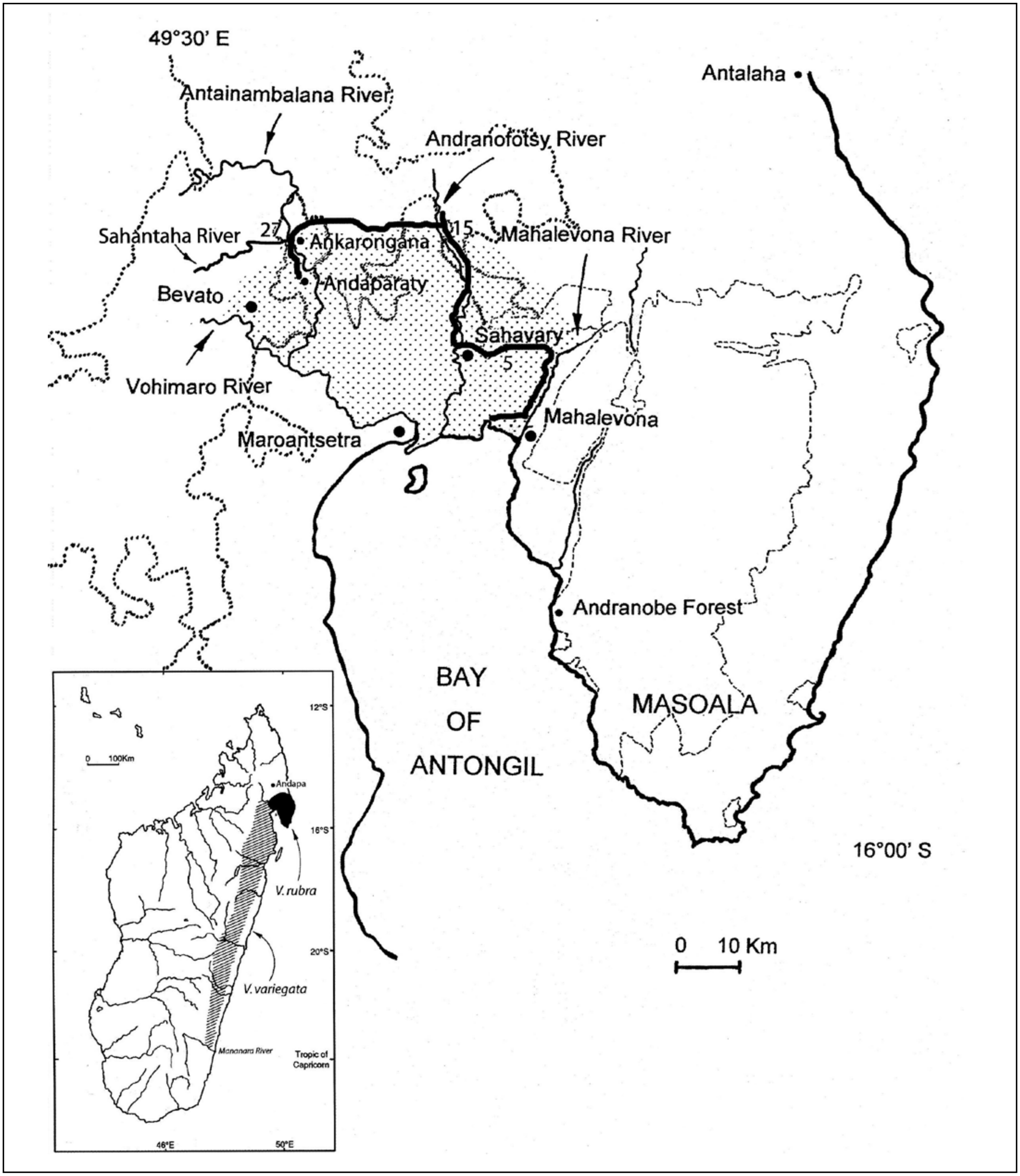


Figure 1. Masoala Peninsula and region north of the Bay of Antongil and its major river drainages. Small black arrows indicate the Mahalevona, Andranofotsy, Antainambalana, Vohimaro, and Sahantaha Rivers. Labelled dots (●) indicate towns or villages mentioned. Stippling (▒) shows area of historical overlap between different species of ruffed lemur where hybridization has occasionally occurred, with hybrids collected at Mahalevona and Bevato (Vasey and Tattersall 2002). Dashed lines (----) mark boundaries of the Masoala National Park. Dotted lines (……) mark the boundaries of the Makira Protected Area and its link to the Masoala National Park near Sahavary. (Note that boundaries of the Makira Protected Area extend beyond the region depicted to the north, west, and south). Thick black line (▬) running from Mahalevona to Andaparaty represents the route for the habitat survey, September 1998. Numbers along route indicate localities where *Varecia* were observed or heard, and correspond to geo-referenced localities in Table 1 (5 = Belampona River; 15 = Ampoantsatroka Village; 27 = Sahantaha Village). Inset shows the general distributions of black-and-white and red ruffed lemurs (hatching and black areas indicate approximate distributional limits of each species but do not imply continuous distributions within the indicated regions. Figure adapted from Vasey and Tattersall (2002).

pelage patterns (Buettner-Janusch and Tattersall 1985; Vasey and Tattersall 2002).

Beginning in the late 1980s, habitats surrounding the Bay of Antongil were identified as priority areas for Integrated Conservation and Development Projects (ICDP). The region north of the Bay of Antongil, in particular, was considered an area of exceptional biological importance (e.g., Ganzhorn *et al*. 1997). Two protected areas have since been established there: the Masoala National Park, created in 1996, encompassing 230,000 ha, most of which lies on the Masoala Peninsula east of the Bay of Antongil; and the Makira Protected Area, established in 2004, encompassing 371,000 ha, mostly west and northwest of the Bay of Antongil (Fig. 1). North of the bay, in their narrowest sections, the two protected areas are contiguous, joined together by forest blocks that are linked by narrow forest corridors, thereby spanning all three river drainages mentioned above. The Masoala National Park harbors *V. rubra*, while the Makira Protected Area contains both *V. rubra* and *V. variegata*, including some zones where the two species overlapped historically.

The establishment of ICDPs, such as those surrounding the Bay of Antongil, depended upon information on the distribution, abundance, and habitat requirements of threatened species, and the size, condition of, and threats to forest remnants (e.g., Merenlender *et al.* 1998; Kremen *et al*. 1999). The accomplishments of ICDPs should not be undervalued, even though this approach is currently undergoing considerable revision — creating protected areas hand-in-hand with improving livelihoods for local people proved more difficult to implement than to plan (Randrianandianina *et al*. 2003; Kauffman 2006). The Masoala National Park, for example, was created to protect the largest remaining tracts of lowland rainforest in Madagascar and, although designed to maintain a large, relatively pristine core area, its management regime allows for experimental timber harvesting along a number of river drainages previously subjected to substantial disturbance in the form of slash-and-burn agriculture, referred to in Malagasy as *tavy* (CARE/WCS/TPF 1995). Thus, the protected forest blocks in the northern part of the Masoala National Park lie between river drainages, while the protected forest corridors run across (or near) their headwaters.

Surveys conducted in the Antainambalana and Andranofotsy river drainages in the mid-1980s appeared to validate the species boundaries for *V. rubra* and *V. variegata* established by Petter *et al*. (1977). Few animals were sighted, however, suggesting that *Varecia* populations were small and difficult to detect in these areas due to anthropogenic habitat degradation and hunting (Simons and Lindsay 1987). Recent ecological studies on *Varecia* suggest that this obligate frugivore is a denizen of the largest trees in primary forest and for this reason is the most susceptible of the extant lemurs to habitat disruption resulting from selective logging and forest clearing (Vasey 1997, 2002; Balko and Underwood 2005). Ecologically sensitive taxa are prime candidates for population and habitat viability analysis because the conservation measures designed to protect them are likely to contribute to the survival of many other species residing in the same biotic community (see, for example, Soulé 1987).

The goals of this project were threefold: 1) to determine the extent of suitable habitat for *Varecia* populations in selected areas of the three river-drainages directly north of the Bay of Antongil; 2) to assess the extent of human exploitation of this taxon in the region; and 3) to obtain data on the northern and, particularly, the western boundaries of *V. rubra*. Our work thus provides information on the conservation status of ruffed lemurs in a critical part of their range — an area where the two *Varecia* species overlapped historically, would occasionally hybridize, and where periodic reassessments of their habitat in and near protected areas are warranted in order to further implement and adapt current conservation measures. The enduring value of the geo-referenced habitat survey and interview results presented below comes from their use as comparators for future population and habitat assessments in the region north of the Bay of Antongil subsequent to the establishment of protected areas.

Methods

Survey techniques and data collection

Our aim was to conduct a brief survey over a relatively large area north of the Bay of Antongil, integrating local knowledge *en route*. With the help of several local assistants we conducted interviews with local informants, completed habitat surveys, and monitored the presence or otherwise of *Varecia*. We worked among the three major river drainages that enter the bay, which are from east to west, the Mahalevona, Andranofotsy, and Antainambalana. For habitat surveys, we used existing trails, which varied in condition from well-used with open canopy to freshly cut trails within relatively intact (i.e., primary) or secondary forest. *En route*, we listened for *Varecia* vocalizations and monitored for any signs of lemur activity (e.g., fruit dropping from the canopy). At sites with intact forest we split into three teams of two, and monitored for lemur activity off trail for 50–100 m. Work was suspended when heavy rain reduced audibility and visibility in the forest. Most rainstorms were brief, however, and we were able to resume our surveys after a pause of 1–2 hrs. In total, we surveyed on every day between 2–14 September 1998, between 0700 and 1800 h. Total effort each day depended on the condition of the forest (i.e., intact or secondary) with an average of 4 hrs spent in each intact forest patch encountered.

Local people were interviewed for information on *Varecia* populations and asked under what circumstances they interacted with the lemurs in their community (n = 16, Table 1). Interviews were conducted in Malagasy by Marius Rakotondratsima. Only open-ended questions were asked. We searched for *Varecia* in the forests where informants indicated they occurred, and carried out assessments of the habitat, estimating canopy cover and the presence of dominant plant species. One of our guides (Jao Aridy) had worked extensively with researchers on a forestry project in the area and was familiar with intact and secondary forest communities. We assessed each area for evidence of recent anthropogenic activity, including the collection of wood or other materials. We used a Garmin GPS12XL unit to collect waypoints at 15-min intervals along the route. These were used to determine total distance covered and to note forest condition between waypoints. Intact forest in surveyed areas was quantified as the percent of the total linear distance surveyed in kilometers. This was repeated for each type of habitat observed (i.e., secondary forest, agricultural land). We also noted the presence of *tavy* and *laly*. *Laly* are long narrow swaths of forest cleared for the purpose of setting snare traps for lemurs. When *Varecia* were sighted, we noted the tree species in which they were located and whether they were feeding, resting, or engaged in other activities. We noted pelage color and patterns and photographed animals using a 300 mm lens. The other diurnal lemur that occurs in the survey area is *Eulemur fulvus albifrons*; when sighted we noted the location, but it was otherwise not a focus of our study.

Survey route

The survey route is shown in Figure 1. Twenty-seven villages, rivers, mountains, and other localities were geo-referenced (see Table 1). On 2 September 1998, we began traveling up the Mahalevona River drainage. We then launched an east-west survey between the village of Fizona and the Andranofotsy River, crossing first into the Sahavary watershed, a tributary of the Andranofotsy. This region contains the westernmost section of the Masoala National Park, a finger-like projection separated from the rest of the park by a narrow corridor less than 1 km wide (Fig. 1). Here, we surveyed an area just south of the park boundary in a region that appeared to be relatively well-forested and sparsely populated according to maps and data collected in 1994 (CARE/WCS/

Table 1. Geo-referenced localities, habitat types, and interview results for the occurrence of *Varecia* north of the Bay of Antongil, northeastern Madagascar.

Locality[1]	Latitude (s)	Longitude (e)	Habitat type[2]	Dist.[3]	*Varecia rubra*	Comments[2]
1. Fizona V.	15°20' 36.7"	49°56' 53.3"	Agriculture	4 km	None	Medium-sized village
2. Besot V.	15°18' 40.9"	49°56' 29.5"	Agriculture/*Tavy*	3 km	None	Vanilla, bananas, rice
3. Mampay R.	15°18' 34.7"	49°56' 10.4"	Agriculture/*Tavy/Laly*	7 km	None	Rice, zebu
4. Mampay V.	15°18' 21.1"	49°55' 21.0"	Agriculture/*Tavy*/*Laly*	3 km	Yes. Interview	Rice, zebu, coffee
5. Belampona R.*	15°18' 50.9"	49°54' 30.5"	Secondary/*Tavy*/*Laly*	6 km	Yes. 4 wild indiv.	Mining camp, wood collecting
6. Abode L.	15°19' 55.0"	49°52' 26.0"	Intact forest	1 km	Unknown	Closed canopy
7. Mahafidy R.	15°20' 31.3"	49°52' 51.8"	Agriculture/*Tavy*	5 km	None	Zebu
8. Jaofaly V.	15°19' 59.6"	49°52' 27.5"	Agriculture/*Tavy*	5 km	None	Zebu, vanilla, coffee
9. Navana R.	15°19' 55.9"	49°52' 27.5"	Intact forest	1 km	Unknown	Mature *Canarium*
10. Sahafotra R.	15°19' 33.9"	49°50' 49.6"	*Tavy*	4 km	Yes. Interview	*Afromomum*
11. Sahavary V.	15°19' 31.9"	49°50' 34.3"	Intact forest/*Tavy*	2 km	Yes. Interview	*Afromomum*, rice, bananas
12. Sakatihina V.	15°15' 11.4"	49°48' 18.6"	Agriculture/*Tavy*	2.5 km	Yes. Interview	Rice, bananas, hunters w/guns
13. Village 1 V.	15°14' 38.6"	49°49' 50.9"	*Tavy*	2.5 km	Yes. Interview	Rice
14. Betsirebika M.	15°12' 13.1"	49°49' 3.1"	Intact forest*/Tavy*	5.6 km	Yes. Interview	Claim *V. rubra* present to northwest
15. Ampoantsatroka V.*	15°08' 40.9"	49°48' 38.5"	*Tavy*	8 km	Yes. Vocalization	Zebu, bananas
16. Ambanivaletra V.	15°07' 12.0"	49°48' 38.5"	Agriculture/*Tavy*	5 km	No. Interview	Rice
17. Antsahimbizono L.	15°07' 58.0"	49°44' 45.8"	Intact forest/*Tavy*/*Laly*	5 km	Yes. Interview	Zebu
18. High ridge L.	15°08' 0.0"	49°43' 30.0"	Intact forest/*Laly*	3 km	Unknown	Closed canopy
19. Ampasimbola V.[4]	15°09' 11.3"	49°44' 43.1"	Agriculture/*Tavy*/*Laly*	8 km	Yes. Interview	Old camp, >10 *laly*/km
20. Betihina 1 M.[5]	15°09' 25.3"	49°43' 6.1"	Intact forest/*Tavy*/*Laly*	7 km	Yes. Interview	Large patches of intact forest
21. Betihina 2 M.	15°09' 19.6"	49°42' 31.4"	Intact forest/*Tavy*	2 km	Unknown	Extensive clearing
22. Maintimbato V.	15°08' 15.4"	49°40' 19.6"	Agriculture/*Tavy*	4 km	Yes. Interview	Claim *V. rubra* present to north
23. Manakana V.[6]	15°08' 24.9"	49°40' 18.3"	Agriculture/*Tavy*	3 km	Yes. Interview	Claim *V. rubra* present till 1996
24. Anjiafotsy V.	15°08' 38.8"	49°38' 40.4"	Agriculture/*Tavy*/*Laly*	5 km	Yes. Interview	560 m elevation
25. Ambodi-Bihalay M.	15°10' 4.5"	49°35' 47.1"	Intact forest/*Tavy*/*Laly*	8 km	Yes. Interview	Extremely steep terrain cleared
26. Ankarongana V.	15°10' 47.2"	49°35' 27.5"	Agriculture/*Tavy*/*Laly*	8 km	Yes. Interview	Claim *V. rubra* present N and E
27. Sahantaha V.*[7]	15°11' 18.0"	49°34' 54.0"	Agriculture/*Tavy*	4 km	Yes. Interview	Claim *V. rubra* present E and 2 km N

[1] Localities are listed in the order in which they were visited along the survey route. Localities with asterisks (*) indicate *Varecia* observations. Abbreviations: V = village; R = river; M = mountain; L = other locality.

[2] Malagasy vernaculars: *Tavy* = slash-and-burn agriculture, *Laly* = narrow swaths of forest cleared for the purpose of setting snare traps for lemurs, Zebu = cattle.

[3] Distance covered over which forest conditions were observed and surveyed (e.g., intact, secondary, agriculture).

[4] *Varecia* difficult to catch, so primarily *Eulemur fulvus* is hunted.

[5] *Eulemur fulvus* observed.

[6] Villagers described red form (i.e., *V. rubra*) but with *V. v. subcinta* coat pattern.

[7] Two captive *V. variegata* (kept as pets).

TPF 1995). We then traveled along the Andranofotsy River as far north as the village of Ambanivaletra. On 11 September, we began traversing the area between the Andranofotsy and the Antainambalana rivers, arriving at the village of Ankarongana. On 15 September, we returned to Maroantsetra traveling down the Antainambalana River in a dugout canoe, and noting forest condition along the shore and adjacent hillsides.

Results

In total, we covered over 120 km of trails in forest remnants. Table 1 provides the results of our geo-referencing and interviews, along with a summary of our findings on habitat for the 27 localities along our route. Habitats were significantly degraded throughout the region, with even intact forest showing evidence of human activity. Only 22% of the total linear distance surveyed was considered to be intact primary or secondary forest. Thirty-seven percent of the geo-referenced localities had one or more recent or active *laly*, and most areas (23 of 27) contained *tavy* (Table 1). In particular, areas thought to be relatively free of human disturbance during earlier surveys (CARE/WCS/TPF, 1995) were clearly used regularly for small scale *tavy* and wood gathering, and some showed evidence of *laly* as well (Table 1). Residents interviewed in 15 of 16 villages (94%) trap and eat *Varecia* despite knowing that it is prohibited by law (Table 1). Many villagers were aware of the declining numbers of ruffed lemurs, and suggested that their absence might be due to forest clearing and hunting. Villagers confirmed that *V. rubra* had disappeared from areas adjacent to villages where they had been present in the previous five years.

We sighted four *V. rubra* individuals in the region east of the Andranofotsy River, along the smaller Belampona River, prior to entering the Sahavary watershed (#5 in Fig. 1 and Table 1). These individuals were either resting or feeding on leaf tips or *Pandanus* seeds. They had large patches of white fur on the outer side of the ankle extending to the mid-thigh, a pelage pattern not seen in captivity. We later heard *Varecia* vocalizations on the west bank of the Andranofotsy at the village of Ampoantsatroka (#15 in Fig. 1 and Table 1). These two records indicate that *Varecia* still occurs between the Mahalevona, Andranofotsy and Antainambalana river drainages, and this is in agreement with interview results and the abundance of *laly* (Table 1). Most villagers indicated that *Varecia* were more active in December, a time when they are more frequently captured in *laly*.

At the village of Ankarongana, near the junction of the Antainambalana and Sahantaha rivers, villagers claimed that *V. rubra* was present to the north on Ambodi-Bilahay Mountain and to the east on Anjanaharibe Mountain (note that this is not the same location as the Réserve Spéciale d'Anjanaharibe-Sud lying further north). Residents of the nearby village of Sahantaha (#27 in Fig. 1 and Table 1) also stated that there were many *V. rubra* on Anjanaharibe Mountain. Furthermore, they related that it was not the "culture" of *varignena* (vernacular name for *V. rubra*) to cross the Antainambalana River, and that only *varikandana* (vernacular for *V. variegata*) is known from further west on Anjorompingotra Mountain.

Families living on both sides of the Antainambalana River at Sahantaha kept *V. variegata* as pets. The two pet lemurs we observed were captured as babies in *laly*, 1–2 km north of the village on the west side of the river, and both exhibited a *subcincta* coat pattern, the variety of *V. variegata* known from the west side of the Antainambalana River (Petter *et al.* 1977). These families regularly cross the river by canoe, taking chickens and other domestic animals with them, and presumably their pet *V. v. subcincta* arrived on the east side of the Antainambalana River in this manner.

Although we did not sight any wild *Varecia* between the Andranofotsy and Antainambalana rivers, villagers consistently referred to the ruffed lemurs in this area as *varignena* (i.e., *V. rubra*). Yet in the village of Manakana some informants described these animals as having a belt of white fur encircling the torso, as seen in the *subcincta* variety of *V. variegata* known from the west side of the Antainambalana River (Table 1; Petter *et al.* 1977).

Discussion

Our interviews with villagers suggest that the Antainambalana River currently remains the western limit of *V. rubra*'s range. The westernmost distribution of *V. rubra* that we were able to detect (through interviews) was near the confluence of the Antainambalana and Sahantaha rivers. *Varecia rubra* has been observed further northeast; several animals were sighted in the Besariaka forest corridor, about 20 km southwest of Andapa, in what is now part of the Makira Protected Area (Ranorovelohanta 1996). This is the northernmost confirmed report of *V. rubra* in recent years. Our sighting of *V. rubra* along the Belampona River was approximately 10 km east of a previous sighting near the village of Sahavary (Simons and Lindsay 1987). Limited observations of *Varecia* during our survey were likely due to their rarity and sparse distribution on account of hunting and habitat disturbance, as well as their relative inactivity at this time of year (*V. rubra*, for example, spends more time resting [~60%] in June – September than at other times of the year [Vasey 2005; see also Morland 1993]). Early September is also a period of limited fruit availability for *Varecia*, when even their keystone fruit *Canarium* is unavailable (Vasey 2000).

Villagers in the survey area noted only the presence of *V. rubra*, not *V. variegata*. However, the pelage pattern of *V. rubra* described by villagers at Manakana, between the Antainambalana and Andranofotsy rivers, is unusual, and seems to resemble that of a specimen on display at the American Museum of Natural History which has been described as a hybrid (Buettner-Janusch and Tattersall 1985). This AMNH specimen has a belt of white fur encircling its torso, similar to the *subcincta* variety of *V. variegata* known from west of the Antainambalana River (Petter *et al.* 1977; Simons and Lindsay 1987). However, as we saw no *Varecia* near Manakana village, any intimation concerning natural hybridization between *V. rubra* and *V. variegata* in this locality remains speculative — it may simply be clinal variation, as seen in *V. variegata* along the east coast of Madagascar (Vasey and Tattersall 2002).

Only 22% of the area surveyed in the region north of the Bay of Antongil was considered primary or secondary forest. Furthermore, *tavy* and *laly* were ubiquitous along the survey route. From these findings we conclude that the natural habitat of the westernmost populations of *V. rubra* is disappearing at a dramatic rate. At the time of our survey, populations of *V. rubra* west of the Masoala National Park appeared extremely fragmented and were all under threat of extirpation by trapping and hunting. In fact, it appeared that populations of *Varecia* between the Andranofotsy and Antainambalana rivers (south of the east-west trail we surveyed at latitude 15°08′15″S) were completely isolated from other populations. The recent establishment of protected forest blocks and forest corridors in the region was critical (Hekkala and Rakotondratsima 1999), as these will provide the only connections between certain *Varecia* populations that appeared entirely isolated in forest patches surrounded by spreading agricultural land. The only links between the Masoala National Park and the north-south belt of eastern rain forest in Madagascar are these passages in the Antainambalana and Andranofotsy river drainages, now part of the Makira Protected Area.

The establishment of such corridors, in the sense described by Holloway (2000), includes the replanting of native trees to reconnect the forest blocks. Although *Varecia* are known to be highly sensitive to habitat disturbance, their densities can become quite high in coastal regions experiencing frequent natural habitat perturbation (Vasey 1996, 1997), and they have even incorporated large portions of pioneering, invasive species into their diet in protected forests that are being allowed to recover from cyclone damage and human degradation (e.g., *Clidemia hirta*, *Cecropia peltata*; see Ratsimbazafy 2002; Ralainasolo *et al.* 2005). Forest corridors created north of the Bay of Antongil, especially when planted with native trees, may ultimately prove successful in maintaining and connecting *Varecia* populations. The next round of surveys and in-depth field studies should focus on an examination of how *Varecia* populations are adapting to conditions in and near forest corridors.

The establishment of protected areas, however, can comprise only one part of an effective conservation management plan for ruffed lemurs. As food, *Varecia* has dual status, being both less expensive and more tasty (according to local palates) than domestic meats, such as chicken and beef (Golden 2005). In the Makira region, these two factors are paramount in reinforcing hunting activity among remote, rural people who do not have the means to either buy or produce domestic meats (Golden 2005). As indicated above, residents trap and eat *Varecia* in all but one of the 16 villages visited in the region north of Antongil Bay. Hence, conserving *Varecia* will require multi-pronged efforts involving the establishment and maintenance of forest corridors, monitoring of the protected areas, and enforcement of environmental legislation, as well as environmental education and development programs that capitalize on and are sensitive to traditional beliefs and practices (including palates). The enduring value of the geo-referenced interviews and habitat survey presented here is that they can be used as comparators for future population and habitat assessments in the region north of the Bay of Antongil subsequent to the establishment of protected areas and allied conservation measures.

Acknowledgments

For their funding, we are indebted to the Wildlife Conservation Society (WCS) and the Center for Environmental Research and Conservation (CERC) at Columbia University. We gratefully acknowledge the permission granted by ANGAP and the Parc National Masoala to conduct surveys in the area. This work could not have been completed without the vital contributions of our Malagasy assistants. In particular, Messieurs Georges Rufin, Tata Giles Florent, Jacquelin Mila, Cyrien, and Jao Aridy provided daily insight into both the forest condition and village perspective on lemurs and habitat. We thank Stephen D. Nash, State University of New York, Stony Brook, for allowing us to adapt some of his line art for the inset in Figure 1.

Literature Cited

Balko, E. A. and H. B. Underwood. 2005. Effects of forest structure and composition on food availability for *Varecia variegata* at Ranomafana National Park, Madagascar. *Am. J. Primatol.* 66: 45–70.

Buettner-Janusch, J. and I. Tattersall. 1985. An annotated catalogue of Malagasy primates (Lemuridae, Indriidae, Daubentoniidae, Megaladapidae, Cheirogaleidae) in the collections of the American Museum of Natural History. *Am. Mus. Nov.* 2834: 1–45.

CARE/WCS/TPF. 1995. Proposition des limites du Parc National Masoala. Report by CARE International Madagascar, Antanarivo, Wildlife Conservation Society, New York, and the Peregrine Fund, Antananarivo.

Ganzhorn, J. U., B. Rakotosamimanana, L. Hannah, J. Hough, L. Iyer, S. Olivieri, S. Rajaobelina, C. Rodstrom and G. Tilkin. 1997. Priorities for Biodiversity Conservation in Madagascar. *Prim. Rep.*, *Special Issue* 48-1: 1–81.

Golden, C. D. 2005. Eaten to endangerment: Mammal hunting and the bushmeat trade in Madagascar's Makira Forest. Undergraduate Honor's thesis, Harvard University, Cambridge, MA.

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Groves, C. P. 2005. Order Primates. In: *Mammal Species of the World: A Taxonomic and Geographic Reference*, 3rd Edition, Vol. 1, D. E. Wilson and D. M. Reeder (eds.), pp.111–184. Johns Hopkins University Press, Baltimore.

Hekkala, E. R. and M. Rakotondratsima. 1999. Report on preliminary surveys for distribution and population genetic structure of the red-ruffed lemur (*Varecia variegata rubra*) in the Antainambalana/Andranofotsy River Basin of Madagascar: An assessment of forest remnants as corridors for conservation. Report, Wildlife Conservation Society (WCS), Antananarivo, Madagascar.

Holloway, L. 2000. Catalysing rainforest restoration in Madagascar. In: *Diversité et Endémisme á Madagascar*, W. R. Lourenço and S. M. Goodman (eds.), pp.115–124. Mémoires de la Société de Biogéographie, Paris.

IUCN. 2006. *2006 IUCN Red List of Threatened Species*. Website: <www.iucn.redlist.org>. Accessed 28 December 2006.

Kauffman, J. C. 2006. The sad opaqueness of the environmental crisis in Madagascar. *Conservation and Society* 4: 179–193.

Kremen, C., V. Razafimahatratra, R. P. Guillery, J. Rakotomalala, A. Weiss and J. Ratsisompatrarivo. 1999. Designing the Masoala National Park in Madagascar based on biological and socioeconomic data. *Conserv. Biol.* 13: 1055–1068.

Merenlender, A., C. Kremen, M. Rakotondratsima and A. Weiss. 1998. Monitoring impacts of natural resource extraction on lemurs of the Masoala Peninsula, Madagascar. Conservation Ecology 2. Website: <www.consecol.org/Journal/vol2/iss2/art5/>.

Morland, H. S. 1993. Seasonal behavioral variation and its relationship to thermoregulation in ruffed lemurs (*Varecia variegata variegata*). In: *Lemur Social Systems and Their Ecological Basis*, P. M. Kappeler and J. U. Ganzhorn (eds.), pp.193–203. Plenum Press, New York.

Petter, J. J., R. Albignac and Y. Rumpler. 1977. Mammifères, lémuriens (Primates, Prosimiens). *Faune de Madagascar* 44: 1–513. ORSTOM/CNRS, Paris.

Ralainasolo, F. B., H. J. Ratsimbazafy, V. H. Jeannoda and R. Letsara. 2005. Etude comportementale et nutritionelle de *Varecia variegata variegata* dans la forêt de Manombo, Madagascar. *Lemur News* (10): 22–25.

Randrianandianina, B. N., L. R. Andriamahaly, F. M. Harisoa and M. E. Nicoll. 2003. The role of the protected areas in the management of the island's biodiversity. In: *The Natural History of Madagascar*, S. M. Goodman and J. P. Benstead (eds.), pp.1423–1432. University of Chicago Press, Chicago.

Ranorovelohanta, R. 1996. Evaluation du rôle du corridor forestier de Besariaka à partir d'une analyse de sa diversité biologique. Mémoires de fin d'études, Université d'Antananarivo, Madagascar.

Ratsimbazafy, J. 2002. On the brink of extinction and the process of recovery: Responses of black-and-white ruffed lemurs (*Varecia variegata variegata*) to disturbance in Manombo forest Madagascar. PhD Dissertation, State University of New York, Stony Brook, New York.

Simons, H. J. and N. B. Lindsay. 1987. Survey work on ruffed lemurs (*Varecia variegata*) and other primates in the northeastern rainforests of Madagascar. *Primate Conserv.* (8): 88–91.

Soulé, M. 1987. Introduction. In: *Viable Populations for Conservation*, M. Soulé (ed.), pp.1–10. Cambridge University Press, Cambridge, UK.

Tattersall, I. 1977. Distribution of lemurs. Pt. 1: The lemurs of northern Madagascar. *Ann. New York Acad. Sci,* 293: 160–169.

Tattersall, I. 1982. *The Primates of Madagascar*. Columbia University Press, New York.

Vasey, N. 1996. Clinging to life: *Varecia variegata rubra* and the Masoala Coastal Forests. *Lemur News* 1(2): 7–9.

Vasey, N. 1997. How many red ruffed lemurs are left? *Int. J. Primatol.* 18: 207–216.

Vasey, N. 2000. Plant species composition of diet in two sympatric lemurs: *Varecia variegata rubra* and *Eulemur fulvus albifrons*. *Am. J. Phys. Anthropol.* [suppl] 30: 309–310.

Vasey, N. 2002. Niche separation in *Varecia variegata rubra* and *Eulemur fulvus albifrons*: II. Intraspecific patterns. *Am. J. Phys. Anthropol.* 118: 169–183.

Vasey, N. 2005. Activity budgets and activity rhythms in red ruffed lemurs (*Varecia rubra*) on the Masoala Peninsula, Madagascar: Seasonality and reproductive energetics. *Am. J. Primatol.* 66: 23–44.

Vasey, N. and I. Tattersall. 2002. Do ruffed lemurs form a hybrid zone? Distribution and discovery of *Varecia*, with systematic and conservation implications. *Am. Mus. Nov.* (3376): 1–26.

Authors' addresses:

Evon R. Hekkala, Department of Biology, University of Nevada, Reno, NV 89557, USA, e-mail: <ehekkala@yahoo.com>.

Marius Rakotondratsima, Peregrine Fund Madagascar Project, B.P. 4113, Antananarivo 101, Madagascar, e-mail: <pfundmad@wanadoo.mg>.

Natalie Vasey, Department of Anthropology, Portland State University, Portland, OR 97207, USA, e-mail: <nvasey@pdx.edu>.

Received for publication: January 2007
Revised: April 2007

Primate Conservation 2007 (22): 97–105

Census and Conservation Assessment of the Red Colobus (*Procolobus rufomitratus tephrosceles*) on the Ufipa Plateau, Southwest Tanzania: Newly-discovered, Threatened and Extinct Populations

Tim R. B. Davenport , Noah E. Mpunga and Sophy J. Machaga

Wildlife Conservation Society, Mbeya, Tanzania

Abstract: Surveys were carried out in the last remaining forests of southwest Tanzania's Ufipa Plateau to determine the presence, distribution and abundance of the red colobus *Procolobus rufomitratus tephrosceles*. In 2002, we investigated the Chala and Misheta forests. Chala was in poor condition, and no primates were seen, although it is not known if red colobus ever existed there. There was almost no natural forest remaining in Misheta, and we consider its red colobus population to be now extinct. Analysis of satellite imagery revealed that the Nsangu Forest no longer exists, and we assume its population is also now extinct. In August 2006, a previously undocumented red colobus population was discovered in Mbuzi, 55 km north of the only other extant population in Mbizi. Complete count censuses were performed in Mbuzi and Mbizi. A total of 1,217 individuals were recorded in Mbizi and 137 individuals in Mbuzi, giving a combined total of 1,354 individual Ufipa red colobus. Mean group size in Mbizi was 40.56 (n = 30; SD = 6.57; range 30–56) and in Mbuzi was 34.25 (n = 4; SD = 13.07; range 24–50). The Mbuzi subpopulation may no longer be viable and the subpopulation of Mbizi may be declining. Both forests are heavily degraded and require urgent conservation attention.

Key Words: red colobus, *Procolobus rufomitratus tephrosceles*, census, distribution, Ufipa, Tanzania

Introduction

Red colobus are represented by five species and eighteen taxa in evergreen forests across equatorial Africa (Struhsaker 1975, 2005; Kingdon 1997; Grubb *et al*. 2003). None of these taxa is sympatric (Struhsaker 2005) and most comprise a single geographical population. A conspicuous exception however, is the variously named Uganda, Central African or ashy red colobus *Procolobus rufomitratus tephrosceles*, thought to be restricted to five discrete forests, but spread across 1,000 km of East Africa (Rodgers 1981). These distinct populations are found in western Uganda in Kibale, and in western Tanzania in Biharamulo on the southwestern shores of Lake Victoria, Gombe and Mahale Mountains on the eastern shores of Lake Tanganyika, and Mbizi and Misheta on the Ufipa Plateau (Rodgers 1981; Rodgers *et al.* 1984).

Struhsaker (2005) described the conservation status of *P. r. tephrosceles* as 'Vulnerable' throughout its range, with perhaps the only viable population being in Kibale with at least 17,000 individuals. However, long-term studies have indicated significant declines in Kibale's red colobus numbers, including a >43% decline over 24–30 years (Mitani *et al.* 2000; Struhsaker 2005) and a 40% decline in 28 years in a different part of the forest (Chapman *et al.* 2000). Similarly, red colobus group sizes declined by almost 50% over a 25-year period (Stanford 1998). At least some of these declines are the result of predation by chimpanzees *Pan troglodytes* (Watts and Mitani 2002), with between 16 and 40% annual red colobus mortality attributed to them (Wrangham and Bergmann-Riss 1990). There are insufficient data for Mahale, although in one small portion of the forest the red colobus population was stable between 1996 and 2002 (Uehara 2003) in an area where chimpanzee predation is between 1 and 9% per year (Ihobe and Uehara 1999; Boesch *et al.* 2002).

The southernmost population of *P. r. tephrosceles* has previously been subject to just one investigation; by Rodgers *et al.* (1984), who studied the status of Mbizi Forest and its red colobus population in early April 1980. A census produced an estimate of 250 individuals in the ~15% of the forest surveyed, although a total population was not determined as there were no data on red colobus density in the remaining 85% of the habitat. This study also reported the presence of another population of *P. r. tephrosceles* in the Misheta forests (Fig. 1), although no further information was reported (D. Moyer and

R. Stjernstedt, in Rodgers *et al.* 1984). A third subpopulation was subsequently recorded in a forest patch near the village of Nsangu during an ornithological survey (Moyer and Stjernstedt 1986). No estimates have been made of the abundance or full extent of the distribution of either the Misheta or Nsangu subpopulations, and there have been no subsequent investigations of any of the red colobus in Ufipa.

Mbizi Forest sits on the escarpment overlooking Lake Rukwa. Described as a relict montane cloud forest (Kerfoot 1963), it reaches 2,441 m above sea level, and experiences frost more than 50 nights a year. As a consequence, its red colobus population endures ecological conditions very different from those of the other four populations. Although regarded as the same taxon as those further north, they are geographically isolated by 350 km. The Mbizi animals differ from all other *P. r. tephrosceles* in having longer and thicker body hair, giving a woolly appearance, and shorter tails and a greater incidence of stump tails. These two characteristics are presumably indicative of adaptation to the cold (Rodgers *et al.* 1984). They also differ in having longer grayish cheek whiskers and usually a fuller red cap extending more down the forehead and the side of the face (Rodgers *et al.* 1984). Comparative genetic analyses will reveal how close the populations are.

In order to ascertain the current conservation status of all red colobus subpopulations in Ufipa, as well as to make comparisons with data obtained 26 years earlier and assess current habitat quality, we investigated all the forests in Ufipa known to have red colobus, as well as an additional one that we had heard may have harbored red colobus. We subsequently carried out complete counts employing sweep census techniques of all known red colobus subpopulations, and also assessed human impacts we recorded along the transects.

Methods

Study sites

All the montane forests investigated in this study are found on the Ufipa Plateau in Rukwa Region, southwest Tanzania (Fig. 1). They are separated by a range of vegetation types, the most notable of which is a unique forb-rich montane grassland that forms a mosaic with sparse woodland and savanna (Rodgers *et al.* 1984). Mbizi (spelt with a 'z' in the local KiFipa language and an 's' in KiSwahili) incorporates 2,930 ha of montane 'cloud' forest between 2,100 to 2,441 m above sea level, and within the 3,248 ha Lyambo Hills Forest Reserve. It is 14 km north of the town of Sumbawanga on the escarpment overlooking Lake Rukwa (7º40'S, 31º40'E) within the administrative district of Sumbawanga Urban. The vegetation and conservation of Mbizi have been reported elsewhere (Mtuy and Mkude 1974; Ruffo and Mabula 1987; Kikula 1979; Rodgers *et al.* 1984; Davenport 2002, 2005). Mbizi represents the easternmost portion of congolian forest in Tanzania and is characterized by 40 meter-high *Euphorbia obovalifolia* trees protruding through the canopy. The forest has been heavily logged over the years, and is especially susceptible to burning. Nsangu sits on the same escarpment 35 km southeast of Mbizi (08º03'S, 31º53'E), whereas the Misheta forest patches (08º17'S, 31º34'E) lie on the west-facing escarpment overlooking Lake Tanganyika, some 55 km to the south of Mbizi. Mbuzi Forest is situated on the eastern ridge of the Ufipa Plateau in Nkansi District, 14 km northeast of Chala and 54 km northwest of Mbizi (07º29'S, 31º32'E). This forest has no official protection status and covers just 611 ha between 1990 and 2.122 m above sea level, the highest point being the peak of Mt. Kisusi.

Study methods

Different methods were employed to determine the distribution and abundance of red colobus in Ufipa. The first sought to ascertain presence/absence of red colobus in various forests, and the second was employed to census the monkeys and assess human activity. The continuing presence of red colobus in the Misheta forests and speculation about their presence in Chala were investigated by TD in November 2002, when both forests were visited on foot. Subsequently, orthorectified LandSat5 TM satellite images (CSIR, South Africa; p171r065) acquired on 12 July 2006, were analyzed using ArcView 3.2 and ERDAS 9.1 software to confirm the amount of forest cover in Misheta and to investigate forest cover in Nsangu. The presence of red colobus in Mbizi has been known (Rodgers 1981; Rodgers *et al.* 1984) and monitored (Davenport 2002, 2005) for some time, and in Mbuzi Forest was verified by sight on the 26 August 2006.

In order to ascertain the red colobus population in Mbizi and Mbuzi as accurately as possible, the 'complete count' method, accepted as being the most accurate primate census technique, was used (Struhsaker 1981; Whitesides *et*

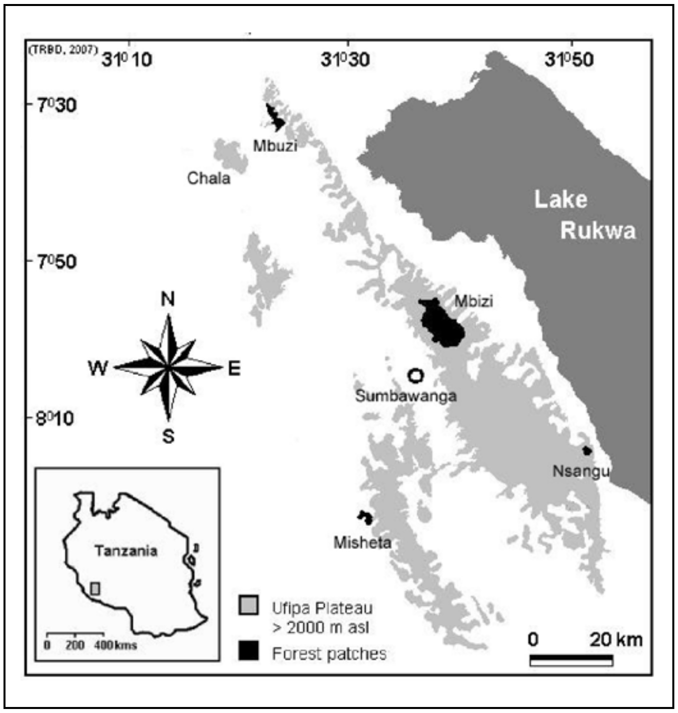


Figure 1. Map of Ufipa Plateau, southwest Tanzania, showing red colobus sites and the location of Mbizi and Mbuzi.

al. 1988; Plumptre and Cox 2006). This method was made easier by the small total areas of each forest, and the fact that they are heavily degraded and interspersed by open pasture. To increase accuracy, collection methods were based on direct observations of individual animals only, thus adapting the gorilla census methods developed by Harcourt and Fossey (1981) and McNeilage *et al.* (2001), who carried out complete counts of indirect sign. In this way, the aim was to arrive at a population number that was neither an estimate nor extrapolation based on density, but an absolute figure (Davenport *et al*. in press).

The censuses were carried out over 12 days in Mbizi (9–20 August 2006) and three days in Mbuzi (26–28 August 2006). In each case, four teams (each consisting of one experienced WCS member of staff and one local hunter from a village adjacent to the forest) walked parallel pre-planned linear transects 100 m apart. Transects were usually perpendicular to the length of discrete forest patches. Using compass and GPS units (Garmin 3+), the teams followed the same direction but taking the path of least resistance when necessary, rather than cutting through thick understorey. When a team encountered a red colobus group, enough time was taken to allow an accurate count of individuals in the group before continuing along the transect. Unlike other species (Davenport *et al.* in press) and contrary to previous reports (Rodgers *et al.* 1984) the colobus rarely moved far and usually permitted close inspection of the entire group; a process facilitated by the severely degraded nature of the forests. Total counts were made and the number of clinging infants in the group, time, vegetation type, GPS location, altitude and association with other species were recorded.

Grid reference positions of each group were also recorded by GPS every 15 minutes upon sighting. All observation data were also geo-referenced and accompanied with a distance and compass bearing between the observers and the animals. Discrete groups were generally easy to identify. However, to avoid confusion, the direction they moved during the encounter was recorded and cross-checked *a posteriori.* Groups were considered unique if they were recorded more that 200 m apart at the same time, and subsequently moved in different directions, and/or they were also seen at the same time by different observation teams, spending more than 75% of the observation time at a distance of at least 200 m apart. This was also verified *a posteriori.* In addition, all signs of human activity within each forest, such as saw pits, charcoal pits, tree felling, cultivation, traps and burned areas were recorded and GPS locations taken.

Results

The presence/absence survey in Misheta revealed that there is little if any forest left of any consequence in the area. The few remaining indigenous trees were found in narrow stream gullies, but no monkeys were seen and neither did it seem possible that any could still inhabit the site. Remote imagery of the whole area confirmed the absence of any forest stands, and we must assume that the Misheta population of red colobus is now extinct. The survey in Chala revealed that there are no red colobus in the forest, and that forest quality is extremely poor. It is unclear if the monkey ever existed in Chala. Remote image analysis demonstrated that there are no forest patches left in or near Nsangu, and this was corroborated by aerial observations (D. Moyer pers. comm.). We assume therefore that the Nsangu population of *P. r. tephrosceles* is also now extinct. The continuing presence of red colobus in Mbizi was already known (Davenport 2005). However, rumors from village hunters of red colobus in Mbuzi Forest were confirmed by sightings on the 26 August 2006. This represents a new and previously unrecorded population of *P. r. tephrosceles*.

During the census, 174.4 km of transect were walked in Mbizi and 18.3 km in Mbuzi. Table 1 provides information on all the groups found in both forests and the maximum number of individuals (and clinging infants) counted in each group. A total of 34 distinct groups of red colobus were encountered during the census; 30 groups in Mbizi and four in Mbuzi. A population of 1,217 *P. r. tephrosceles* individuals were recorded in Mbizi and 137 individuals in Mbuzi, giving a combined total of 1,354 for the Ufipa red colobus population. The mean group size recorded in Mbizi was 40.56 (n = 30; SD = 6.57; SE = 1.20; range 30–56 individuals) and in Mbuzi was 34.25 (n = 4; SD = 13.07; SE = 6.54; range 24–50 individuals). A total of 53 clinging infants were counted in Mbizi, giving a mean of 1.77 infants per group across all groups (n = 30), and a mean of 3.79 infants per group, amongst groups in which infants were recorded (n = 14). The ratio of infants to group size ranged from 0 to 20.6% with a mean of 4.36%. In Mbuzi, a total of 15 clinging infants were counted in just one of the four groups seen, giving a mean of 3.75 infants per group across all groups (n = 4). The ratio of infants to group size ranged from 0 to 30% with a mean of 7.5%.

Of the 34 groups encountered, 6 (17.6%) were found feeding alongside Sykes' monkeys *Cercopithecus mitis*, the only other diurnal primate in these forests. This represents a basic total rate of association similar to the 19.6% documented in Kibale by T. T. Struhsaker (in Rodgers *et al.* 1984). Figures 2 and 3 show the location of all *P. r. tephrosceles* groups recorded in Mbizi and Mbuzi, respectively. The monkeys rarely moved more than 200 m from a central fixed point in a day, and on many occasions two discrete groups were found 200 to 300 m apart (Table 1; Figs. 2 and 3). In Mbizi, red colobus were mainly concentrated in the southern section, and in Mbuzi the few groups were found in the central south. According to many inhabitants of villages surrounding Mbizi, red colobus are still occasionally hunted. Despite this, however, they were not shy of humans, rarely moving away and usually just continuing to feed.

A variety of human activities were observed in the two forests. Large numbers of sawpits and snares were recorded in both. Mbizi has been heavily degraded in the past by logging, fire, charcoal burning, and hunting. At the moment, these activities seem to have reduced slightly since two forest guards began patrols in late 2005. However, there was still much evidence of cultivation, with gardens of marijuana, tobacco and garlic inside the forest, as well as tree-felling for firewood collection, and evidence of burning. Mbuzi is being further fragmented by considerable cultivation of beans and wheat, logging for timber and fuel, and fires that burn regularly. Despite heavy hunting pressure in both forests, a few other mammals of interest were recorded. In Mbizi these included red duiker *Cephalophus harveyi*, bush duiker *Sylvicapra grimmia*, large spotted genet *Genetta maculata*, bush pig *Potamochoerus larvatus*, serval *Felis serval*, chequered elephant shrew *Rhynchocyon cirnei*, and in Mbuzi there was evidence of leopard *Panthera pardus*, bushpig and bushbuck *Tragelaphus scriptus*.

Discussion

Whilst an estimate of the population size of red colobus *Procolobus rufomitratus tephrosceles* in 15% of Mbizi has been made (Rodgers *et al.* 1984), this study is the first complete assessment of the distribution, conservation status and abundance of the southernmost population of *P. r. tephrosceles* across Ufipa. The value of red colobus monkeys as indicators of forest condition has been well documented (Struhsaker 2005; Marshall 2007; Marshall *et al.* in press). A number of authors have demonstrated a strong correlation between a decrease in *P. r. tephrosceles* density and group size, with declining habitat quality (Skorupa 1986, 1988; Struhsaker 1975, 1997; Chapman and Chapman 1999; Chapman *et al.*

Table 1. Group identity number (ID), location (Grid reference) in decimal degrees, maximum number of individuals counted (∑) per group and in parentheses the maximum number of infants counted per group (In), and ratio of infants to adults as a percentage (%In), in the Mbizi and Mbuzi Forests.

ID	Grid reference	∑ (In)	% In
	Mbizi		
1	S7.89904 E31.69218	31	0
2	S7.88995 E31.67359	32 (4)	12.9
3	S7.88023 E31.67464	38 (5)	13.2
4	S7.88961 E31.68224	30	0
5	S7.86249 E31.65258	40	0
6	S7.89356 E31.67520	37 (1)	2.7
7	S7.84841 E31.65325	39 (2)	5.1
8	S7.88213 E31.68091	49 (5)	10.2
9	S7.90193 E31.68434	44	0
10	S7.89427 E31.67757	42 (2)	4.8
11	S7.87525 E31.68810	40 (4)	10
12	S7.88907 E31.67806	35	0
13	S7.89173 E31.66530	45 (5)	11.1
14	S7.90657 E31.68165	47	0
15	S7.89958 E31.67044	34 (7)	20.6
16	S7.88583 E31.65797	46	0
17	S7.88422 E31.66057	40 (2)	5
18	S7.87177 E31.65880	48	0
19	S7.88407 E31.66187	49	0
20	S7.88136 E31.67744	50	0
21	S7.88125 E31.65471	36	0
22	S7.88688 E31.67228	43 (5)	11.6
23	S7.87702 E31.68776	35	0
24	S7.88170 E31.66586	35(1)	2.9
25	S7.88099 E31.68995	49	0
26	S7.88469 E31.67229	56(7)	12.5
27	S7.87575 E31.67677	37	0
28	S7.85347 E31.65170	33	0
29	S7.88993 E31.68959	41	0
30	S7.87654 E31.66232	36(3)	8.3
	Total	*1217(53)*	
	Mean	*40.56*	4.36
		(SD=6.57; SE=1.20)	
	Mbuzi		
31	S7.50955 E31.38645	50 (15)	30
32	S7.51039 E31.38574	40	0
33	S7.51060 E31.38017	23	0
34	S7.50866 E31.37732	24	0
	Total	*137 (15)*	
	Mean	*34.25*	7.5
		(SD=13.07;SE=6.54)	
	Ufipa Total	**1354 (68)**	
	Mean	**39.82**	**4.73**
		(SD=7.60; SE=1.30)	

2000, 2006). Gillespie and Chapman (2001) meanwhile, demonstrated a relationship among group size, day range and food availability, but not necessarily between any two variables alone. They showed that red colobus can be food limiting and deplete forest patches.

The status of *P. r. tephrosceles* in Ufipa seems representative of the condition of Ufipa's few remaining forests. Our data have shown that two subpopulations of *P. r. tephrosceles* in Ufipa, those in Misheta and Nsangu forests, are now almost certainly extinct. The discovery of a previously unknown subpopulation in Mbuzi is encouraging. However, it was clear even before the census was carried out that this 'new' subpopulation and its habitat were also at risk of imminent extinction. Rukwa is the furthest administrative region from Dar es Salaam, with limited resources for the environment (Davenport 2002). The fact that so little of Ufipa's natural forests now remain, and that their flagship species is now seriously threatened, is unfortunately understandable.

Many primate census methods have been developed and compared (Struhsaker 1981, 2002; Brockelman and Ali 1987; Plumptre and Cox 2006; Rovero *et al.* 2006). Given the small and highly fragmented nature of both Mbizi and Mbuzi forests, we were able to perform a complete count, thus ensuring a very accurate population estimate. This method relies on locating every group and ensuring that each is unique (Davenport *et al.* in press). The survey protocol we used, however, in small fragmented forests with relatively immobile study animals, give us confidence that most, if not all, currently existing groups (and individuals within them) were located and counted as accurately as possible. Interestingly, Rodgers *et al.* (1984) reported that most groups they observed were shy of humans, with a flight distance of about 65 m. The dense nature of the forest and the fact that the monkeys disappeared into the forest on seeing humans hampered their research. This was not the case during this study, with the monkeys rarely moving away, usually continuing to feed, and thus permitting complete counts to be made with relative ease. We estimated an average flight distance of <30 m.

Our data show that a total of at least 1,354 red colobus survive on the Ufipa Plateau, with 1,217 in Mbizi and 137 in

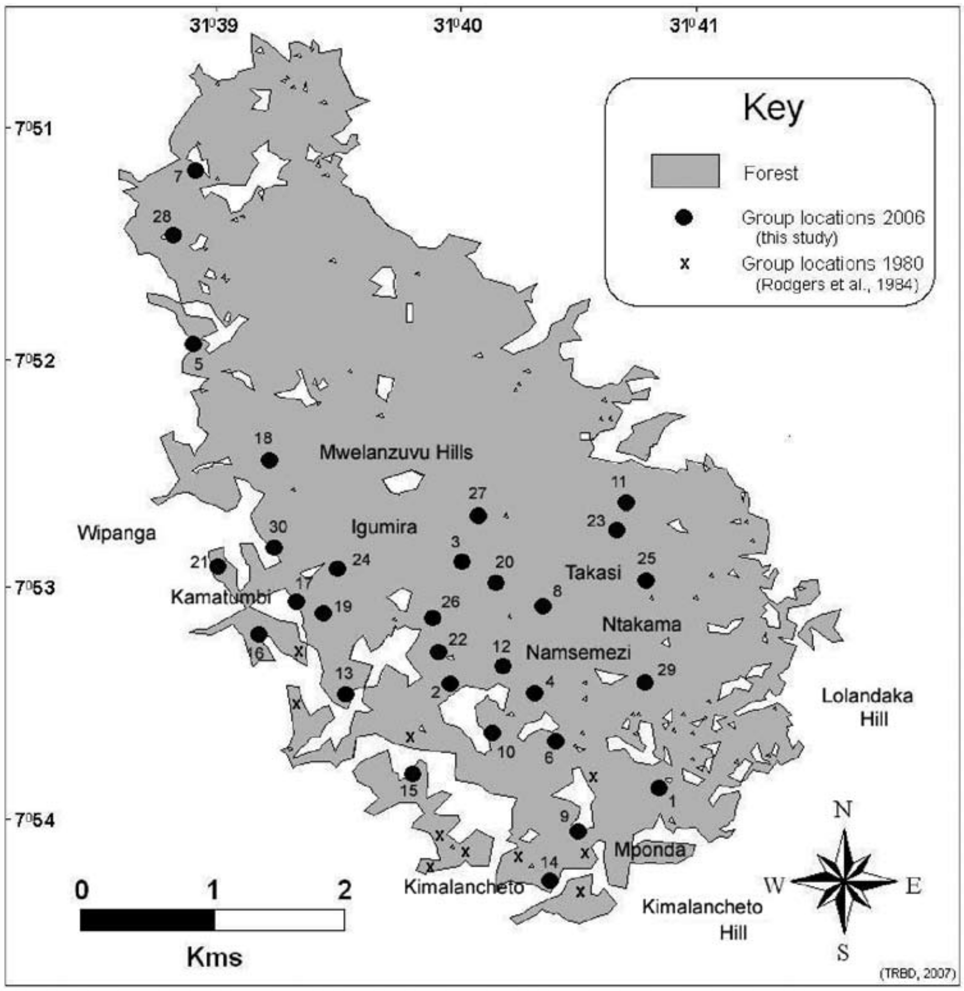


Figure 2. Map of Mbizi Forest showing locations of all groups encountered in this study and in the last study of 15% of the forest 26 years earlier. Group numbers correspond to the data in Table 1.

Mbuzi. These numbers are low, and it must be assumed that this southernmost population of *P. r. tephrosceles* is severely threatened. Mbuzi's total of 137 individuals is far below the long-term minimum effective breeding population (Harcourt 2002), and it is probable that this subpopulation is no longer viable. The mean group size of 34.25 is low and is similar to that of 30 for heavily logged forest in Kibale (Chapman *et al.* 2000). With just four groups remaining and an unmanaged forest being cut down for agriculture, there are few grounds for optimism unless immediate action is taken.

A total of 1,217 animals in Mbizi is more than had been anticipated given the amount of forest degradation observed over the last seven years (Davenport 2005). As no estimate of the total population of Mbizi was made in the previous study in 1980 (Rodgers *et al.* 1984), it is difficult to make categorical statements on population trends. However, some simple comparative analyses are possible, based in part on the map in Figure 2 and the figures in Table 2. Rodgers *et al.* (1984) reported 10 groups with a mean of 25 individuals per group occurring in 15% of 3,000 ha of Mbizi. Figure 2 illustrates the approximate location of the groups they counted, as well as the location of all groups recorded in this current study. It would seem from the map that in 1980 there were more groups in the 15% (known as 'Kimalancheto') than were recorded in 2006. This is corroborated by the group density (Table 2) which was 2.22 groups/km² in 1980, but 1.02 groups/km² in 2006 for the entire forest and 0.75 groups/km² for approximately the same 15% of forest studied in 1980. This represents a 66.2% reduction in group density in Kimalancheto. However, individual density for the same area seems to have remained stable, being 0.018 individuals/km² in 1980 and 0.018 individuals/km² in 2006. The value for the entire forest meanwhile, was little higher at 0.024 individuals/km². The difference between the reduced group density and the stable individual density in Kimalancheto may be explained by the difference in mean group size, which in 1980 was estimated at 25 animals per group, but in 2006 was 41.5 for Kimalancheto, and 40.56 for the entire forest.

Although these data seem to suggest that the total red colobus population is stable in terms of overall numbers of individual monkeys, there are a number of reasons why we believe this may not be the case. Firstly, mean group size (25) in 1980 was an estimate, made because entire groups were difficult to see. It is possible that these were conservative estimates and the real mean group size was larger. Today the forest is relatively easy to walk through, indicative not of a return to a more primary and clear-understorey condition, but because the forest patches have been greatly reduced by charcoal manufacture, fuelwood collection and burning. Secondly, comparisons of areas photographed during the 1980 census (T. T. Struhsaker pers. comm.) with the same areas in 2006 reveal extensive habitat degradation over the last 26 years. With such a marked reduction in forest condition in Kimalancheto, and continued hunting, it is unlikely that the population would have remained stable. Finally, there is a much reduced group density (Table 1) and when coupled with habitat loss and the possibility of group size under-estimates, it is more likely that there has been a reduction in total population size, both in Kimalancheto and Mbizi as a whole. This is, however, conjecture.

The vast majority of *P. r. tephrosceles* groups in Mbizi were located in the south and west of the forest (Fig. 2), with none in the more northeast or near the forest edge in the southeast. Mbizi is made up of small inter-connected forest patches which are generally larger and wetter in the south, and smaller, drier and more degraded in the north and east close to the escarpment overlooking Lake Rukwa. The southwest also has taller trees and is lower in altitude, and thus presumably warmer. The northeast is more remote and less visible from the road to Sumbawanga. It has probably been more extensively hunted as a result. According to local villagers red colobus used to inhabit all portions of the forest, and it is probable that a number of factors, including habitat heterogeneity and vegetation structure (Oates *et al.* 1990; Rovero and Struhsaker 2007) due to forest damage, are influencing this distribution.

Comparisons with data on *P. r. tephrosceles* collected over 28 years in Uganda's Kibale Forest (Chapman *et al.* 2000; Mitani *et al.* 2000; Table 2) further highlight the precarious situation of the Ufipa red colobus. In unlogged portions of Kibale, group density was recorded from 5.46 to 5.5 groups/km². Even heavily logged areas had between 3.08 and 4.43 groups/km², all considerably greater than the 1.02 and 1.53 groups/km² in Mbizi and Mbuzi respectively. Similarly, individual densities in unlogged parts of Kibale of between 1.063 and 0.56 indivs/km², although greatly reduced over 28 years, in part due to predation by chimpanzees, and the densities in heavily logged forest of between 0.567 and 0.292 indivs/km², are all considerably higher than the 0.24 and 0.045 indivs/km² recorded respectively in Mbizi and Mbuzi. Clearly the Ufipa animals now exist at very low individual densities. Interestingly, although the mean group size of 34.25 (n = 4) in Mbuzi is undoubtedly low, the mean group size of 40.56 (n = 30) in Mbizi is more comparable with the Kibale figures of 40 and 41 for unlogged and lightly logged forest. Given the highly disturbed nature of Mbizi (Rodgers *et al.* 1984; Davenport 2002, 2005) and the fact that most colobines have been shown to demonstrate significantly smaller group sizes in heavily disturbed areas (Marshall *et al.* in press), this is perhaps surprising. However, Struhsaker (1975) and Skorupa (1988) recorded average group sizes of 50 and 47 in unlogged and lightly logged parts of Kibale respectively, and it may be that these figures are more representative of the norm, and the Mbizi mean group size does reflect a reduction. Only long-term monitoring will shed more light on this.

A total of 53 clinging infants were observed in Mbizi. This equates to 1.76 infants per group and represents a mean ratio of infants to adults in a group of 4.36%. In Mbuzi, we saw 15 clinging infants, equating to 3.75 per group and a mean ratio of 7.5%. However, all infants in Mbuzi were seen in one large group of 50 individuals. That the majority of groups in Mbizi had no infants is of interest. We are confident that very few, if any, infants were missed and so must seek an alternative explanation. A reduction in food availability has been

Table 2. Group density, individual density and mean group size for the Mbizi and Mbuzi forests, and comparisons with figures for different parts of Kibale in western Uganda, and Mbizi in 1980.

	Kibale 1981 Chapman *et al.* (2000)	**Kibale 1997 Chapman *et al.* (2000)**	**Mbizi 1980 Rodgers *et al.* (1984)**	**Mbizi 2006 This study**	**Mbuzi 2006 This study**
	Group density (groups/km²)				
Unlogged	5.46	5.5	—	—	—
Lightly logged	5.78	4.35	—	—	—
Heavily logged	3.08	4.43	2.22	1.02 (0.75)	1.53
	Individual density (individuals/km²)				
Unlogged	1.063	0.56	—	—	—
Lightly logged	0.71	0.459	—	—	—
Heavily logged	0.567	0.292	0.018	0.024 (0.18)	0.045
	Group size (mean)				
Unlogged	—	40	—	—	—
Lightly logged	—	41	—	—	—
Heavily logged	—	30	~ 25	40.56 (41.5)	34.25

Figures in parentheses indicate analysis for groups 6, 9, 10, 13, 14, 15 from the same 15% of the forest surveyed in 1980.

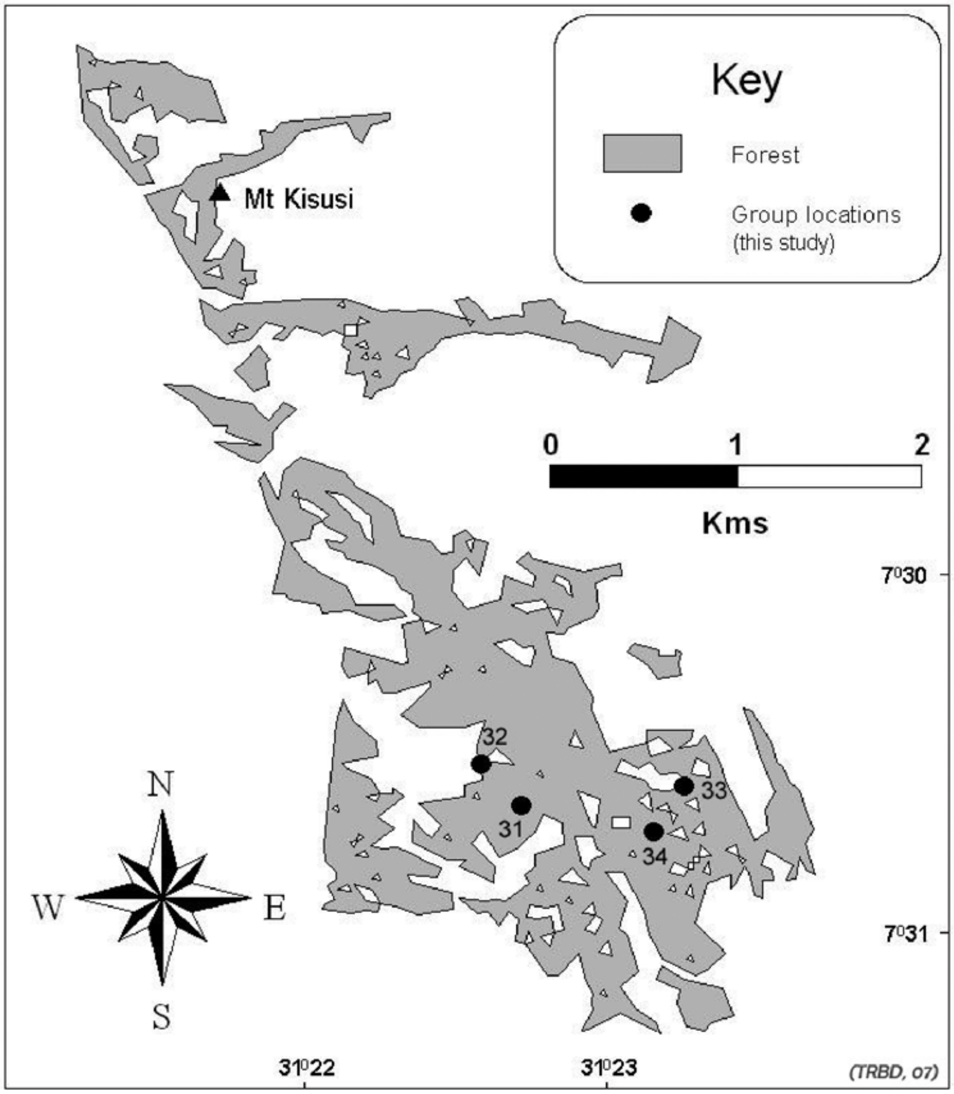


Figure 3. Map of Mbuzi Forest showing locations of all groups encountered in the study. Group numbers correspond to the data in Table 1.

documented to lead to increased infant and juvenile mortality (Chapman *et al.* 2000), and although seasonality cannot be ruled out, it is likely that this reflects a stressed population.

The main human impacts recorded in both Mbizi and Mbuzi were logging, hunting and agricultural encroachment. Hunting of bush pig, bushbuck and red duiker continues, and hunters were observed and snares found in the forest. The fact that all these species still survive in Mbizi is, however, a great surprise given the hunting intensity and forest damage. Two red duiker were seen, and whilst it is assumed that they are *Cephalophus harveyi* further work is planned to confirm this. *Procolobus r. tephrosceles*, meanwhile, is still hunted although it was difficult to know to what extent. We were given a skull and a skin from hunters who claimed that the skin is used for witchcraft. However, it is also hunted for food and the extent of this is the subject of on-going research. Burning and fire, caused mainly by hunters, pastoralists and neighbouring subsistence farmers, and originating from both inside and outside the forest are a major threat to the integrity of both Mbizi and Mbuzi. Mbizi's forest grassland mosaic with exposed ridges and finger-like extensions of forest becomes more rapidly isolated by fire, and therefore more accessible to human disturbance (Rodgers *et al*. 1984; Davenport 2002). The many footpaths and one motorable road that run through the forest also continue to contribute to fragmentation (Davenport 2005).

There needs to be immediate intervention if Mbuzi is not to be lost completely following the recent fate of both the Misheta and Nsangu forests. The forest patch is very small, isolated and has no protected status or management. It is also being rapidly fragmented by the cultivation of beans and wheat, logging, and regular burning. The forest still has value as a water catchment for a number of communities, especially the adjacent villages of Swaila and Majengo, and is also the only source of fuelwood and non-timber forest products for these villages and beyond. Mbizi meanwhile, is the only remaining montane forest of any size in Ufipa, the only source of water for Sumbawanga's growing population, and probably the last refuge for the red colobus in Ufipa. Unsustainable human activities such as clearing for agriculture, hunting, charcoal manufacture, and burning need to be much better managed (Davenport 2002). Red colobus are selective folivores (Gillespie and Chapman 2001), sensitive to habitat degradation, and are very vulnerable to hunting (Struhsaker 1975, 1997, 2005; Waltert *et al.* 2002). Management that protects closed-canopy, old growth forest is essential for the survival of this sensitive forest primate (Marshall 2007). In the case of the last remaining forest patches of Ufipa, such management is also needed for the future of Sumbawanga's vital water resources, and needs to begin immediately.

Acknowledgments

This work was funded by the Wildlife Conservation Society through its Southern Highlands Conservation Programme. Special thanks to Karen and Dan Pritzker and an anonymous donor. Research permission was granted by the Tanzania Wildlife Research Institute, Tanzania Commission for Science and Technology, Tanzania Forestry and Beekeeping Division, and Sumbawanga Municipal Council. Buto Kilasa, Sylvanus Kimiti, Atupele Mwamtobe, Obadia Mwaipungu, Willy Mwalwengele, and Alex Mnakabenga provided valuable field assistance. Thanks to Daniela De Luca, Tom Struhsaker, Kirstin Siex, Francesco Rovero, Andrew Marshall, Guy Picton Phillipps, David Moyer, Tim Caro, Monique Borgerhoff Mulder, and the anonymous referees for advice and/or comments on various drafts of the manuscript.

Literature Cited

Boesch, C., S. Uehara and H. Ihobe. 2002. Variations in chimpanzee-red colobus interactions. In: *Behavioural Diversity in Chimpanzees and Bonobos*, C. Boesch, G. Hohmann and L. F. Marchant (eds.), pp.221–230. Cambridge University Press, Cambridge, UK.

Brockelman, W. Y. and R. Ali. 1987. Methods of surveying and sampling forest primate populations. In: *Primate Conservation in the Tropical Rain Forest*, C. W. Marsh and R. A. Mittermeier (eds.), pp.23–62. Alan R. Liss, New York.

Chapman, C. A. and L. J. Chapman. 1999. Implications of small scale variation in ecological conditions for the diet and density of red colobus monkeys. *Primates* 40: 215–231.

Chapman, C. A., S. R. Balcomp, T. R. Gillespie, J. P. Skorupa and T. T. Struhsaker. 2000. Long-term effects of logging on African primate communities: a 28-year comparison from Kibale National Park, Uganda. *Conserv. Biol.* 14: 207–217.

Chapman, C. A., J. L. Michael and H. A. C. Ealey. 2006. What hope for African primate diversity? *African J. Ecol.* 44: 116–133.

Davenport, T. R. B. 2002. The conservation of Mbizi Forest, Sumbawanga, Rukwa Region. Report, Wildlife Conservation Society (WCS), New York. 11pp.

Davenport, T. R. B. 2005. The status of Mbizi Forest, Sumbawanga: current forest condition and a comparison with 2002. Report, Wildlife Conservation Society (WCS), New York. 6pp.

Davenport, T. R. B., D. W. De Luca, T. Jones, N. E. Mpunga, S. J. Machaga and G. Picton Phillipps. In press**.** The kipunji *Rungwecebus kipunji* of southern Tanzania: first census and assessments of distribution and conservation status. *Oryx*.

Gillespie, T. R. and C. A. Chapman. 2001. Determinants of group size in the red colobus monkey (*Procolobus badius*): an evaluation of the generality of the ecological-constraints model. *Behav. Ecol. Sociobiol.* 50: 329–338.

Grubb, P., T. M. Butynski, J. F. Oates, S. K. Bearder, T. R. Disotell, C. P. Groves and T. T. Struhsaker. 2003. Assessment of the diversity of African primates. *Int. J. Primatol.* 24(6): 1301–1357.

Harcourt, A. H. 2002. Empirical estimates of minimum viable population sizes for primates: tens to tens of thousands? *Anim. Conserv.* 5: 237–244.

Harcourt, A. H. and D. Fossey. 1981. The Virunga gorillas: decline of an island population. *African J. Ecol.* 19: 83–97.

Ihobe, H. and S. Uehara. 1999. A preliminary report on the impact of chimpanzee hunting on mammal populations at Mahale, Tanzania. *Primate Research* 15: 163–169.

Kerfoot, O. 1963. A preliminary account of the vegetation of the Mbeya Range, Tanganyika. *Kirkia* 4: 191–206.

Kikula, M. 1979. The Vegetation of Rukwa Region. MSc thesis, University of Dar es Salaam, Dar es Salaam.

Kingdon, J. 1997. *The Kingdon Field Guide to African Mammals*. Academic Press, London.

Marshall, A. R. 2007. Disturbance in the Udzungwas. Responses of Monkeys and Trees to Forest Degradation. PhD thesis, University of York, York.

Marshall, A. R., J. C. Lovett and P. C. L. White. In press. Can vertebrates be good indicators? A test using monkeys in lowland Udzungwa. *Biol. Conserv.*

McNeilage, A., A. J. Plumptre, A. Brock-Doyle and A. Vedder. 2001. Bwindi Impenetrable National Park, Uganda, gorilla census, 1997. *Oryx* 35: 39–47.

Mitani. J. C., T. T. Struhsaker and J. S. Lwanga. 2000. Primate community dynamics in old growth forest over 23.5 years at Ngogo, Kibale National Park, Uganda: implications for conservation and census methods. *Int. J. Primatol.* 21: 269–286.

Mtuy, C. M. P. and M. J. Mkude. 1974. An inventory of four forest reserves in Sumbawanga District. *Forest Resources Study* 4. Maliasili, Tanzania.

Moyer, D. C. and R. Stjernstedt. 1986. A new bird for East Africa and extensions of range of some species for south-west Tanzania. *Scopus* 10: 99–102.

Oates, J. F., G. G. Whitesides, A. G. Davies, P. G. Waterman, S. M. Green, G. L. Dasilva and S. Mole. 1990. Determinants of variation in tropical forest biomass: new evidence from West Africa. *Ecology* 71: 328–343.

Plumptre, A. J. and D. Cox. 2006. Counting primates for conservation: primate surveys in Uganda. *Primates* 47: 65–73.

Rodgers, W. A. 1981. The distribution and conservation status of colobus monkeys in Tanzania. *Primates* 22(1): 33–45.

Rodgers, W. A., T. T. Struhsaker and C. C. West. 1984. Observation on the red colobus (*Colobus badius tephrosceles*) of Mbisi Forest, south-west Tanzania. *African J. Ecol.* 22: 187–194.

Rovero, R., T. T. Struhsaker, A. R. Marshall, T. A. Rinne. U. B. Pedersen, T. M. Butynski, C. L. Ehardt and A. S. Mtui. 2006. Abundance of diurnal primates in Mwanihana Forest, Udzungwa Mountains, Tanzania: a multi-observer comparison of line-transect data. *Int. J. Primatol.* 27(3): 675–697.

Rovero, R. and T. T. Struhsaker. 2007. Vegetative predictors of primate abundance: utility and limitations of a fine-scale analysis. *Am. J. Primatol.* DOI: 10.1002/ajp.20431.

Ruffo, C. K. and Mabula, C. K. 1987. Botanical report of Mbizi Forest Reserve. Report, Tanzania Forest Research Institute, Dar es Salaam. 19pp.

Skorupa, J. P. 1986. Responses of rainforest primates to selective logging in Kibale Forest, Uganda: a summary report. In: *Primates: The Road to Self-Sustaining Populations,* K. Benirschke (ed.), pp.57–70. Springer Verlag, New York.

Skorupa, J. P. 1988. The Effects of Selective Timber Harvesting on Rainforest Primates in Kibale Forest, Uganda. PhD thesis, University of California, Davis.

Stanford, C. P. 1998. *Chimpanzee and Red Colobus: The Ecology of Predator-Prey Ecology.* Harvard University Press, Cambridge, Massachusetts.

Struhsaker, T. T. 1975. *The Red Colobus Monkey.* The University of Chicago Press, Chicago.

Struhsaker, T. T. 1981. Census methods for estimating densities. In: *Techniques for the Study of Primate Population Ecology*, pp.36–80. National Academy Press, Washington, DC.

Struhsaker, T. T. 1997. *Ecology of an African Rain Forest: Logging in Kibale and the Conflict between Conservation and Exploitation*. University Press of Florida, Gainesville.

Struhsaker T. T. 2002. Guidelines for biological monitoring and research in Africa's rain forest protected areas. Report, Center for Applied Biodiversity Science (CABS), Conservation International, Washington, DC.

Struhsaker, T. T. 2005. Conservation of red colobus and their habitats. *Int. J. Primatol.* 26(3): 525–538.

Uehara, S. 2003. Population densities of diurnal mammals sympatric with the chimpanzees of the Mahale Mountains, Tanzania: Comparison between the census data of 1996 and 2000. *African Study Monographs* 24(3): 169–179.

Waltert, M., F. Lien, K. Feber and M. Muhlenberg, M. 2002. Further declines of threatened primates in the Korup Project Area, south-west Cameroon. *Oryx* 36: 257–481.

Watts, D. P. and J. C. Mitani. 2002. Hunting behavior of chimpanzees at Ngogo, Kibale National Park, Uganda. *Int. J. Primatol.* 23: 1–28.

Whitesides, G. G., J. F. Oates, S. M. Gress and R. P. Kluberdanz. 1988. Estimating primate densities from transects in a West African rainforest: a comparison of techniques. *J. Anim. Ecol.* 57: 345–367.

Wrangham, R. W. and E. L. Bergmann-Riss. 1990. Rates of predation on mammals by Gombe chimpanzees, 1972–1975. *Primates* 38: 157–170.

Authors' addresses:
Tim R. B. Davenport, Wildlife Conservation Society, PO Box 1475, Mbeya, Tanzania. Email: <tdavenport@wcs.org>.
N. E. Mpunga, Wildlife Conservation Society, PO Box 1475, Mbeya, Tanzania. Email: <nmpunga@wcs.org>.
S. J. Machaga, Wildlife Conservation Society, PO Box 1475, Mbeya, Tanzania. Email: <smachaga@wcs.org>.

Received for publication: April 2007
Revised: September 2007

Primate Conservation 2007 (22): 107–110

New Northwestern and Southwestern Range Limits of De Brazza's Monkey, Mbam et Djerem National Park, Cameroon, and Bateke Plateau, Gabon and Congo

Fiona Maisels[1], Nicolas Bout[2,3], Clement Inkamba-Inkulu[4], Liz Pearson[3], Paul Aczel[3], Rufin Ambahe[5], Edgar Ambassa[5] and Roger Fotso[5]

[1]*Wildlife Conservation Society, Bronx, New York, USA*
[2]*Wildlife Conservation Society, Libreville, Gabon*
[3]*John Aspinall Foundation, Franceville/Mpassa, Gabon*
[4]*Wildlife Conservation Society, Brazzaville, Republic of Congo*
[5]*Wildlife Conservation Society, Yaoundé, Cameroon*

Abstract: Recent surveys carried out in Cameroon in the Mbam Djerem National Park, in Gabon in the Bateke Plateau National Park, and the adjoining Bateke Plateau area in Congo, have recorded the presence of de Brazza's monkey (*Cercopithecus neglectus*) on both sides of the Djerem River in Cameroon, along the Mpassa and its tributaries in Gabon, along the Nambouli River in the Lefini Reserve in Congo, and up to the right bank of the Ogooué River on the Congo side of the border. These areas lie at the northern and southern edges of the Central African forest block, where rivers have relatively wide bands of riparian forest. As for the range extension of the talapoin (this volume), the species may simply have been overlooked by previous rapid wildlife surveys. It has an antipredator behavior that renders it relatively inconspicuous, tends to live in small family groups in the region, and lives in habitats that are difficult to survey on foot. However, unlike talapoin, it calls every morning along major watercourses, and can be heard for some distance. It is possible that the southern limit of this species in Gabon may be the Ogooué River. Future survey teams are encouraged to familiarize themselves with the long call of this species and to be aware that it can occur in gallery forests throughout the savannas of the Bateke Plateau and also in the area between the Mbam, the Djerem, and the Lom in Cameroon.

Résumé: Les recensements récents au Cameroun dans le parc national de Mbam et Djerem, au Gabon dans le parc national de Plateau Bateke, et dans les savanes Bateke avoisinante au Congo ont notée la présence du singe de Brazza (*Cercopithecus neglectus*) sur les deux rives du Djerem au Cameroun, le long de l'Mpassa et ses tributaires au Gabon, le long de la rivière Nambouli dans la Reserve de la Lefini au Congo, et jusqu'au rive droite de la rivière Ogooué sur la coté Congolaise de la frontière. Les deux zones se trouvent aux bords nord et sud du grand bloc forestier du bassin du Congo, et contiennent les rivières importantes, qui coulent dans les galeries assez larges de foret ripicole. Comme pour les talapoins (ce volume), l'espèce a été peutêtre simplement ratée par les équipes de recensement dans la région auparavant. Il a un comportement anti-prédateur qui le rend très discret, une tendance à vivre par petits groupes familiaux, difficiles à repérer, de plus occupe un habitat plus difficilement accessible à un observateur à pied les habitats de la plupart des autres guenons. Néanmoins, et contrairement au comportement des talapoins, chaque matin il pousse des cris très caractéristiques, audible sur des grandes distances le long des grandes rivières. Il est possible que la limite sud de cette espèce au Gabon soit la rivière Ogooué. Les équipes de recensement de la faune sont encouragées de se familiarisée avec les vocalisations de cette espèce, et garder à l'esprit que le singe de Brazza peut être présent dans les forets galeries dans toutes les savanes du plateaux Batéké et aussi, au Cameroun, la zone entre les rivières Mbam, Djerem, et Lom.

Key Words: de Brazza's monkey, biogeography, distribution, Gabon, Cameroon, Congo

Introduction

De Brazza's monkey (*Cercopithecus neglectus*) is widely distributed in Central Africa, from the Atlantic coast of southern Cameroon, through Equatorial Guinea down to northern Gabon, and then eastward through the forest block and some of the fringing transitional forests to the Ruwenzoris (Kingdon 1997; IEA 1998). In West Central Africa it has been assumed that their distribution is limited to the north, as it is in many other species, by the Sanaga River. The southern limit is less clear. It was earlier thought that the species did not occur south of the Ivindo watershed (Malbrant and Maclatchy 1949) but later maps show them to half way between the Ivindo and the Ogooué (Kingdon 1997; IEA 1998). The published maps (Kingdon 1997; IEA 1998) suggest that they are absent from the Bateke Plateau and from the "Lake region" between the Komo and the Ogooué rivers (Fig. 1).

Observations

The Mbam et Djerem National Park was created in 2000 in central Cameroon. It lies across the Guinea-Congolia/Sudania regional transition zone (White 1983) between the main forest block and the Guinean savannas to the north (Fig. 1). The Djerem River, which is, in fact, the upper reaches of the Sanaga, runs north-south through this park, and is lined by a broad band of riparian forest. The southeastern part of the park is lowland, tropical, semideciduous forest; the northwestern part is wooded and bush savannah with gallery forests lining the watercourses. The transition between the forest and the savannah has a relatively high biodiversity because of the interlacing of the two main habitats. The forest has been slowly creeping north since the 1950s (evidenced by the old maps of the region and present conditions, which show the contrast between savannah in the past and young colonizing woodland today).

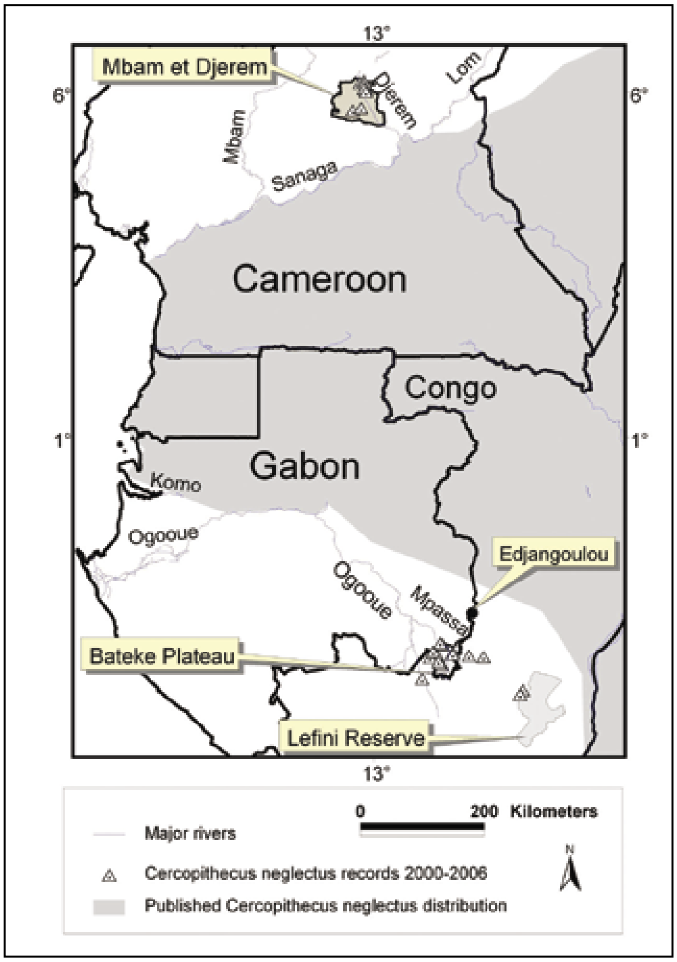


Figure 1. Range of *Cercopithecus neglectus*, after Kingdon (1997) and IEA (1988), and the recent records from Mbam et Djerem National Park, Cameroon; the Lefini Reserve, Congo; and the Bateke Plateau area in Gabon and Congo.

Another new national park, Bateke Plateau, was created in 2002, in southeastern Gabon. The vegetation is structurally similar to that of Mbam et Djerem: The main forest block of Gabon is at the extreme northwest of the park and there is a progression through forest-savannah mosaics to bush savannah and some extensive areas of grass savannah toward the east, at the Gabon-Republic of Congo international border. The Bateke Plateau in general is a savannah and gallery forest mosaic that extends far to the east, across the Republic of Congo, into western Democratic Republic of Congo. The Lefini Reserve is also in the Bateke Plateau, a little farther south than the Gabonese Bateke National Park (Fig. 1) and has the same vegetation: a mosaic of galley forests and savannas. The Bateke Plateau National Park in Gabon is bisected north-south by the Mpassa River, which like the Djerem in Cameroon, runs through a wide corridor of riparian forest.

A series of wildlife and vegetation surveys were carried out in all three protected areas (Mbam et Djerem, Cameroon; Bateke National Park, Gabon; and the Lefini Reserve, Congo) between 2000–2005, partly as reconnaissance missions but mostly to provide the baseline for the park monitoring of wildlife and human impact. In addition, in the Congolese part of the Bateke Plateau just across the border from Gabon, a wildlife and socioeconomic survey was carried out in 2004 to evaluate the potential for an additional protected area that could form a transboundary park in the future.

De Brazza's monkeys were recorded nine times along the Djerem River and three times on various tributaries in Mbam et Djerem. In the Bateke Plateau (Gabon) it was recorded at least a dozen times: in the riparian forest along the Mpassa River and on eight different tributaries. In the Bateke Plateau (Congo) it was seen along two of the upper tributaries of the Congo (just across the frontier, south of the village of Edjangoulou: Fig. 1), several times on the Ogooué River, and twice in the Lefini Reserve along the Nambouli River.

We also asked local hunters about the monkey species present in the areas. In Mbam et Djerem de Brazza's monkeys are well known by their (onomatopoeic) local name, *founga*, in Gbaya (very similar to the Mboko name *pounga* from Odzala in Congo [F. Maisels pers. obs.] and to the Bakota name, *pounnga*, in Gabon [Malbrant and Maclatchy 1949]). By contrast, the Bateke hunters in Gabon ascribed the characteristic long call of the species to *Cercopithecus cephus.* However, one Gabonese hunter knew the species and its calls, and noted that it was found also at Edjangoulou, about 60 km farther north on the plateau, corroborating the observations on the Congo side (Fig. 1). The Gabonese Teké name is *mfoue*; the Congolese Teké name is *nfua.*

Discussion

These records show that de Brazza's monkey occurs about 100 km farther north in Cameroon, about 140 km farther south in Gabon, and about 80 km farther west in Congo than was previously known. However to the east (Central African Republic and Republic of Congo), it occurs (or occurred) much farther north and south, respectively, so it is likely that this species was simply missed during surveys in the past. Downer (1998) carried out a wildlife survey and also questioned hunters in the Lefini Reserve in 1996 in Republic of Congo. Although the species was not recorded during the survey, the hunters said that de Brazza's monkeys occurred there, which was confirmed during the 2005 survey. The Bateke Plateau is heavily hunted (especially on the Congo side) so monkeys in the area will be very wary and in probably much reduced in numbers.

De Brazza's monkey is considerably more inconspicuous than most other guenons. It generally avoids living in polyspecific troops, and at least in Gabon, northern Congo, the Bateke Plateau and central Cameroon, lives in small family parties (Gautier-Hion 1988; N. Bout, C. Inkamba-Nkulu and F. Maisels pers. obs.). In areas where they are hunted, they freeze, being motionless sometimes for hours when disturbed, and hide their otherwise highly visible white beard and buttocks by crouching (Gautier-Hion and Gautier 1978). Like the talapoins, *Miopithecus*, and Allen's swamp monkey, *Allenopithecus nigroviridis*, their habitat is inundated forest along watercourses, which makes them less likely than terrestrial species to be seen by survey teams walking through forests and savannas. In fact, they are most often detected by their calls in the early morning, or from a canoe while traveling along rivers. To people unfamiliar with their vocalizations, the "boom" could be confused with that of *Mona* superspecies (*C. mona* in the northwest and *C. pogonias* in most other places west of the Congo River [Lernould 1988; Kingdon 1997; IEA 1998]). Recordings of *C. neglectus* calls can be found on the CD of primate vocalizations in Gautier-Hion *et al*. (1999), and it is important to note that (1) the two booms are longer than those of *C. mona*; (2) they are separated by a soft, audible sub-boom caused by the re-inflation of the vocal sac, and (3) that the "cough" following the booms is a series of single notes, unlike the rapid double cough of *C. mona.*

Although de Brazza's monkeys are not listed as threatened by the IUCN, they are nevertheless listed in Appendix II of CITES (Inskipp and Gillett 2005). At least in parts of the Bateke Plateau, it is clear that they are uncommon and very wary of humans; despite their antipredator behavior they are vulnerable to hunters if they are detected. We urge wildlife survey teams to be aware that de Brazza's monkeys may be present along rivers in the savannas of the region, and to familiarize themselves with the vocalizations of this rather secretive species. In Gabon, the species almost certainly occurs up to the right bank of the Ogooué River in the Bateke Plateau area, and perhaps also in the very marshy lake region between the Komo and the Ogooué to the west of the country. Unless it has been hunted out, in Congo it is almost certainly present along watercourses across the whole of the Bateke Plateau between the Congo River and the Ogooué,. In Cameroon, attention should be paid to the possibility of this species occurring along the major watercourses to the east and west of the Djerem: the Mbam and the Lom (Fig. 1).

Acknowledgments

We thank the Governments of Cameroon (MINFOF), Gabon (CNPN and the DFC) and Republic of Congo (DFAP) for their efforts in wildlife conservation. For funding, we are grateful to the following: USAID (Congo Basin Forest Project); FEDEC (Foundation for Environment and Development in Cameroon); the British High Commission, Yaoundé: Global Opportunities Funds; the John Aspinall Foundation; WCS New York; WCS Cameroon; WCS Gabon; and WCS Congo. Thanks to all the staff of the projects at Mbam et Djerem, Bateke Plateau (both Gabon and Congo), Lefini, the JAF–Mpassa project, WCS Cameroon, WCS Congo, and WCS Gabon. Finally, enormous thanks to the trackers and porters from all sites.

Literature Cited

Downer, A. 1998. A series of preliminary surveys: Ecological, demographic, socio-economic and their implications as regards the sustainability of the Lefini Game Reserve. Report, Wildlife Conservation Society (WCS) – Congo, Brazzaville.

Gautier-Hion, A. 1988. Polyspecific associations among forest guenons: Ecological, behavioural and evolutionary aspects. In: *A Primate Radiation. Evolutionary Biology of the African Guenons*, A. Gautier-Hion, F. Bourlière, J. P. Gautier and J. Kingdon (eds.), pp.452–476. Cambridge University Press, Cambridge, UK.

Gautier-Hion, A. and J. P. Gautier. 1978. Le singe de Brazza: Une stratégie originale. *Z. Tierpsychol.* 46: 84–104.

Gautier-Hion, A., M. Colyn and J.-P. Gautier. 1999. *Histoire Naturelle des Primates d'Afrique Centrale*. ECOFAC, Libreville, Gabon.

IEA. 1998. Cercopithecus neglectus. *African Mammals Databank—A Databank for the Conservation and Management of the African Mammals.* Vols. 1 and 2. Institute of Applied Ecology (IEA), European Commission Directorate, Brussels. Website: <http://gorilla.bio.uniroma1.it/amd/amd072.html>. Accessed 14 July 2006.

Inskipp, T. and H. J. Gillett (eds.). 2005. *Checklist of CITES Species and Annotated CITES Appendices and*

Reservations. CITES Secretariat, Geneva, Switzerland and UNEP-WCMC, Cambridge, UK. 339pp. and CD-ROM.

Kingdon, J. 1997. *The Kingdon Field Guide to African Mammals.* Academic Press, London.

Lernould, J.-M. 1988. Classification and geographical distribution of guenons: A review. In: *A Primate Radiation: Evolutionary Biology of the African Guenons*, A. Gautier-Hion, F. Bourlière, J.-P. Gautier and J. Kingdon (eds.), pp.54–78. Cambridge University Press, Cambridge, UK.

Malbrant R. and A. Maclatchy. 1949. *Faune de l'Equateur Africain Francais. Tome II. Mammifères*. Paul Lechevalier, Paris.

White, F. 1983. *The Vegetation of Africa*. UNESCO, Paris.

Authors' addresses:
Fiona Maisels, Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York, NY 10460-1099, USA. E-mail: <fmaisels@wcs.org>.
Nicolas Bout, WCS Gabon, BP 7847, Libreville, Gabon *and* John Aspinall Foundation, John Aspinall Foundation, BP 583, Franceville, Gabon.
Clement Inkamba-Inkulu, presently at University of East Anglia, Norwich NR4 7TJ, UK.
Liz Pearson and **Paul Aczel**, John Aspinall Foundation, BP 583, Franceville, Gabon.
Rufin Ambahe, **Edgar Ambassa** and **Roger Fotso**, Wildlife Conservation Society, BP 3055, Yaoundé, Cameroon.

Received for publication: 5 August 2006
Revised: 10 August 2006

Primate Conservation 2007 (22): 111–115

Confirmation of the Presence of the Red-capped Mangabey (*Cercocebus torquatus*) in Mayumba National Park, Southern Gabon, and Conkouati-Douli National Park, Southern Republic of Congo

Fiona Maisels[1], Quevain Pambou Makaya[2] and Jean-Robert Onononga[3]

[1]*Wildlife Conservation Society, Bronx, New York, USA*
[2]*Wildlife Conservation Society, Gabon, Libreville*
[3]*Wildlife Conservation Society, Brazzaville, Congo*

Abstract: Surveys were carried out in Gabon in Mayumba National Park in 2006 and in the Conkouati-Douli National Park in the Republic of Congo in 1996 and 2000. Red-capped mangabeys, *Cercocebus torquatus*, (also known as white-collared mangabeys) were recorded in both parks in areas about 30 km distant from hunting pressure. The distribution of this species is known to extend from west of the Niger River to just south of the Ogooué River in Gabon, but its presence in Southern Congo, while suspected in 1949, had never been confirmed. These observations extend the confirmed published range by about 250 km south, and into the Republic of Congo. The published distribution is probably much too uniform, as the species now appears to be absent in areas with even low to medium hunting pressure. We call for resurveys of the sites where it has been previously recorded in the past to confirm continued presence and to clarify its conservation status. We also call for surveys along the coastal forests outside protected areas, especially within Gabon, to identify remaining populations.

Résumé: Les recensements de la faune ont été menés au Gabon dans le Parc National de Mayumba en 2006 et dans le Parc National de Conkouati-Douli en République du Congo en 1996, puis en 2000. La presence du *Cercocebus torquatus* a été confirmée dans les deux parcs a environ 30 km des zones de préssion de chasse. Cependant, la distribution connue de cette espèce part de l'ouest du Nigeria jusqu'au sud du fleuve Ogooué au Gabon; sa presence avait été supposée au sud du Congo en 1949 mais n'avait jamais été confirmée. Les observations que nous avons faites augmentent la distribution confirmée de cette espèce autour de 250 km vers le sud, et confirme sa présence en République du Congo. Néanmoins, la distribution dans la littérature est probablement trop uniforme, parce qu'il semble que l'espèce est absente dans les sites où la pression de chasse est faible ou moyenne. Nous suggérons que les sites ou l'espèce était connue auparavant soient réexaminés pour confirmer sa présence et clarifier son statut de conservation. Nous suggérons aussi que les forets le long de la côte Atlantique hors des aires protégées, surtout au Gabon, soient examinées afin d'identifier les populations restantes.

Key Words: Red-capped mangabey, white-collared mangabey, *Cercocebus*, biogeography, distribution, Congo

Introduction

The red-capped mangabey *Cercocebus torquatus* (Kerr, 1792) is a medium-sized (females 5–8 kg; males 7–12.5 kg) (Kingdon 1997) monkey that occurs along the Atlantic forest coastal area of west and central Africa (Malbrant and Maclatchy 1949; Lee *et al.* 1988; Oates 1996; Kingdon 1997; IEA 1998; Gautier-Hion *et al*. 1999). Opinions differ as to its taxonomic status: IEA considers the species to include both *C. atys* (sooty mangabey) as *C. torquatus atys*, as well as the red-capped mangabey (as *C. t. torquatus*), whereas Kingdon (1997) and Oates (1996) keep *C. atys* and *C. torquatus* separate. Here we refer to *C. torquatus* as the animals living east of the Dahomey gap, in other words from the Nigeria-Benin border eastwards and southwards along the coast.

According to Malbrant and Maclatchy it was (in 1949) "abundant in the coastal region of Gabon and Moyen-Congo" (now the Republic of Congo). They write "The Congo (river) seems to be its southernmost limit: at least Schouteden has not recorded it in the Belgian Congo" suggesting that the Congo River marked the southern limit of its distribution. A survey forty years later by Dowsett and Granjon (1991) in the Kouilou area, just south of the present Conkouati-Douli National Park (Fig. 1), showed no sign of this species. Because all place names cited in Malbrant and Maclatchy's text were actually in Gabon and not Moyen-Congo, Dowsett and Granjon wrote that “we accept, with hesitation, its past presence in Congo, but there are no recent confirmations”. It is highly possible that the species had been hunted out of the area surveyed by Dowsett and Granjon, as had most of the other large monkey species (Dowsett and Granjon 1991; Wilson and Wilson 1991).

In 1996, the *Status Survey and Conservation Plan for African Primates* (Oates 1996) called for more surveys in southwest Gabon. This note reports on the presence of red-capped mangabeys recorded during surveys on both sides of the Gabon-Congo border on the Atlantic shore, and discusses the implications for their conservation.

Observations

Troops of red-capped mangabeys were seen during surveys in 1996 and in 2000 in what is now the Conkouati-Douli National Park (Republic of Congo: Fig. 1). Mangabeys were recorded on sixteen occasions at a number of sites in the area. They were sometimes in polyspecific groups with one or more of the guenons *Cercopithecus nictitans*, *C. pogonias* and *C. cephus*. Groups were also seen three times in a third survey in 2006 in the Mayumba National Park in Gabon, just on the other side of the border (Fig. 1). Red-capped mangabeys are fairly conspicuous because they are very vocal and relatively large. They also tend to be spread through the undergrowth and in the trees (they are semi-terrestrial), moving branches and leaves as they forage. Red-capped mangabeys are sympatric with mandrills at both the Conkouati and the Mayumba sites, and both species were seen in large groups at both sites.

During the two Conkouati surveys, red-capped mangabeys were never seen in the forests near the coast. This was assumed to be due to habitat preference — there is a marked gradient in vegetation type with increasing distance from the coast. The mangabeys seen in Conkouati were all in steeply sloping, closed-canopy forest and in gallery forests in the savannas, more than 30 km from the coast. The coastal forests tend to be very marshy. However in the Mayumba National Park, they were common right up to a few hundred metres behind the beach, in the littoral forests along the shore, and, indeed, in the marsh forests along the lagoon. In Mayumba, however, they were not recorded closer than 30 km from the Congo-Gabon border, although they were seen at several sites north of this limit, still within the park.

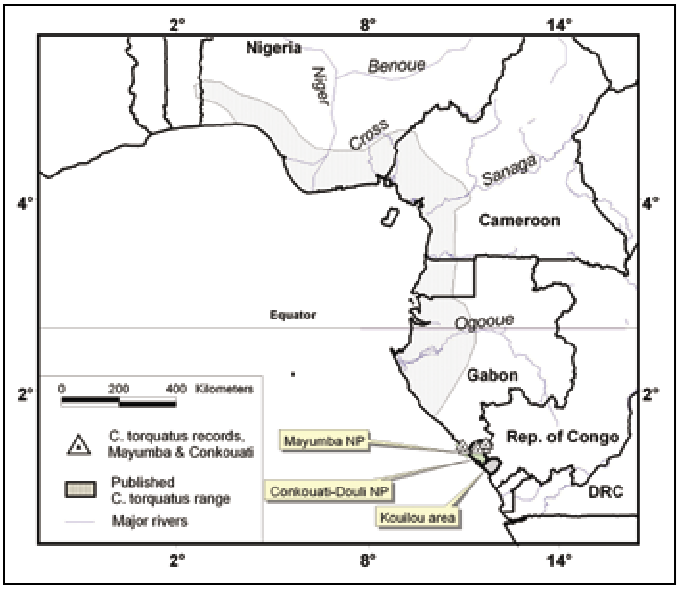


Figure 1. Range of *Cercocebus torquatus*, after the “certain” range of IEA (1998), and the recent records from Conkouati-Douli and Mayumba National Parks, Gabon and Congo.

Data on wildlife and signs of human presence were collected during all three surveys. In Conkouati, in 1996 and 2000, hunting was intensive all along the coast. Several large villages are situated inside the protected area along the coast. Densities of large mammals were very low along the littoral forests there (extending to about 30 km from the coast). The only exception was chimpanzees, which are protected by local custom in this region. In Mayumba, the area along the Congo-Gabon border (on the Gabon side) had recently been exploited by a logging company, so access into the area was relatively easy along the road network.

Discussions with Congolese and Gabonese field staff revealed that Congolese hunters were in the habit of crossing the border to hunt in the Mayumba region of Gabon. This was partly because of the paucity of wildlife remaining on the Congo side of the border, and partly because the risk of being apprehended by the wildlife (or immigration) authorities on the Gabon side was perceived to be very low. The meat would then be walked back to the Congo border and transported by vehicle to Pointe-Noire, the regional capital of southern Congo, for the bushmeat trade.

Discussion

Cercocebus torquatus was apparently absent, or at densities too low to detect, in Mayumba, Gabon, within 30 km from the Congolese border, and it was not seen on our surveys within 30 km of the coastal villages in Conkouati. Human pressure is largely responsible for their present distribution at these sites. The areas where the monkey was not seen were identified by signs of human activities in the two parks, as well by conversations with local hunters (converted to field assistants) to be areas subject to the highest hunting pressure at the time the data were collected. This would also explain why, even fifteen years ago, the survey team in Kouilou (Dowsett and Granjon 1991) failed to find this species (and also did not record any other medium-sized monkey except a few *Cercopithecus nictitans* and *C. cephus*: they also said that grey cheeked mangabeys [*Lophocebus albigena*] and mandrills [*Mandrillus sphinx*] had become very rare in the area near the villages). The large size of the red-capped mangabey, semi-terrestrial habits, and conspicuous and quite far-carrying vocalizations (Gautier-Hion *et al*. 1999) make it easy to locate and a worthy reward for the cost of a single cartridge. It is also possible that, being semi-terrestrial, it is often caught in wire snares commonly set around villages to trap small ungulates and larger rodents. Even in 1991 in the Kouilou area south of Conkouati in Congo, hunters recognized that all large mammals had become rare (Dowsett-Lemaire and Dowsett 1991; Wilson and Wilson 1991), and they particularly noted that monkeys had become very hard to find since the introduction of firearms in the 1960s. This is echoed in the complaints of local hunters within the Conkouati villages in 1996 and 2000, situated even further from the commercial bushmeat market of Point Noire.

At present, the species is considered Low Risk (Near threatened) in the IUCN Red Data List (IUCN 2006), and is on Appendix II of CITES (Inskipp and Gillett 2005). Our data show that red-capped mangabeys occur about 250 km further south than was previously reported in the published accounts of its southern range (Kingdon 1997; IEA 1998), and we have been able to confirm that they occur in the Republic of Congo as was suggested by Malbrant and Maclatchy (1949). It is likely that this species can only maintain populations where hunting pressure is relatively low. Its quite large distribution contains only a few protected areas, but in not all of them is there effective anti-poaching, and in many of them the species may already have been drastically reduced in number. The alarm bells have already sounded in previous IUCN publications (Lee *et al.* 1988; Oates 1996). Current threats are listed as habitat loss and harvesting (IUCN 2006).

In Gabon, red-capped mangabeys occur in the National Parks of Loango, Moukalaba-Doudou, and Pongara (Le Duc Yeno 2006; Latour 2006, Maisels (unpubl. data), but they have not been recorded in the Monts de Cristal, despite an extensive survey effort in 2005 (Aba'a Nseme 2006; Maisels *et al.* 2006).

Surveys in Equatorial Guinea in 1998 failed to find them in the three proposed (at the time) protected areas of Rio Campo, Monts de Mitra, and Altos de Nsork (Larison *et al.* 1999). They had, however, been present in the first two areas in 1967 (Sabater Pi and Jones 1967) and Fa (1991, in Larison *et al.* 1999) was told by local hunters that they still occurred in the Altos de Nsork in 1991. They were still present in Monte Alen in 1994 (Garcia and Mba 1997). However, unless those surveying are familiar with the call of the species, they may miss them if they are not actually seen.

Red-capped mangabeys were known to occur in southern Cameroon by Malbrant and Maclatchy (1949), where, however, they noted that the species was rare (Jeannin 1936, in Malbrant and Maclatchy 1949). They have been recorded more recently in several areas in south-west Cameroon (for example, in Banyang Mbo: Willcox and Nambu 2006; Greengrass and Maisels 2007; and in Korup: Waltert *et al.* 2002), but at very low densities. They have been seen on Mt. Etinde next to Mt. Cameroon (Nku 2004). They were not, however, recorded during the fairly extensive surveys of the Takamanda forest 1997–2002, nor were they known to local people (Sunderland-Groves and Maisels 2003) even though they were there twenty years ago (Thomas 1988) and were collected from Atolo in 1933 (just to the northeast of the Takamanda forest) (Sanderson 1940). Nku (2001) still had them on the list of large mammals of Campo Ma'an, but it is not clear if his data was from direct observations or from a literature review, in which case the sightings could have been much earlier; they were certainly present there in the 1980s (Mitani 1989).

Schlitter *et al.* (1973) published the range if this species in Nigeria, which was basically all along the coast from east to west nearly up to the western border. More recently, red-capped mangabeys have been shown to still be present in the following areas: southwest Nigeria (Greengrass 2006); the Oban area and between the Niger and the Cross rivers (Oates 1996; Oates *et al.* 2004; see also Happold 1987). Oates (pers. comm.) suggested that they may be naturally less common in Cameroon and Nigeria because of competition with drills *Mandrillus leucophaeus*. However, in Mayumba and Conkouati large troops of both mandrills *Mandrillus sphinx* (which are in a similar niche to drills) and of red-capped mangabeys were recorded living sympatrically.

We suggest that, in future surveys, attention be paid to the presence (or absence) of *Cercocebus torquatus*. Their vocalizations are fairly far-carrying and, although slightly similar to those of *Lophocebus albigena,* are slower and more raucous. Survey teams should ensure that they are familiar with the calls of both species before fieldwork begins (using, for example, the reference CD of Gautier-Hion *et al.* 1999). Museum records should be checked, to further clarify the historical range of the species, and then, where possible, sites outside Gabon where they used to occur should be checked to verify if they still do, with particular attention on Equatorial Guinea and southern Cameroon, including the Douala-Edea Reserve, Mount Cameroon/Etinde, and Campo Ma'an. We also call for surveys along the coastal forests outside protected areas, where possible, especially in Gabon, to identify remaining populations. These data will clarify the distribution and conservation of this species and should play a part in any future assessment of its Red List status.

Acknowledgments

We thank the Governments of Gabon and Congo for their support for conservation in their countries, including the Conseil National des Parcs Nationaux (Gabon) and the Ministry of Forests in both countries. Conservateurs Solange Ngouessono and Noé Mabiala helped enormously at the two sites. Thanks to Richard Parnell, Aimee Sanders and the staff of the WCS Mayumba Project, to Bruno Paris and Marcel Taty and their staff (IUCN-Conkouati), Bryan Curran, then of the WCS-Congo Protected Areas project, and to Aliette Jamart and her staff (HELP-Congo). The work of field assistants Souami Nzassi and Alain Djimbi Mavoungou (in Gabon) and of 'Farel' Mavoungou François and Tchitiamouna Guy-Noël (in Congo) was greatly appreciated. The Wildlife Conservation Society, USAID, and IUCN provided support for the authors. A particular thank-you goes to John Oates for his pertinent comments and suggestions and his knowledge of the species' range, which have greatly improved the manuscript.

Literature Cited

Aba'a Nseme, R. 2006. Abondance relative des grands mammifères et des activités humaines au parc National des Monts de Cristal et sa peripherie. Report, Wildlife Conservation Society (WCS), Gabon, Libreville.

Dowsett-Lemaire, F. and R. Dowsett. 1991. Observations complementaires sur quelques grands mammiferes dans le bassin du Kouilou au Congo. *Tauraco Research Report* 4: 291–96.

Dowsett, R. J. and L. Granjon. 1991. Liste préliminaire des mammifères du Congo. Flore et faune du bassin de Kouilou (Congo) et leur exploitation. *Tauraco Research Report* (4): 297–310.

Fa, J. E. 1991. *Conservación de los Ecosistemas Forestales de Guinea Ecuatorial*. UICN – Unión Mundial para la Naturaleza, Comisión de las Comunidades Europeas, Gland, Switzerland.

Garcia, J. E. and J. Mba. 1997. Distribution, status and conservation of primates in Monte Alen National Park, Equatorial Guinea. *Oryx* 31: 67–76.

Gautier-Hion, A., M. Colyn and J. -P. Gautier. 1999. *Histoire Naturelle des Primates d'Afrique Centrale*. ECOFAC, Libreville, Gabon.

Greengrass, E. J. 2006. A survey of chimpanzees in south-west Nigeria. Report, NCF-WCS Biodiversity Research Programme, Wildlife Conservation Society (WCS), New York. 51pp.

Greengrass, E. J. and F. Maisels. 2007. Conservation of the Nigerian-Cameroon Chimpanzee *P. t. vellerosus* (and other mammals) in and around the Banyang-Mbo Wildlife Sanctuary, South-west Province, Cameroon. Report, WCS Cameroon Programme, Wildlife Conservation Society (WCS), New York. 74pp.

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Groves, C. P. 2005. Order Primates. In: *Mammal Species of the World: A Taxonomic and Geographic Reference*, 3rd Edition, Vol. 1, D. E. Wilson and D. M. Reeder (eds.), pp.111–184. Johns Hopkins University Press, Baltimore.

Grubb, P., T. M. Butynski, J. F. Oates, S. K. Bearder, T. R. Disotell, C. P. Groves and T. T. Struhsaker. 2003. Assessment of the diversity of African primates. *Int. J. Primatol*. 24(6): 1301–1357.

Happold, D. C. D. 1987. *The Mammals of Nigeria*. Clarendon Press, Oxford, UK.

IEA. 1998. *Cercocebus torquatus* (Kerr, 1792). *African Mammals Databank —A Databank for the Conservation and Management of the African Mammals*, 2 vols. Institute of Applied Ecology (IEA), European Commission Directorate, Bruxelles. Website: <http://gorilla.bio.uniroma1.it/amd/amd062.html>. Accessed 20 July 2006.

Inskipp, T. G. and H. J. Gillett. 2005. Checklist of CITES species and Annotated CITES Appendices and reservations. CITES Secretariat and UNEP-WCMC, Geneva, Switzerland and Cambridge, UK.

IUCN. 2006. *2006 IUCN Red List of Threatened Species*. Website: <www.iucn.redlist.org>. Accessed: 8 January 2007.

Jeannin, A. 1936. *Les Mammifères sauvages du Cameroun* Lechevalier, Paris.

Kingdon, J. 1997. *The Kingdon Field Guide to African Mammals*. Academic Press, London.

Larison, B., T. B. Smith, D. Girman, D. Stauffer, B. Milá, R. C. Drewes, C. E. Griswold, J. V. Vindum, D. Ubick, K. O'Keefe, J. Nguema, and L. Henwood. 1999. *Biotic Surveys of Bioko and Rio Muni, Equatorial Guinea*. Biodiversity Support Program, World Wildlife Fund, Washington, DC.

Latour, S. 2006. Recensement des elephants et de grands singes dans le region du parc national de Pongara (Gabon). Report, Wildlife Conservation Society (WCS) / Espèces Phares, Libreville, Gabon.

Le Duc Yeno, S. 2006. Suivi des grands mammifères dans le secteur Sud Parc National de Loango. Report, World Wide Fund for Nature (WWF), Libreville, Gabon.

Lee, P. C., J. Thornback and E. L. Bennett. 1988. *Threatened Primates of Africa: The IUCN Red Data Book*. IUCN, Gland, Switzerland, and Cambridge, UK.

Maisels, F., R. Aa'ba, G. Abitsi, M. Bechem, N. Bout, H. Kuehl, S. Latour, P. Walsh and M. Ella Akou. 2006. Gabon's national park system: Baseline wildlife and human impact surveys. In: *Abstracts: Society for Conservation Biology, 20th Annual Meeting*, San José, California, USA, 24–28 June 2006. http://www.conbio.org/Activities/Meetings/2006/oral_abstracts.pdf.

Malbrant, R. and A. Maclatchy. 1949. *Faune de l'Equateur Africain Francais. Vol. 2: Mammifères.* Lechevalier, Paris.

Mitani, M. 1989. *Cercocebus torquatus*: adaptive feeding and ranging behaviours related to seasonal fluctuations of food resources in the tropical rainforest of south-western Cameroon. *Primates* 30: 307–323.

Nku, E. 2001. Frequency of Large Mammal Visits to a Forest Clearing: A Case Study of Ecotourism Potential in the Campo Ma'an National Park, Southern Cameroon. MSc thesis, University of Kent, Canterbury, UK.

Nku, E. 2004. Large M ammal Reconnaissance Surveys of Mt. Etinde Forest Reserve, SW Province, Cameroon. Report, Wildlife Conservation Society (WCS) Cameroon, Limbe.

Oates, J. F. 1996. *African Primates: Status Survey and Conservation Action Plan*. The World Conservation Union – IUCN, Species Survival Commission (SSC), Primate Specialist Group (PSG), Gland.

Oates, J. F., R. A. Bergl and J. M. Linder. 2004. Africa's Gulf of Guinea forests: Biodiversity patterns and conservation priorities. *Advances in Applied Biodiversity Science* (6): 90pp. Center for Applied Biodiversity Science, Conservation International, Washington, DC.

Sanderson, I. T. 1940. The mammals of the north Cameroon forest area. *Trans. Zool. Soc. Lond.*, 24: 623–725.

Schlitter, D.A., J. Phillips and G. E. Kemp. 1973. The distribution of the white-collared mangabey, *Cercocebus torquatus*, in Nigeria. *Folia Primatol*. 19: 380–383.

Sunderland-Groves, J. L. and F. Maisels. 2003. Large mammals of Takamanda Forest Reserve, Cameroon. In: *Takamanda – The Biodiversity of An African Rainforest*, J. A. Comiskey, T. C. H. Sunderland and J. L. Sunderland-Groves (eds.), Vol. 8, pp.111–127. Smithsonian Institution Press, Washington, DC.

Thomas, D. 1988. Status and Conservation of Takamanda Gorillas (Cameroon). Final Report, No. WWF-1613, World Wildlife Fund (WWF). Washington, DC.

Waltert, M., Lien, K. Faber and M. Muhlenberg. 2002. Further declines of threatened primates in the Korup Project Area, south-west Cameroon. *Oryx* 36: 257–265.

Willcox, A. S. and D. M. Nambu. 2007. Wildlife hunting practices and bushmeat dynamics of the Banyangi and Mbo people of southwestern Cameroon. *Biol. Conserv.* 134: 251–261.

Wilson, V. J. and B. L. P. Wilson. 1991. La chasse traditionnelle et commerciale dans le sud-ouest du Congo. *Tauraco Research Report* (4): 279–289.

Authors' addresses

Fiona Maisels, Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York, NY 10460-1099, USA, e-mail: <fmaisels@wcs.org>.
Quevain Pambou Makaya, Wildlife Conservation Society, BP 7847, Libreville, Gabon, e-mail: <mckevin30@yahoo.com>.
Jean-Robert Onononga, Wildlife Conservation Society, BP 14537, Brazzaville, Congo, e-mail: <yhareve@yahoo.com>.

Received for publication: March 2007
Revised: August 2007

Primate Conservation 2007 (22): 117–122

A New Population of De Brazza's Monkey in Kenya

Iregi Mwenja

Institute of Primate Research of the National Museums of Kenya, Nairobi, Kenya

Abstract: Until recently, de Brazza's monkey (*Cercopithecus neglectus*) was not known to occur east of the Great Rift Valley in Kenya. However, after eight months of intensive surveys in the remote and isolated Mathews Range Forest Reserve of Samburu, we were able to count a total of 162 de Brazza's monkeys in 24 groups; including 139 adults and sub-adults and 23 infants. They were found in ten separate *laggas* distributed throughout the mountain range, with the highest concentration in the central part of the reserve. By extrapolating information gathered on this study — from interviews and field observations — the population of the entire Mathews Range Forest Reserve was estimated at 200–300. Although the threats arising from the human activities in the forest ecosystem are generally minimal, they were considerable on the lower elevations, affecting especially this species. The most affected habitats are those near human settlements on the lower altitudes (where 75% of the total population of de Brazza's monkeys occurs) since they are easily accessible. During the onset of the dry season and periods of drought, communities invade these areas with large herds of livestock, where they feed them on leaves of evergreen tree species such as *Faidherbia albida, Ficus* sp., and *Olea* sp. The people cut the branches almost denuding the tree. These species are important in the diet of de Brazza's monkey. The study resulted in the first record of de Brazza's monkeys occurring above 2,100 m above sea level. They were seen in Olkaela in the Mathews range at an elevation of 2,203 m.

Key Words: de Brazza's monkey, *Cercopithecus neglectus*, Mathews Range, survey, population distribution, local community, Kenya

Introduction

De Brazza's monkey (*Cercopithecus neglectus*) is one of the most unusual species in the group of Old World monkeys commonly known as guenons (Nowak 1991; MacDonald 1993). They live in forests along the banks of streams and rivers, at the mid or lower canopy layers of the forest. De Brazza's are arboreal, spending 70% of their time in the understorey and 20% on the ground (Gautier-Hion 1988). They are good swimmers. They feed mainly on fruits and seeds, leaves, arthropods, flowers and mushrooms (Staaden 1996).

The species is fairly common in its core range, in riparian and swamp forests in the Congo Basin, in southeast Cameroon, Equatorial Guinea, and Angola. It is rare, and found only in isolated pockets, in some parts of extreme east and west Uganda, western Kenya and southwest Ethiopia (Brennan 1984; Decker 1995). Although large populations of de Brazza's monkey exist in central Africa (Gautier-Hion and Gautier 1978), the population in Kenya is small and under immense anthropogenic pressure (Brennan and Else 1984; Brennan 1985; Decker 1995).

In Kenya, knowledge on the distribution of de Brazza's monkey has expanded over the years, as interest has increased in the study of this species. Prior to a report by Booth (1962), the species was believed to be restricted to the western slopes of Mt. Elgon. Booth (1962) reported that it also occurred 60 km further east in the Cherangani Hills. Its range was found to extend northwards to southwest Ethiopia by Brown and Urban in 1969 (Wahome, 1993). Brennan (1984) found further groups in the western range of the species, between Mt. Elgon and Cherangani, while Wahome (1989) extended its southern range to Kisere forest, north of Kakamega forest. Mwenja (2004) added more new sightings in the region; more than tripling the known population in Kenya. Douglas-Dufresne (2005) reported a new population of the species in the Mathews Range, the first found east of the Rift Valley: before then, the species was believed to be restricted to western Kenya (Brennan 1985; Decker 1995; Karere 1995).

In Kenya, threats to the survival of de Brazza's monkey arise mainly from the rampant deforestation caused by the ever-increasing demand for firewood, timber and farmland, and accompanying growth of human settlements. Their diminishing forests result in small populations, reduced opportunities for dispersal, and heightened competition from other species (Brennan 1984; Olubayo 1998). Those that have survived have been, and continue to be, pushed to higher altitudes along the rivers, or are left in small, isolated remnant habitats that cannot sustain them, and expose them to poaching (Mwenja 2004). Today, the majority of the population is spread through very thin, increasingly fragmented, strips of riparian forest on private farms; usually in small, isolated groups. These pockets of habitat maintain populations of only a few individuals, which may not be genetically viable (Brennan 1984; Mwenja 2004). However, the situation in Mathews Range Forest Reserve is different, given that it suffers little anthropogenic pressure (Bronner 1990; Blackett 1994) when compared to western Kenya.

Study Area and Methods

The Mathews Range Forest Reserve was originally gazetted in 1956 as a Crown Forest, due to its importance as a water catchment area (Fig. 2). In 1964, it was declared a Central Forest with an area of 93,765 ha. The mean annual rainfall is 700 mm at lower elevations and 1100 mm at the top of the range, with a peak in October and April. The minimum temperatures range from 14ºC–20ºC in the dry season. Daily maximum temperature exceeds 30ºC in the dry season (Bronner 1990; Blackett 1994). There are three main forest types found in Mathews Range: those dominated by *Croton megalocarpus*; *Juniperus/Juniperus-Olea*; and mixed *Podocarpus* (Beentje 1990; Blackett 1994).

The Mathews Range forms the southern part of a mountain chain (formed since the Precambrian) that crosses the savannah plains of Samburu. The soils, developed on an undifferentiated basement system, are somewhat excessively drained, shallow to moderate deep, reddish brown, friable sandy clay loams. The lower slopes of the mountains are rocky, and at the higher elevation the soils are quite acidic (Blackett 1994).

The survey was carried out from 14 May 2007 to 28 December 2007, covering a total of 53 km within the selected survey transects (Table 1). I used general survey methods suitable for collection of data on geographical distribution, estimating densities, and assessing habitat, as well as obtaining limited information on age and sex composition, as described by Struhsaker (1981). Given that de Brazza's monkey is largely riparian (Hill 1966; Kingdon 1974; Gautier-Hion and Gautier 1978), all field visits were directed at surveying river valleys (*laggas*). I surveyed in the morning hours, from 08:00 to 11:00, and in the afternoon from 15:00 to 17:00 when the monkeys are active. I walked along the *laggas* slowly and quietly, at less than 1 km/hr, stopping every 60 m for 50 seconds (Butynski 1984).

Time spent on each *lagga* depended on its length and accessibility. Adjacent *laggas* were surveyed concurrently to avoid the error of double counting. Each *lagga* was surveyed at least twice during both the dry and wet seasons to increase the chances of sighting the monkeys. Surveys were made throughout the altitudinal range of 800 m to 2,400 m above sea level. The data collected included: date, name of the location, time spent (starting and finishing time), number sighted (adults and young), activity, association with other animals, tree species, elevation, GPS co-ordinates, mode of detection, and any other aspects of interest. Each data sheet represented one *lagga*, which in turn represented a single transect or sampling unit.

Interviews targeted people living near the forest and those who would visit it regularly. The livelihoods of the Dorobo depend on the forest, and they were the key respondents given their knowledge and understanding of its biodiversity. Interviews complimented the data collected from the field surveys.

Results

A total of 162 de Brazza's monkeys in 24 groups were counted during the survey. These included 139 adults and sub-adults and 23 infants (Table 1). These were found in ten separate *laggas* throughout the mountain range, save for the northwestern part where the presence of the species needs to be investigated further. By extrapolating information gathered on this study — from interviews and field observations — the population of the entire Mathews Range Forest Reserve was estimated at 200–300. The first ever record of de Brazza's monkey occurring above 2,100 m above sea level was recorded in the Mathews Range at 2,203 m at Olkaela.

Figure 1. The map of distribution of de Brazza's monkey (*Cercopithecus neglectus*) in Africa, showing the newly discovered population in Mathews Range Forest Reserve (black dot), the first record of the species east of the Great Rift Valley.

The areas where these 24 groups were found at high elevations and in the interior of the forest, included Napuruwaso, Olkaera, Manoea, Rapaelpapit Nachapa, Kiserian, Kojos, Ntukuda and Wamba. At Nkii, Murit, Miwaa, Sitin, Ngare narok and Ngare naibor, they were found at lower elevations and along forest edges.

Although the threats arising from the human activities in the forest are generally minimal, their impact at the more easily accessible lower elevations of Ngare narok, Nkii, Sitin Miwaa and Murit during the dry season is significant. During the dry season and periods of drought, these areas are invaded, and when the browse is exhausted cattle are taken into the interior of the forest, where they are fed leaves of evergreen trees such as *Faidherbia albida*, *Ficus* spp., and *Olea* spp. by cutting the branches and practically denuding the trees. These species happen to be some of the most preferred by de Brazza's monkeys; hence the conflict.

The forest and the vegetation along the rivers are often burnt, either by the honey collectors or livestock keepers, in order to trigger pasture regeneration and control ticks. Areas near settlements are largely grazed, but more distant areas are also affected by honey harvesting — often leading to forest fires. We found no signs of direct persecution of the de Brazza's monkeys by the local people: poaching/hunting, poisoning, or snaring were not evident in the area. As a result the Forest Reserve is currently one of the least disturbed habitats for de Brazza's monkeys in Kenya. The people living there are pastoralists, and their culture does not allow them to kill wildlife for food. Its cousin, *Colobus guereza percivali,* listed as Endangered on the IUCN Red List of Threatened Species, on the other hand, is killed for the beautiful skins it provides.

Discussion

Obviously, this relatively large population of an otherwise rare species has been thriving in the Mathews Range for many years. The species' quiet nature, large inter-individual distances within groups (Gautier-Hion and Gautier 1978), relatively small group sizes, and, unlike other primates, rare use of group calls, and lack of alarm calls (Maté *et al.* 1995), explain why so little is known about it there. The area is also remote and has a history of insecurity that has made it difficult for biologists to work there. According to Kingdon (1974), Brennan (1984) and Wahome (1989), de Brazza's monkeys keep close to water ranging not farther than 200 m. away. All the de Brazza's monkeys seen in the Mathews Range were within 200 m of water, except for one group at Ntukuda that was seen 1,000 m away from the nearest water, probably the first such record.

Seven of the ten most preferred plants, which make up 80% of the de Brazza's monkey's diet in Kisere Forest Reserve (Wahome 1989) are also found in the Mathews Range (Blackett 1994) where they are also among the most preferred species (see Table 2). This implies that the habitat of this satellite population is similar to those occupied by de Brazza's monkeys in western Kenya. It also explains why the species is present in Kisere but absent in neighboring forests in western Kenya, such as South Nandi, Buyangu and Isecheno forests of the wider Kakamega forest (Mwenja 2006) which have significant differences in their floristic communities and lacking de Brazza's monkeys' most preferred plant species (Karere 2000).

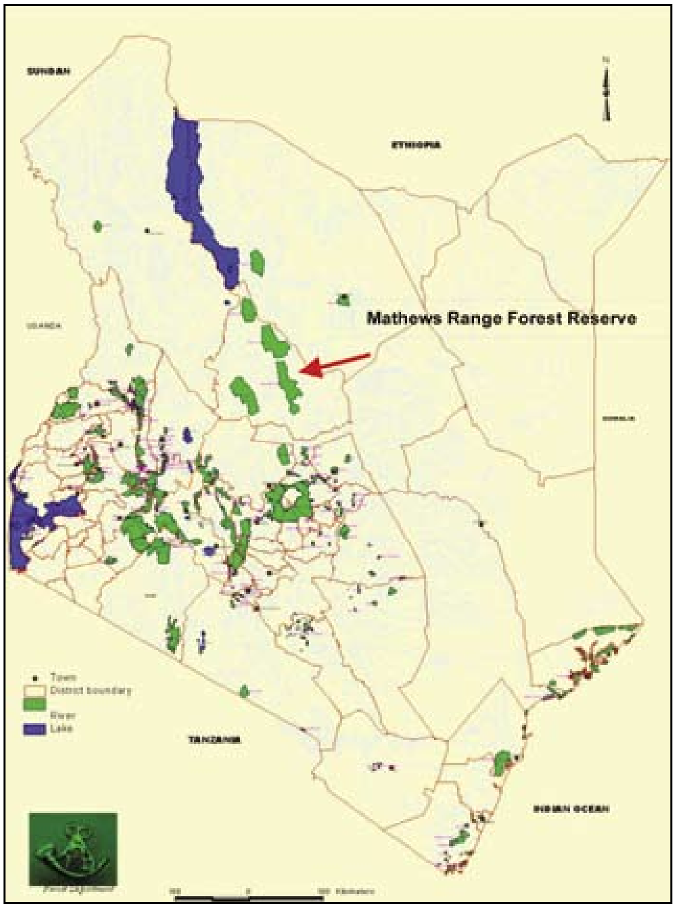


Figure 2. Map of Kenya's Forest Reserves showing Mathews range Forest Reserve.

Figure 3. Livestock grazing at Sitin, adjacent to an important area for de Brazza's monkeys in the Mathews Range, Kenya. Photo by Iregi Mwenja.

Other species exploited by de Brazza's monkeys in Kisere (Wahome 1989) and also found in Mathews Range Forest Reserve include: *Ficus sur, Ficus sycomorus*, *Ficus natalensis*, *Trichilia emetica*, *Strychnos usambarensis*, *Dombeya* spp., *Diospyros abyssinica*, and *Croton megalocarpus.*

The species is known to avoid polyspecific associations (Gautier-Hion and Gautier 1978; Wahome 1989), but I noted some association of de Brazza's monkey with other primates at Mathews Range, including the vervets and guereza colobus. This contrasts with my observations in western Kenya, where vervet monkeys keep a safe distance from de Brazza's monkeys (Mwenja 2006). At Ngare narok, vervet groups were seen on three occasions feeding in the same tree with de Brazza's monkeys. At Ntukuda, a group of guereza colobus was found together with a group of de Brazza's monkeys. This confirms Mwenja (2004), Wahome (1989) and Decker (1995) that the de Brazza's monkeys sometimes tolerate the colobus. The guereza colobus specialized on feeding at the top of the canopy, while the de Brazza's monkeys forage in the lower canopy layer (Gautier-Hion 1988; Wahome 1989). This niche

Table 1. A summary of the distribution and abundance of de Brazza's monkey (*Cercopithecus neglectus*) in Mathews Range, Kenya.

Lagga	**Distance covered (km)**	**GPS Coordinates**	**Elevation (m)**	**Number seen**		**No. of Groups**	**Tree species where they were seen**
				Adults	**Young**		
Napuruwaso	3	01.17571 N 037.26918 E	2,059	4	3	1	*Ficus thonningii* *Neonotonia wightii*
Rapaelpapit	1	01.25451 N 037.25695 E	2,054	3	0	1	*Neonotonia wightii* *Podocarpus falcatus*
Nachapa	2	01.29343 N 037.27028 E	1,897	1	0	1	*Ficus sycomorus* *Trichilia emetica*
Olkaela	2	01.24943 N 037.26859 E	2,203	1	0	1	*Faidherbia albida*
Rocheta	5	01.27118 N 037.28797 E	1,456	7	0	1	*Celtis africana*
Kiserian	2	01.20616 N 037.34498 E	1,369	1	0	1	*Ficus sycomorus* *Trichilia emetica*
Ntukuda	4	01.22111 N 037.34515 E	-	3	0	1	*Ficus sycomorus* *Trichilia emetica*
Nkii	7	1.23174 N 037.3538 E	1,152	18	5	2	*Ficus* spp. *Faidherbia albida*
Murit	3	01.18610 N 037.36497 E	-	14	3	2	*Scutia myrtina* *Neonotonia wightii*
Ngare narok	6	01.33887 N 037.19995 E	1,157	26	5	3	*Ficus sycomorus* *Trichilia emetica*
Sitin and Miwaa	12	01.27418 N 037.34284 E	866 to 1,335	46	4	8	*Scutia myrtina* *Faidherbia albida*
Wamba	3	-	-	6	1	1	*Ficus natalensis*
Ol doinyo lenkio	3	-	-	8	2	1	*Ficus* spp. *Faidherbia albida*
Total	**53**			**139**	**23**	**24**	

Table 2. The top ten most important species used by the de Brazza's monkey in Kisere Forest.

Plant species in Kisere	**% use**	**Recorded in Mathews**
Ficus thonningii	25.4	Yes
Celtis durandii	17.6	Yes
Manilkara butugi	15.9	Yes
Chaetachme aristata	9.5	Yes
Neonotonia wightii	7.8	Yes
Isoglossa laxa	6.1	-
Prunus africana	5.3	-
Celtis africana	4.4	Yes
Ipomoea wightii	4.4	-
Blighia unijugata	3.6	-

Source: Wahome (1989)

Figure 4. De Brazza's monkey (*Cercopithecus neglectus*) at Ngare narok in the Mathews Range Forest Reserve, Kenya. Photo by Iregi Mwenja.

differentiation between the colobus and de Brazza's monkeys is no doubt a key aspect in allowing them to coexist.

Kingdon (1971, 1997) put the highest elevation of the species at 2,100 m, but this was not the case for one group which I found at slightly above 2,200 m at Olkaela. However the overwhelming majority of the population inhabited areas below 2,100 m. Seventy-five percent of the population was concentrated between the elevations of 900 m to 1,300 m above sea level. The remaining 25% occurred at elevations between 1,300 m and 2,200 m.

Polygamous groups were the case for most of the groups in the Mathews Range, with most having a dominant male, making this population similar to others in Kenya (Brennen 1984; Wahome 1989; Mwenja 2004), but unlike those in the Gabon basin where they are evidently monogamous (Quris 1976; Gautier-Hion and Gautier 1978). Group sizes recorded ranged from 1–18, similar in size to those observed by Wahome (1993) in the Kisere Forest Reserve: 1–16 with an average of 10.1. Although the Mathews Range Forest Reserve recorded a higher population of de Brazza's monkeys than in any other Protected Area in Kenya, most people who live around the forest were unfamiliar with the species — 22 (75%) of the 29 people interviewed had never seen it, a rather higher percentage than in western Kenya, where 40 (60%) of 67 people interviewed had no knowledge of the species (Mwenja 2006). The few people who know the animals are the 'Dorobo' people of the Samburu, who rely on forest products for their livelihood.

Richard Leakey (pers. comm.) suggests that a population that has been isolated for over 500,000 years is likely to speciate or at least exhibit genetic divergence from the mainstream population, and for this reason special value may need to be given to these de Brazza's monkeys, which may even have been isolated for a time sufficient for them to be considered a distinct subspecies.

Acknowledgments

I acknowledge the generous assistance from Fauna and Flora International (FFI) Flagship Species Fund (FSF) Small Grants Programme, Conservation International's Primate Action Fund, and Rufford Small Grants for Nature Conservation for funding this project; the Institute of Primate Research of the National Museums of Kenya, the Milgis Trust, Namunyak Wildlife Conservancy and East African Wildlife Society (EAWLS) for logistical support; and my mentor Dr. Richard Leakey for his guidance and invaluabe support.

Literature Cited

Beentje, H. J. 1990. The forests of Kenya. *Mitteilingen des Instituts für Allgemeine Botanik Hamburg* 23(a):265–286.

Bernie, R. 2005. Creating Sustainable Living in Kenya's Indigenous Forests. Report, Wilderness Foundation, UK.

Blackett, H. L. 1994. Forest inventory report of the Mathews Range Forest Reserve. *KIFCON, Nairobi* (8): 1–14.

Booth, C. 1962. Some observations of *Cercopithecus* monkeys. *N. Y. Acad. Sci*. 102: 477–487.

Brennan, E. J. 1985. De Brazza's monkeys (*Cercopithecus neglectus*) in Kenya: census, distribution and conservation. *Am. J. Primatol.* 8: 271–277.

Brennan, E. J. 1989. Demographics of captive de Brazza's guenons. *Zoo Biol.* 8: 37–47.

Brennan, E. J. and J. G. Else. 1984. Can Kenya's de Brazza's monkeys survive? *Swara Magazine* 7(3): 12–14. East African Wildlife Society (EAWLS), Nairobi.

Bronner, G. 1990. Vegetation and land use in Mathews Range area, Samburu District, Kenya. *Dissertationes Botanicae* 160: 1–182.

Butynski, T. M. 1985. Primates and their conservation in the Impenetrable (Bwindi) Forest, Uganda. *Primate Conserv.* (6): 68–72.

Decker, B. S. 1995. Survey of de Brazza's in Tororo district of eastern Uganda and Trans-Nzoia and west Pokot districts of western Kenya. *J. East African Nat. Hist.* 84(1): 25–34.

Douglas-Dufresne, H. 2005. Proof positive. *Swara Magazine* 28(2): 68. East African Wildlife Society (EAWLS), Nairobi.

Gautier-Hion, A. and J. P. Gautier. 1978. Le singe de Brazza: une strategie originale. *Z. Tierpsychol*. 46: 84–104.

Gautier-Hion, A., F. Bourlière, J. P. Gautier and J. Kingdon (eds.). 1988. *A Primate Radiation: Evolutionary Biology of the African Guenons*. Cambridge University Press, Cambridge, UK.

Karere, G. M. 1995. Survey of de Brazza's monkeys in Mt. Elgon and the Cherangani Hills, Western Kenya. Report, Kenya Wildlife Service (KWS) and Institute of Primate Research, Nairobi.

Karere, G. M. 2000. Some Ecological Studies of De Brazza's Monkey (*Cercopithecus neglectus*) and its Habitat Prior to Translocation. MSc thesis, University of Nairobi, Nairobi.

Kingdon, J. 1997. *The Kingdon Field Guide to African Mammals.* Academic Press, London.

Macdonald, D. W. (ed.). 1993. *The Encyclopaedia of Mammals*. Facts on File, New York.

Mittermeier, R. A. and D. L. Cheney. 1987. Conservation of primates and their habitats. In: *Primate Societies*, B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham and T. T. Struhsaker (eds.), pp.477–490. The University of Chicago Press. Chicago

Mwenja, I. 2004. National rapid durvey on the status and distribution of de Brazza's monkeys in Kenya. *Swara Magazine* 27(4): 18–21. East African Wildlife Society (EAWLS), Nairobi.

Mwenja, I. 2006. A detailed survey of de Brazza's monkey in western Kenya: focus on vulnerable groups outside protected areas. Report to East African Wildlife Society (EAWLS), Nairobi.

Nowak, R. M. 1991. *Walker's Mammals of the World*. Vol. 1. 5th edition. Johns Hopkins University Press, Baltimore.

Quris, P. 1976. Données comparatives sur la socioécologie de huit espèces de Cercopithecidae vivant dans une même zone de forêt primitive periodiquement inondée (nord-est du Gabon). *Terre et Vie* 30: 193–209.

Staaden, S. 1996. *North American Regional Studbook for de Brazza's monkey,* Cercopithecus neglectus. 1st edition. North Carolina Zoological Park, Asheboro, NC.

Struhsaker, T. T. 1981. Census methods for estimating densities. In: *Techniques for the Study of Primate Population Ecology*, pp.36–80. National Academy Press, Washington, DC.

Wahome, J. M. 1989. The Ecology of the De Brazza's Monkey (*Cercopithecus neglectus* Schlegel) in Kisere Forest Reserve. MSc Thesis, University of Nairobi, Nairobi.

Wahome, J.M. 1993. The de Brazza's monkey: A species under siege in Kenya. *Swara* 16:33–34.

Wolfheim, J. H. 1983. *Primates of the World: Distribution, Abundance, and Conservation*. University of Washington Press, Seattle.

Author's address:
Iregi Mwenja, Associate Research Scientist, Institute of Primate Research of the National Museums of Kenya, P.O. Box 606, Ruaraka, 0618, Kenya. E-mail: <iregim@yahoo.com>.

Received for publication: July 2007
Revised: October 2007

Primate Conservation 2007 (22): 123–128

The Endemic Uganda Mangabey, *Lophocebus ugandae*, and Other Members of the *albigena*-Group (*Lophocebus*)

Colin P. Groves

School of Archaeology and Anthropology, Australian National University, Canberra, Australia

Abstract: Revising the grey-cheeked mangabeys (*Lophocebus albigena* group) in the light of the Phylogenetic Species Concept reveals more taxonomic diversity than was formerly suspected. The three subspecies recognized by Groves (1978) are diagnosably distinct, and are here upgraded to species rank. Most significantly, the mangabeys of Uganda, not recognized as distinct at all in the 1978 revision, are now shown to constitute a fourth species, *Lophocebus ugandae* (Matschie, 1912), which is apparently confined to Uganda, and as such probably Uganda's only endemic primate

Key Words: Mangabey, *Lophocebus albigena*, *Lophocebus osmani*, *Lophocebus johnstoni*, *Lophocebus ugandae*, Uganda endemicity

Introduction

Mangabeys of the genus *Lophocebus* are allied to baboons (*Papio*) and geladas (*Theropithecus*), whence Kingdon (1997; p.47) calls them "baboon-mangabeys." According to Goodman *et al*. (1998), the three groups diverged only in the mid-Pliocene, some 4 million years ago, which would be too recent to support generic separation under their preferred model (which requires two clades to have diverged at least 7 million years ago in order to merit separate genera). Despite the fact that genera (and families, and orders) are currently recognized in a fashion that is still quite arbitrary (except that they must be monophyletic), the proposal by Goodman *et al.* (1998) to introduce this objective criterion has still not achieved wide acceptance. As such, I here continue to recognize *Lophocebus* as a genus.

Groves (1978) recognized five taxa, which he classed as subspecies of a single species, *Lophocebus albigena* (Gray, 1850). The five subspecies were as follows:

L. a. albigena (Gray, 1850)
L. a. osmani Groves, 1978
L. a. johnstoni (Lydekker, 1900)
L. a. aterrimus (Oudemans, 1890)
L. a. opdenboschi (Schouteden, 1944)

The last two admittedly stand apart from the other three, and this was given expression in Groves (2001), where *Lophocebus aterrimus* and *L. opdenboschi* were given status as separate species. The three resulting species are certainly diagnosably and geographically distinct, and can be instantly recognized by characters of the crest on the crown, cheek whiskers, and pelage in general. *L. opdenboschi* is particularly poorly known, from only a few localities, along the Kwilu and Kwango rivers in southwestern DRC, and is a prime candidate for future field surveys. Grubb *et al.* (2003) continued to separate *L. aterrimus* specifically, but relegated *opdenboschi* to the status of a subspecies of it; they also expressed some misgivings about the status of the subspecies of *L. albigena*. In the present brief report, I restrict myself to the *L. albigena* group, i.e., the first three 'subspecies' listed above, commonly known as grey-cheeked mangabeys.

The three 'subspecies' remaining in *L. albigena*, after the removal of *L. aterrimus* and *L. opdenboschi*, are briefly described in Groves (2001), but for further details see Groves (1978); beautiful paintings of them will be found in Gautier-Hion *et al.* (1999). The most noticeable distinctions are in the colour of the mantle of elongated hair over the foreparts:

L. a. osmani – rusty-brown,
L. a. albigena – light grey, sometimes with faint straw tones,
L. a. johnstoni – from dark grey-brown to very pale, whitish-grey to chocolate.

In *L. a. osmani* and *albigena*, there is usually a black patch on the nape and withers, but this is rare in *L. a. johnstoni*. The underside is yellow-grey in *L. a. osmani,* but not noticeably lighter than the upper side in the other two. The cheek-whiskers are long and bright grey or golden-white in *L. a. osmani*; more creamy in *L. a. albigena*; and light grey-brown, passing to white lower down in *L. a. johnstoni,* but the lower cheeks are so thinly haired that this is hardly noticeable. In *L. a. albigena* and *johnstoni*, the crown hair is long and scruffy, often forming two little 'horns' above the brows. The crown hair is 'neater' in *osmani*, and never forms 'horns'.

The distribution of *L. a. osmani* extends from the Cameroon Plateau (Batouri district) northwestward across the Sanaga River to Mamfe on the border of Nigeria; mostly it seems to occupy higher altitudes, 600 m and more, except in the Edea district which is on the coast to the north of the Sanaga River. The range of *L. a. albigena* extends along the coast south of the Sanaga, then west via northern Gabon to the Ubangi River, skirting that of *osmani* to the southwest, south and east, apparently in low-lying, often swampy forests. *L. a. johnstoni* is found in the DRC from Lisala District (2°57'N, 20°07'E) east to the Ituri and Semliki Forests, and from Kabambare (4°13'S, 27°07'E) in the south to Uele District in the north, and southeast to Rwanda and Burundi. These distributions have been mapped in Groves (1978: reproduced here, Fig. 1) and in Gautier-Hion *et al.* (1999).

I have, for some years now, argued for the so-called 'Phylogenetic Species Concept' (PSC): a species must be 'diagnosable', meaning that it must possess consistent differences, in any apparently heritable character, from others. This offers objectivity and repeatability; recognition of species, the units of biodiversity, should not depend on hypotheses of relatedness or that they "might perhaps" interbreed. I will not repeat the arguments here; they have been set out in Groves (2001) and elsewhere. The first observation that needs to be made about what I previously regarded as subspecies of *Lophocebus albigena* is that they are consistently different: under the PSC, they would all rank as distinct species.

For a symposium on mangabeys at the International Primatological Congress in Entebbe, June 2006, Michele Hawkins and I returned to the data which had formed the basis of the revision by Groves (1978). Very little material has accumulated since then; I have not studied the *Lophocebus* material in the North American collections, but the European collections are so copious and have such a wide geographic coverage that they are adequate. It is desktop computers and statistical packages that have in the meantime made all the difference; it is now possible to perform, in a fraction of a second, the sorts of calculations which used to take weeks of preparation, hours of repetitive (and potentially inaccurate) keystrokes, and the need to book time on a central computer system. The gain in flexibility alone makes it all worthwhile! When you are able to try all sorts of ways to analyze the data, all in a single afternoon, you inevitably discover things which you had no inkling of before.

Material and Methods

The material studied, and the methods, and the 17 measurements taken on each skull, are described in Groves (1978), and need not be repeated here. What is new is that the skull measurements were entered in a data file in SPSS version.14.0. Adult male and female variables were entered, separately and in different combinations, both as raw variables and log-transformed, into Discriminant Function Analyses (Direct method), based on geographically constrained samples, which were then grouped as far as the preliminary results warranted. In any given analysis, an attempt was made to avoid Type I Errors ('false positives') by ensuring, where possible, at least as many specimens per group as there were variables in the analysis: the different available sample sizes account for the 'different combinations' mentioned above.

It should be acknowledged right away that, as one referee has pointed out, because Discriminant Analysis 'is very good at distinguishing groups', one must consequently be on the alert for possible circularity. This is why one cannot start by taking 'accepted' taxa for granted: initial samples must be as geographically circumscribed as possible, as if no species/subspecies had ever been described (if samples are large enough).

Results

I first tested the homogeneity of two of the three 'subspecies' by separating them into geographic samples and entering each as a separate group into a Discriminant Analysis (the sample of *L. a. osmani* was not large enough to divide into geographic samples). This was done for males and females separately; only the results for males are shown here.

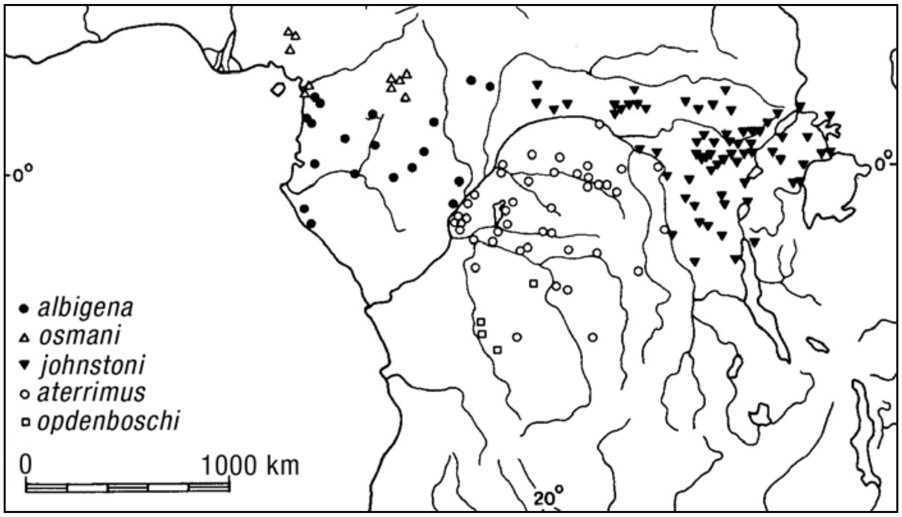


Figure 1. The map of Central Africa showing localities for five taxa of *Lophocebus* that was published in Groves (1978). All were given as subspecies of *L. albigena* at that time.

Figure 2 shows the results for what Groves (1978, 2001) called *L. a. johnstoni*, using nine variables. The Uganda sample stands out strikingly from all the others; no other sample is at all well differentiated, and all the individual specimens, including the one from Burundi, fall well into the range of those from the non-Uganda ones (i.e., Democratic Republic of Congo). Only a skull from Yangambi (Kisangani District) approaches the Uganda sample somewhat. Inspection of the coefficients shows that Function 1, which separates Uganda from DRC, is heavily weighted positively on Basal Length and Facial Length, and negatively on Palate Length; this means that Uganda skulls are small with short faces but relatively long palates (large masticatory apparatus). The table of classification results (which calculates what proportion of each sample is closer to the mean of that sample than of others) records that all of the 10 Uganda skulls are closest to their own mean, whereas the nine Uele, 28 Ituri, and six PNV (Parc National du Virunga) skulls are intermixed with each other but never closer to the Uganda mean.

Figure 3 compares the western Central African samples allocated by Groves (1978, 2001) to *L. a. albigena* and *osmani*, using this time only six variables, as available sample sizes are smaller. Samples ascribed to *L. a. albigena* separate on average but, even given the relatively small sample sizes, there is in no case anything like a complete separation. The subspecies *zenkeri* has sometimes been recognized (Schwarz 1910; Napier 1981) from the Cameroon coast south of the Sanaga River—and these mangabeys do tend to have the greyest mantles—but this sample (n = 9) is also not strongly distinct (the others are Gabon [n = 3] and Sangha region [n = 7]). Whereas these samples are intermixed, 100% of the *L. a. osmani* sample (n = 6) is correctly classified, indeed it is completely distinguished from any sample ascribed to *albigena*; DF1 is strongly positive on both basal length and bicanine breadth, and strongly negative on palate length. A skull (lacking a skin) from Akouafim, just south of the Batouri region from which some of the *osmani* specimens come, identifies itself clearly as *osmani*.

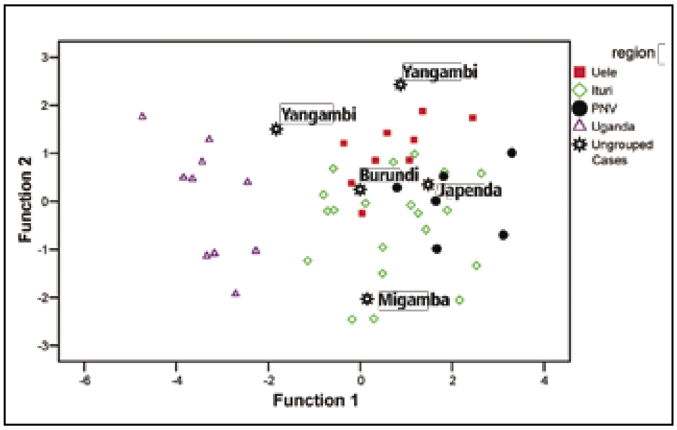


Figure 2. Canonical Discriminant Functions 1 and 2 in samples and individual specimens of males of *Lophocebus albigena johnstoni* (as recognized in Groves 1978 and 2001), utilising nine cranial variables. Function 1 accounts for 86.4% of the total variance, Function 2 for 8.4%.

Figure 5 includes all male skulls of the *L. albigena* group; on the evidence of the results of the first two analyses, all the samples of *L. a. albigena* are combined into one, and the same with *johnstoni* with the exception of the Ugandan sample, so as to give just four groups. Seven variables are used. The Uganda sample (n = 10) still stands out, and again does not overlap with the *johnstoni*-DRC sample (n = 40). The difference between *albigena* (n = 20) and *osmani* (n = 7: the Akouafim specimen has now been added to the original six) has now been to some extent overwhelmed by the separation of Uganda, and they both overlap extensively with the DRC sample. As before, DF1 is strongly positive on Basal Length and Facial Length, and strongly negative on Palate Length.

As just noted, the inclusion of too many groups may ‘swallow up’ some of the discrimination; so a new analysis was made excluding the Uganda sample (Fig. 6). The three remaining taxa remain incompletely separated; *L. a. johnstoni* is somewhat better differentiated from the two western Central Africa taxa than these are from each other. Recall, however, that when *L. a. osmani* and different geographic groupings of *L. a. albigena* are analysed together, the two taxa separate well, and of course all three are absolutely different in external features.

The analyses using females are not reproduced here, because discrimination is less and sample sizes are less. The sexes are significantly different (F = 211.614, p<0.0001), but degrees of sexual dimorphism may differ in the different taxa. Individual measurements were plotted out separately to test this. In Total Skull Length (Fig. 7), *L. a. osmani* is by far the most sexually dimorphic: males average somewhat larger than other taxa, whereas females average noticeably smaller than

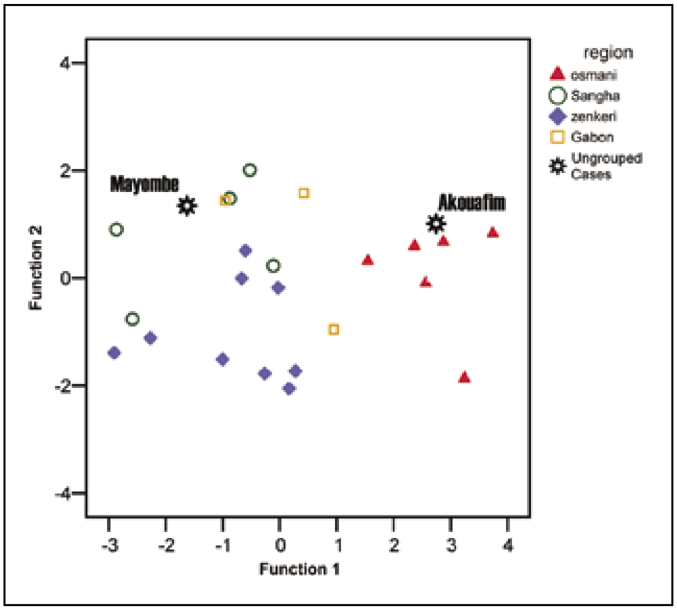


Figure 3. Canonical Discriminant Functions 1 and 2 in samples and individual specimens of males of *Lophocebus albigena albigena* and *osmani*, utilising six cranial variables. Function 1 accounts for 77.1% of the total variance, Function 2 for 21.1%. The name “*zenkeri*” denotes a sample, sometimes recognised as a distinct subspecies, from the Kribi/Bipindi district of the Cameroon coast, south of the Sanaga River.

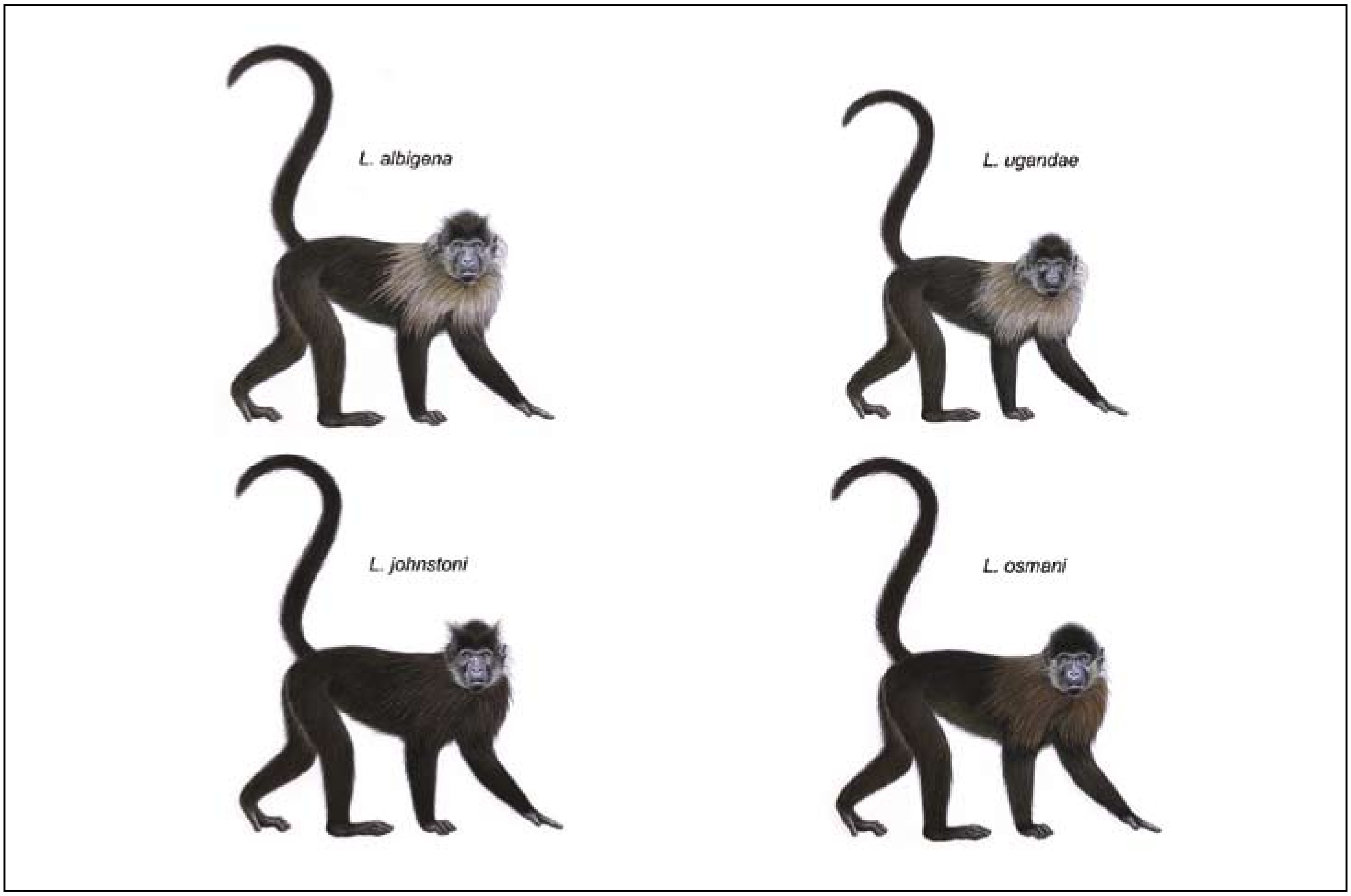


Figure 4. The grey-mantled grey-cheeked mangabey (*Lophocebus albigena*), Ugandan grey-cheeked mangabey (*L. ugandae*), Johnston's grey-cheeked mangabey (*L. johnstoni*), and Osman Hill's grey-cheeked mangabey (*L. osmani*). Illustrations by ©Stephen D. Nash / CI.

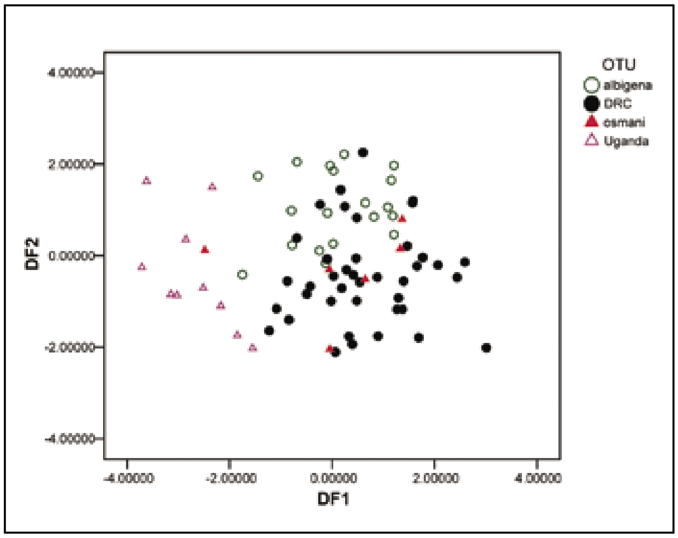


Figure 5. Discriminant Functions 1 and 2 in samples and individual specimens of males of all members of the *Lophocebus albigena* group, utilising seven cranial variables. Function 1 accounts for 56.5% of the total variance, Function 2 for 24.4%. DF3 accounts for the remaining 19.1%, but adds nothing to the discrimination.

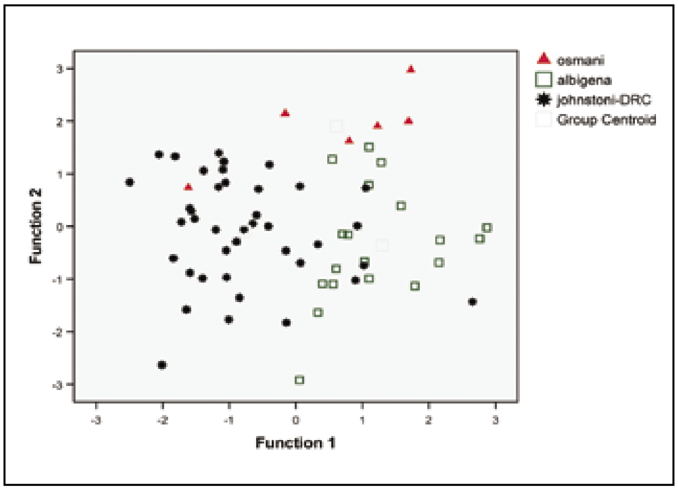


Figure 6. Discriminant Functions 1 and 2 in samples and individual specimens of males of all members of the *Lophocebus albigena* group except for the Uganda form, utilising 10 cranial variables. Function 1 accounts for 71.3% of the total variance, Function 2 for the remaining 28.7%.

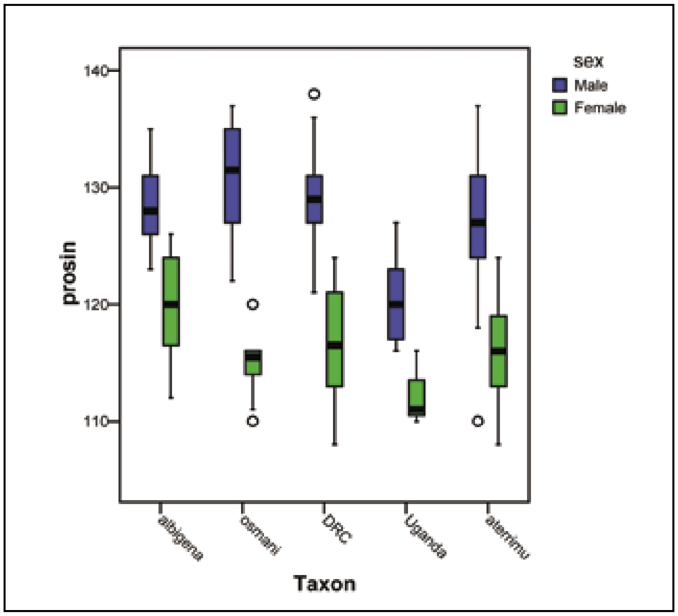


Figure 7. Prosthion-to-Inion distance (=greatest skull length) in adult males and females of the *Lophocebus albigena* group.

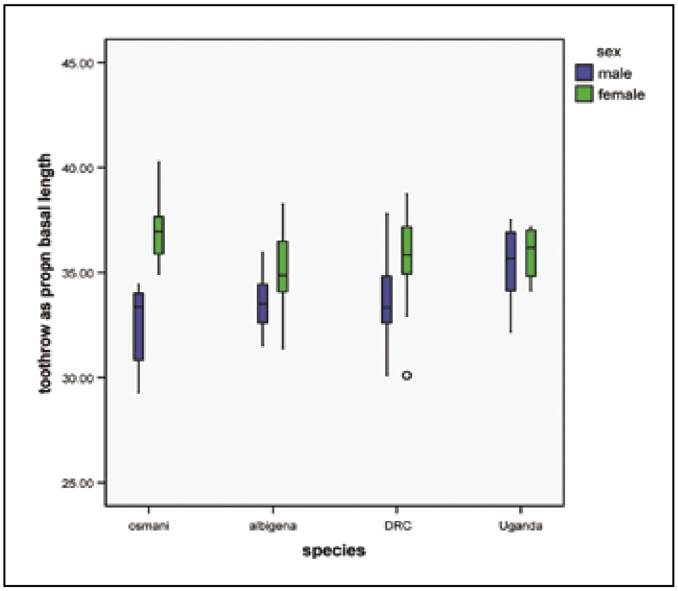


Figure 8. Maxillary toothrow length (premolars and molars) as a percentage of basal skull length (Prosthion to Basion) in adult males and females of the *Lophocebus albigena* group.

all others except for Uganda. Skull size of both sexes is small in Uganda, males being very much smaller than other taxa, females less so.

It is implied by the multivariate analyses that the Uganda taxon, though small in size, has relatively large masticatory apparatus. This is tested by an index relating the length of the maxillary postcanine dentition to basal skull length (Fig. 8). Again, *L. a. osmani* is extremely dimorphic (teeth in females are relatively larger than in males), whereas the Uganda taxon shows no sexual dimorphism at all, as the teeth are relatively enlarged in males as well as females.

Discussion

It is clear from these results that, as far as cranial measurements are concerned, *johnstoni*-Uganda differs more from the taxa *albigena, osmani* and *johnstoni*-DRC than these three do from each other. To a somewhat lesser degree, but still absolutely (without overlap), the taxon *osmani* differs from *L. a. albigena*. We have here four diagnosably distinct taxa, i.e., four species. Three of these are already recognized as distinct subspecies by Groves (1978), and all that needs to be done is to raise them to specific rank: *Lophocebus albigena*, *L. osmani* and *L. johnstoni*. But this analysis has shown that "*johnstoni*" actually consists of two diagnosable entities: one in DRC, Rwanda and Burundi, the other confined to Uganda. Which is the true *Lophocebus johnstoni*, and what is the correct name for the other?

Semnopithecus albigena johnstoni was described by Lydekker (1900) from a living specimen in the London Zoo, said to have been "brought from the country Barundi, at the north end of Tanganyika". Schwarz (1910) fixed the type locality as present-day Burundi; as noted above, a skull from Burundi falls well within the sample from DRC, which is therefore the species that takes the name *Lophocebus johnstoni*. Groves (1978) lists four junior synonyms for *johnstoni*, of which one has its type locality within Uganda: *Cercocebus* (*Leptocebus*) *albigena ugandae* Matschie, 1912 (type locality 'Chagwe'). The available name for the Uganda mangabey is therefore *Lophocebus ugandae* (Matschie, 1912).

The location of Chagwe was given by Groves (1978) as "Nbondo, Nile mouth at Lake Albert", but it is in fact "a large area north of Lake Victoria, east of Kampala, west of the Nile and Jinja, and a little northwards towards Bugerere" (Robert Kityo, pers. comm.), approximately 00°17'– 00°33'N, 32°40'–33°11'E, and more correctly called Kyagwe (Fig. 9). The main forest block in this district, hence probably the restricted type locality, is Mabira Forest.

As we have seen, the skull of *Lophocebus ugandae* differs from other species of the *L. albigena* group in its small size, especially in the males, reduced sexual dimorphism and relatively large masticatory apparatus. Multivariate analysis separates the species 100% from others of the group, although in any one skull measurement there may be a slight overlap.

Matschie (1912) described *ugandae* as having a pale chocolate mane and breast, contrasting with the dark grey-brown mantle of the mangabey of the Ituri Forest. Groves (1978, p.26) described the mantle as "darkish brown, often not too much lighter than body colour": this had reference mainly to the very large Ituri Forest series in the Tervuren Museum. Allen (1925: p.344) likewise described 35 adults from the upper Uele District and Ituri lowlands as varying "but little in colour tones, but considerably in the extensive brownish areas", the mantle being "brown (light seal-brown to pale sepia)". Consistent with this, the type of *johnstoni* (in the Natural History Museum, London) has a mantle which contrasts comparatively little with the body colour. Skins from Uganda in this Museum are more variable, but tend to be somewhat

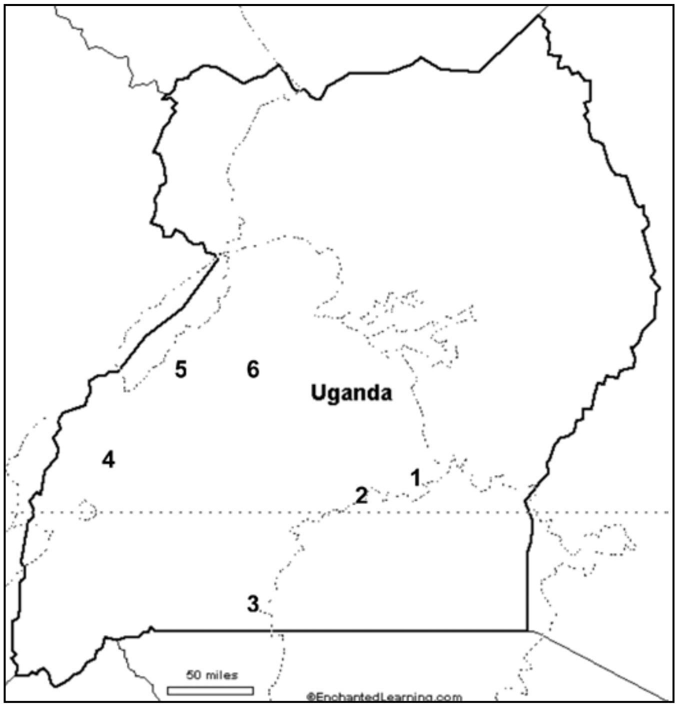


Figure 9. Known distribution (based on museum records) of *Lophocebus ugandae*. 1. Mabira forest (= Kyagwe; type locality). 2. Bujuko and Bukasa forests. 3. Sango Bay forests. 4. Kibale and Mpanga forests. 5. Bugoma forest. 6. Budzi.

more contrasted, the more easterly specimens (Mabira, Bujuko, Kampala District) being light yellow-brown, whereas some of those from Bunyoro, Toro and Sango Bay are somewhat darker grey-brown. Photos published on the web from Kibale forest (see <www.shunya.net/Pictures/Uganda/Kibale/Kibale.htm, www.msnbc.msn.com/id/13421030/, en.wikipedia.org/.../fridge_door>) are also grey-brown, varying from medium to rather light. In summary, the pelage characters need to be restudied, but the evidence to date indicates that the mantle in *Lophocebus ugandae* contrasts more with the general body colour than that in *johnstoni*.

Lophocebus ugandae seems most numerous in the forests along the northern and northwestern shores of Lake Victoria, including Mabira Forest (the type locality), Bujuko and Bukasa Forests, and Sango Bay; and it also occurs in the forests along the eastern side of the Albertine Rift, especially Kibale (Fig. 9). *Lophocebus ugandae* is not known from DRC or Rwanda, but only within Uganda; as far as we know, it is Uganda's only endemic primate.

Acknowledgments

Michele Hawkins entered the skull measurements into a data file, and performed some initial analyses; I am most grateful to her. My sincere thanks to Tom Butynski, Robert Kityo, Anthony Rylands and an anonymous referee for suggestions which have greatly improved the paper. Thank you also to Stephen Nash for his excellent artwork. Finally, I once again record my gratitude to the curators of the collections that I studied in the 1970s (listed in Groves 1978).

Literature cited

Allen, J. A. 1925. Primates collected by the American Museum Congo expedition. *Bull. Am. Mus. Nat. Hist.* 47: 283–499.

Gautier-Hion, A., M. Colyn and J.-P. Gautier. 1999. *Histoire Naturelle des Primates d'Afrique Centrale*. Ecofac, Franceville, Gabon.

Goodman, M., C. A. Porter, J. Czelusniak, S. L. Page, H. Schneider, J. Shoshani and G. Gunnell and C. P. Groves. 1998. Toward a phylogenetic classification of Primates based on DNA evidence complemented by fossil evidence. *Molec Phylogenet. Evol.* 9: 585–598.

Groves, C. P. 1978. Phylogenetic and population systematics of the mangabeys (Primates: Cercopithecoidea). *Primates* 19: 1–34.

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Grubb, P., T. M. Butynski, J. F. Oates, S. K. Bearder, T. R. Disotell, C. P. Groves and T. T. Struhsaker. 2003. Assessment of the diversity of African primates. *Int. J. Primatol.* 24: 1301–1357.

Kingdon, J. 1997. *The Kingdon Field Guide to African Mammals*. Academic Press, San Diego.

Lydekker, R. 1900. Note on two mangabey-like monkeys (*Cercocebus hagenbecki* and *Semnopithecus albigena rothschildi*) now living in the menagerie of the Zoological Society. *Novitates Zoologicae* 7: 593–596.

Napier, P. H. 1981. *Catalogue of Primates in the British Museum (Natural History) and Elsewhere in the British Isles. Part II: Family Cercopithecidae, Subfamily Cercopithecinae*. British Museum (Natural History), London.

Matschie, P. 1912. Über Affen aus dem Belgischen Congo. *Revue Zoologique Africaine* 2: 201–212.

Schwarz, E. 1910. On *Cercocebus aterrimus* and *Cercocebus albigena*. *Ann. Mag. Nat. Hist.* (8) 5: 527–530.

Author's address:
Colin P. Groves, School of Archaeology & Anthropology, Building 14, Australian National University, Canberra, ACT 0200, Australia, e-mail: <Colin.Groves@anu.edu.au>.

Received for publication: 27 March 2007
Revised: 26 June 2007

Primate Conservation 2007 (22): 129–133

Distribution of *Macaca ochreata* and Identification of Mixed *ochreata-tonkeana* Groups in South Sulawesi, Indonesia

Erin P. Riley [1], Bambang Suryobroto [2] and Dario Maestripieri [3]

[1] *Department of Anthropology, San Diego State University, San Diego, California, USA*
[2] *Department of Biology, Bogor Agricultural University, Bogor, Indonesia*
[3] *Animal Behavior Research Group, University of Chicago, Chicago, Illinois, USA*

Abstract: We collected data on the distribution of booted macaques (*Macaca ochreata*) in Faruhumpenai Nature Reserve in South Sulawesi, Indonesia, in order to assess its conservation status. Methodology included censuses conducted along piecewise linear transects established at two sites from April–July 2006. The total distance walked was 45 km for the Matano site, and 20 km for the Kasintuwu site. Group density of booted macaques at the Matano site was 0.97–1.56 per km². At the Kasintuwu site, we encountered groups of booted macaques and Tonkean macaques (*Macaca tonkeana*), as well as mixed groups of *tonkeana* and *ochreata*. The group density of booted macaques was 1.45–2.00 per km². Overall macaque group density (i.e., *Macaca* spp.) at this site was 3.25–4.00 per km². Our study demonstrated that two species of Sulawesi macaques, *M. tonkeana* and *M. ochreata*, as well as mixed *tonkeana-ochreata* groups occur in the forests in and surrounding Faruhumpenai Nature Reserve. The results confirm a more extensive range of *M. ochreata* than was previously recognized; one that extends further north and northwest than the provincial boundary of south and southeast Sulawesi. The conservation status of booted macaques may, therefore, not be as precarious as previously thought, since their habitat is protected in not only two large conservation areas in Southeast Sulawesi (Rawa Aopa National Park and Tanjung Peropa Game Reserve), but also in South Sulawesi in the Faruhumpenai Nature Reserve. Nonetheless, because cacao is frequently planted on the borders of these protected forests, human-macaque conflict resulting from crop raiding may eventually pose a threat.

Key words: Sulawesi macaques, *Macaca tonkeana*, *Macaca ochreata*, distribution, density, mixed species groups, conservation

---

Introduction

The Indonesian island of Sulawesi, which occupies a unique biogeographical position within the transitional zone of Wallacea, harbors a remarkably large number of endemic species (Whitten *et al*. 2002). With regard to nonhuman primates, seven of the 19 species of the genus *Macaca* are endemic to Sulawesi (Fooden 1969: *Macaca nigra*, *M. maura*, *M. tonkeana*, *M. hecki*, *M. ochreata*, *M. brunnescens*, and *M. nigrescens*). Given such high levels of endemism, Wallacea has recently been prioritized as one of the 25 hotspots for biological conservation (Myers *et al*. 2000).

Although the evolution, population genetics, and morphological variation of the Sulawesi macaques have been the focus of a considerable amount of research (for example, Bynum *et al*. 1997; Evans *et al*. 1999, 2001, 2003; Abegg and Thierry 2002; Bynum 2002; Schillaci and Stallman 2005), the behavioral ecology and conservation of these taxa remain relatively understudied. Long-term ecological and behavioral research with conservation implications has only been conducted on wild populations of three species (*M. nigra*: Lee 1997; O'Brien and Kinnaird 1997; *M. nigrescens*: Kohlhaas 1993; *M. tonkeana*: Riley 2005). The remaining species have been the subjects of short-term observations on aspects of social organization and behavior (Watanabe and Brotoisworo 1982; Reed *et al*. 1997; Matsumura 1998; Kilner 2001). With such limited data, our understanding of their habitat needs, current conservation threats, and their ability to respond to these threats, remain unclear (Bynum *et al*. 1999).

The focus of this research is the Sulawesi booted macaque, *Macaca ochreata*. Given the paucity of information on this species, the booted macaque is currently listed as 'Data Deficient' (IUCN 2006). The goal of our study was to collect basic distributional and ecological data on *M. ochreata* in order to assess its conservation status and to inform conservation efforts aimed at protecting the species and its habitat.

Study Site and Data Collection

The research was conducted at Faruhumpenai Nature Reserve, at the provincial border of Central and South Sulawesi, Indonesia (Fig. 1). Faruhumpenai Nature Reserve was established in 1979 with an area of 90,000 ha, providing habitat for 38 listed wildlife species and 205 plants. Censuses were conducted at two research locations using the line-transect method (NRC 1981; Buckland *et al.* 2001): (1) "Matano": at the southeastern border of the Faruhumpenai Nature Reserve, 6 km from the village of Matano, and (2) "Kasintuwu": in the north-northwest section of the nature reserve near the village of Kasintuwu (Fig. 1).

Due to the difficulty of the terrain, three piecewise linear transects were established at each location (Table 1). Piecewise transects are line transects that are segmented due to topography, in which case the length of the survey is obtained by summing all of the transect segment lengths used (Patterson 2001). Transects were walked at the maximum speed of 1 km/hour, beginning at 6:30 am. Each time macaques were encountered, we immediately recorded the animal-observer distance using a rangefinder, and the angle between the forward direction of the transect line and the direction to the macaques. We then recorded the following information: time sighted, location along the transect, species, number of individuals, group composition (if possible), activity of the first animal detected, height of first animal detected, and mode of detection. In addition, to obtain basic ecological information from the research locations, we measured the Diameter at Breast-Height (DBH) of all trees 5 m to the right and left of the transect, at 100 m intervals.

Analysis

Estimates of macaque group density at each research site were calculated using the formula: $D = N/2\ Lw$, where N = number of groups encountered, L is the sum of the transects lengths, and w is the width of the transect that is covered. Two estimates of w were used to calculate density: a standard width strip of 50 m and the maximum animal-observer distance (NRC 1981).

Results

Species distribution, mean encounter rate, and group density

Estimated group densities and mean encounter rates per field site are shown in Table 2. An important external characteristic that enables us to discriminate between booted and Tonkean macaques is the color of the forearms and hindlimbs: those of booted macaques are whitish grey while those of *tonkeana* are black, like the trunk (Watanabe *et al.* 1991)

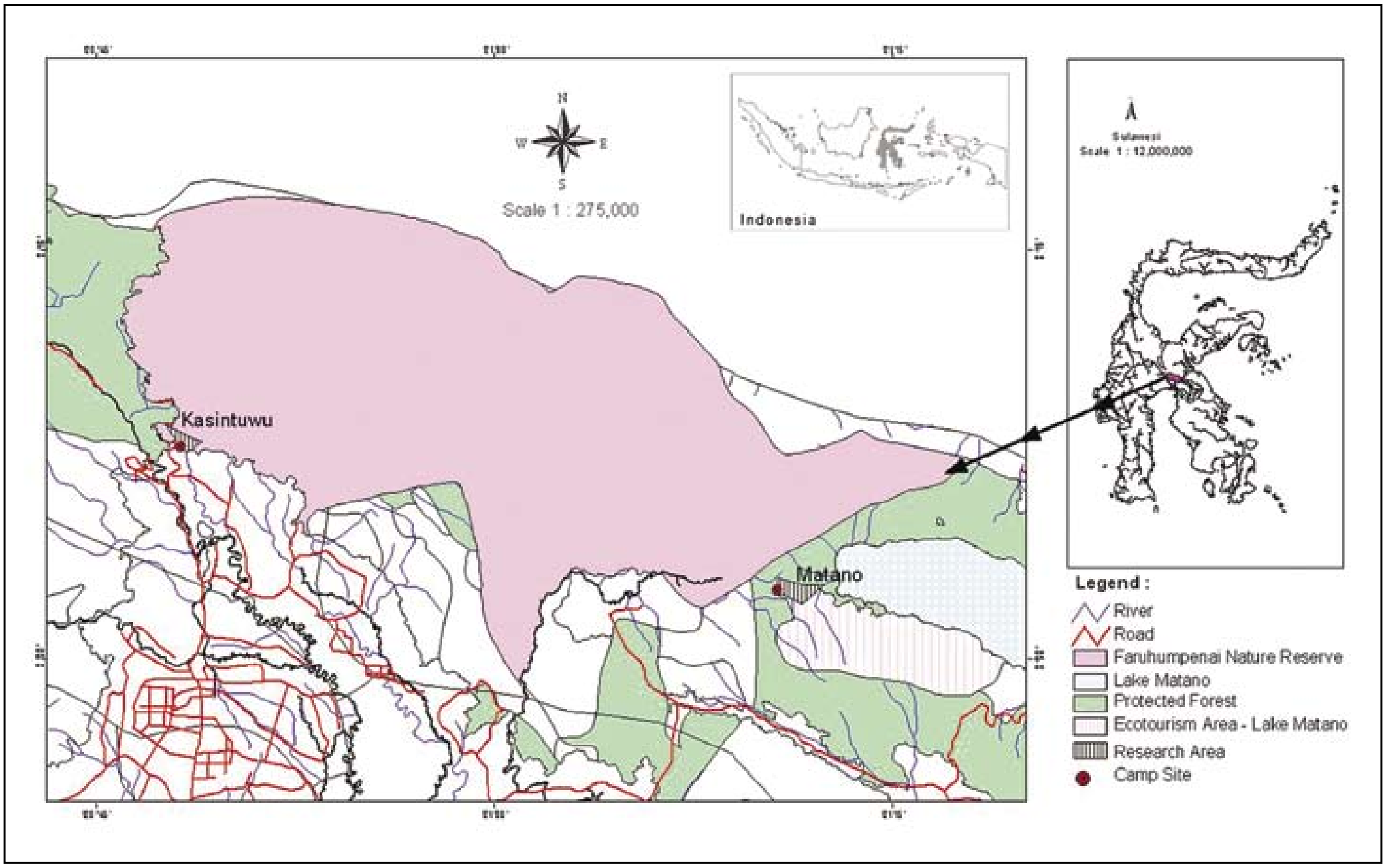


Figure 1. Faruhumpenai Nature Reserve (90,000, ha) at the provincial border of Central and South Sulawesi, Indonesia. The map shows the two research locations: (1) "Matano": at the southeastern border of the Faruhumpenai Nature Reserve, 6 km from the village of Matano, and (2) "Kasintuwu": in the north-northwest section of the nature reserve near the village of Kasintuwu.

(see Figs. 2 and 3). Only groups of booted macaques were encountered at the Matano field site. In a booted macaque group that we regularly encountered, however, we identified a subadult male as *tonkeana* based on the black coloring of his forearms and hindlimbs. At the Kasintuwu field site, groups of booted macaques and tonkean macaques, as well as mixed species groups (individuals from both taxa) were encountered. One of the mixed species groups frequently encountered was comprised of *tonkeana* adult males, *ochreata* adult males, *ochreata* adult females, and a number of juveniles and/or small subadults that appeared to exhibit a mix of traits (i.e., black forearms like *tonkeana* and whitish hindlimbs like *ochreata*).

Ecology and conservation threats

The Matano site included protected forest (*hutan lindung*) and forests within the boundary of the Lake Matano Ecotourism Area (*Taman Wisata Alam Matano*). Mean DBH of trees within 5 m of either side of the three transects was 11.02 cm (n = 101, SD = 11.27). Despite the protected status of these forests, we encountered considerable human-induced disturbance in the form of rattan collection and clearing of forest for agriculture. These activities appear to be facilitated by the recent establishment of a road that connects the villages of Bonepute and Matano to the Trans Sulawesi highway via the village of Tole-Tole. We also found evidence of human-macaque conflict in the form of crop raiding of cacao.

Table 1. Details of transects, sampling efforts, and qualitative evaluation of habitats at research locations.

Transects	Length (km)	Number of walks	Total distance (km)	Protected forest?	Disturbance
Matano	**9**		**45**		
T1	2.5	5		No	Moderate
T2	3	5		Yes	Moderate
T3	3.5	5		No	Heavy (road)
Kasintuwu	**5**		**20**		
T1	1.5	4		Yes	Low
T2	2	4		Yes	Low
T3	1.5	4		Yes	Low

Table 2. Species distribution, mean encounter rate, and group density per location.

Species	Mean encounter rate[a] (±SD)	Density #1[b] (groups/km²)	Density #2[c] (groups/km²)
Matano			
Macaca ochreata	0.24 (±0.05)	0.97	1.56
Kasintuwu			
Macaca ochreata	0.2 (±0.16)	1.45	2.0
Macaca tonkeana	0.05 (±0.1)	0.36	0.5
Mixed *tonkeana-ochreata*	0.2 (±0.16)	1.45	1.5
Macaca spp. groups	0.45 (±0.19)	3.25	4.0

[a] Number of groups encountered per km walked.
[b] Where w = maximum animal-observer distance. (Matano = 126.4 m; Kasintuwu = 69.2 m).
[c] Where w = standard 50 m (animal-observer distance).

The Kasintuwu site included habitat within the boundaries of the Faruhumpenai Nature Reserve. Mean DBH of trees within 5 m on either side of the three transects was 15.71 cm (n = 40, SD = 19.89). Except for the occasional remains of felled ebony trees (*kayu hitam* or *Diospyros celebica*), we found little evidence of human-induced disturbance. On the other hand, the border of the nature reserve is surrounded by cacao plantations, which are frequently raided by macaques. Our camp site was situated at the base of a cacao plantation, the previous owner of which had abandoned his garden due to frequent macaque crop raiding.

Discussion

The estimates of group density of *M. ochreata* (range 0.97 – 2.0 per km²) obtained in our study are lower than those found for other species of Sulawesi macaques: *M. tonkeana*

Figure 2. Pet juvenile male booted macaque (*Macaca ochreata*) in the village of Non Blok, South Sulawesi. Note the white/grey forearms and hindlimbs. Photo by E. P. Riley.

Figure 3. Adult male Tonkean macaque (*Macaca tonkeana*) from Lore Lindu National Park, Central Sulawesi. Note the all black body, including limbs and trunk. Photo by E. P. Riley.

(2.8 groups/km², Riley 2005) and *M. nigra* (3.9 groups/km², Lee 1997). At the Kasintuwu site, we found groups of *ochreata* and *tonkeana*, along with mixed species groups, and the group density estimate for *Macaca* spp. (range = 3.25–4.0 groups/km²) in this area of the nature reserve is much higher than the group densities of individual macaque species. These results suggest that macaque group density is higher in areas of overlap between *M. ochreata* and *M. tonkeana*. The fact that we observed mixed-species groups and individuals with traits of both species (for example, black forelimbs, but grey/white hindlimbs) suggests that hybridization is occurring in these areas of overlap between *tonkeana* and *ochreata*. Furthermore, because the mixed-species groups we observed were dominated by *ochreata* individuals with *tonkeana* only represented by adult males, it may be *tonkeana* males that are migrating into *ochreata* groups and breeding with *ochreata* females.

Based largely on the sampling of pet monkeys, along with occasional observations of wild groups, Watanabe *et al.* (1991) suggested that the distribution of *M. ochreata* extended north-northwest of the provincial boundary between South and Southeast Sulawesi. Our research confirmed that *M. ochreata* inhabits forests around the Matano, Towuti, and Mahalona lake system and that the distribution of *M. ochreata* extends as far north-northwest as the Faruhumpenai Nature Reserve at the border of South and Central Sulawesi. Our identification of a *tonkeana* subadult male in a group surveyed at Matano suggests that the distribution of *M. tonkeana* may extend further southeast than was previously believed (see Watanabe *et al*. 1991).

Our confirmation of a more extensive range of *M. ochreata* suggests that its conservation status may not be as precarious as was previously thought. We now know that its range includes the protected Faruhumpenai Nature Reserve (90,000 ha), in addition to two other protected areas in Southeast Sulawesi: Rawa Aopa National Park (105,000 ha) and Tanjung Peropa Game Reserve (38,937 ha). Nonetheless, human-macaque conflict resulting from crop raiding may eventually pose a threat as farmers attempt to find ways (for example, hunting, trapping, and/or poisoning) to stop them. This problem is likely to be exacerbated as more habitat is cleared for the planting of cacao. Conservation management of these forest-plantation edges will need to involve coordinated efforts among local farmers, PHKA personnel, and agriculturalists to determine how to minimize crop raiding; experimenting, for example, with the planting of tree crops of no interest to the macaques at forest-plantation edges to serve as buffers.

Future research involving the non-invasive collection of DNA via fecal samples is needed to confirm the occurrence of hybridization between *M. tonkeana* and *M. ochreata* in Faruhumpenai Nature Reserve. Genetic analyses must also be accompanied by research on the behavior and ecology of *M. ochreata* and these mixed species groups to understand the extent of behavioral differentiation between the two species and to assess how hybridization may be affecting their behavior and ecology. This information will ultimately be critical for conservation management of these hybrid zones.

Acknowledgments

We thank the Indonesian Institute of Sciences (LIPI) and the BKSDA Sulawesi Selatan II for permission to conduct research in Sulawesi. Erin Riley is grateful to Pak Bambang Suryobroto from IPB, Pak Oka and Pak Restu from UNHAS for sponsoring the research, and Joe Erwin for providing detailed information about the field site area. Financial support was provided by the Margot Marsh Biodiversity Foundation. Logistical support was provided by PT INCO in Soroako, South Sulawesi. The map of Faruhumpenai Nature Reserve was prepared by Mahdi from BKSDA Sulawesi Selatan I in Makassar, Sulawesi. Finally, Erin Riley offers many thanks to those who assisted her in the field: Nenny Babo, Agus Suseno, Pian, Hamsah, and Pak Jupri.

Literature Cited

Abegg, C. and B. Thierry. 2002. Macaque evolution and dispersal in insular south-east Asia. *Biol. J. Linn. Soc.* 75: 555–576.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. Borchers and L. Thomas, L. 2001. *Introduction to Distance Sampling: Estimating Abundance of Biological Populations.* Oxford University Press, Oxford.

Bynum, E. L., D. Z. Bynum, J. W. Froehlich and J. Supriatna. 1997. Revised geographic ranges and hybridization in *Macaca tonkeana* and *Macaca hecki*. *Trop. Biodiv.* 4: 275–283.

Bynum, E. L., A. K. Kohlhaas and A. H. Pramono. 1999. Conservation status of Sulawesi macaques. *Trop. Biodiv.* 6:123–144.

Bynum, E.L. 2002. Morphological variation within a macaque hybrid zone. *Am. J. Phys. Anthropol.* 118: 45–49.

Evans B. J., J. C. Morales, J. Supriatna and D. J. Melnick. 1999. Origin of the Sulawesi macaques (Cercopithecidae: *Macaca*) as suggested by mitochondrial DNA phylogeny. *Biol. J. Linnean Soc.* 66: 539–560.

Evans, B. J., J. Supriatna and D. J. Melnick. 2001. Hybridization and population genetics of two macaque species in Sulawesi, Indonesia. *Evolution* 55: 1686–702.

Evans, B. J., J. Supriatna, N. Andayani, M. Iqbal Setiadi, D. C. Cannatella, and D. J. Melnick. 2003. Monkeys and toads define areas of endemism on Sulawesi. *Evolution* 57: 1436–1443.

Fooden, J. 1969. Taxonomy and evolution of the monkeys of Celebes (Primates: *Cercopithecidae*). *Bibliotheca Primatol.* 10: 1–148. Basel: Karger.

IUCN. 2006. 2006 IUCN Red List of Threatened Species. Website: <http://www.redlist.org>. Accessed January 2006.

Kilner, T. J. 2001. A preliminary study of the behaviour and ecology of the Buton macaque (*Macaca brunnescens*). *Primate Eye* 74: 24–31.

Kohlhaas, A. K. 1993. Behavior and Ecology of *Macaca nigrescens*: Behavioral and Social Responses to the Environment and Fruit Availability. PhD thesis, University of Colorado, Boulder.

Lee, R. J. 1997. The Impact of Hunting and Habitat Disturbance on the Population Dynamics and Behavioral Ecology of the Crested Black Macaque (*Macaca nigra*). PhD thesis, University of Oregon, Eugene.

Matsumura, S. 1998. Relaxed dominance relations among female moor macaques (*Macaca maurus*) in their natural habitat, South Sulawesi, Indonesia. *Folia Primatol.* 69(2): 346–356.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca and J. Kent. 2000. Biodiversity hotspots for conservation priorities. *Nature, Lond.* 403: 853–858.

NRC. 1981. *Techniques for the Study of Primate Population Ecology*. National Research Council, National Academy Press, Washington, DC.

O'Brien, T. G. and M. F. Kinnaird. 1997. Behavior, Diet, and Movements of the Sulawesi Crested Black Macaque. *Int. J. Primatol.* 18: 321–351.

Patterson, J. D. 2001. *Primate Behavior: An Exercise Workbook*, 2nd Edition. Waveland Press, Prospect Heights, Illinois.

Reed, C., T. G. O'Brien, and M. F. Kinnaird. 1997. Male social behavior and dominance in the Sulawesi crested black macaque (*Macaca nigra*). *Int. J. Primatol.* 18(2):247–260.

Riley, E. P. 2005. Ethnoprimatology of *Macaca tonkeana*: The Interface of Primate Ecology, Human Ecology, and Conservation in Lore Lindu National Park, Sulawesi, Indonesia. Ph.D. thesis, University of Georgia, Athens.

Schillaci, M. A. and R. R. Stallmann. 2005. Ontogeny and sexual dimorphism in booted macaques (*Macaca ochreata*). *J. Zool., Lond.* 267: 19–29.

Watanabe, K. and E. Brotoisworo. 1982. Field observation of Sulawesi macaques. *Kyoto Univ. Overseas Res. Rep. Asian Nonhuman Primates* 2: 3–9.

Watanabe, K., S. Matsumura, T. Watanabe and Y. Hamada. 1991. Distribution and possible intergradation between *Macaca tonkeana* and *M. ochreata* at the borderland of the species in Sulawesi. *Primates* 32: 369–385.

Whitten, T., G. S. Henderson and M. Mustafa. 2002. *The Ecology of Sulawesi*. Vol. 4, *The Ecology of Indonesia*. Periplus, Singapore.

Authors' addresses:

Erin P. Riley, Department of Anthropology, San Diego State University, San Diego, California 92182-6040, USA. E-mail: <epriley@mail.sdsu.edu>.

Bambang Suryobroto, Department of Biology, Bogor Agricultural University, Zoology Laboratory, Jalan Pajajaran, Bogor 16144, Indonesia.

Dario Maestripieri, Animal Behavior Research Group, University of Chicago, 5730 S. Woodlawn Avenue, Chicago, Illinois 60637, USA.

Received for publication: April 2007
Revised: August 2007

Primate Conservation 2007 (22): 135–138

Status and Diversity of Temple Primates in Northeast India

Rekha Medhi[1,2,3], Dilip Chetry[1,2], Choudhury Basavdatta[1] and P. C. Bhattacharjee[1]

[1]*Animal Ecology and Wildlife Biology Laboratory, Department of Zoology, Gauhati University, Guwahati, Assam, India*
[2]*Primate Research Centre, Northeast India, Guwahati, Assam, India*
[3]*Department of Zoology, J. N. College, Boko, Kamrup, Assam, India*

Abstract: The northeastern region of India, comprising the seven states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, has the highest primate diversity of the country. There are numerous populations of primates living in and around the temples of the region but none have been documented. Of the 17 primates found in India, 11 occur in the tropical and subtropical forests of these northeastern states. A primate survey was carried out from April 2003 to October 2003 in Assam, Arunachal Pradesh, Manipur, and Tripura to assess the status and diversity of temple primates. We found 16 temple sites in the region that support nonhuman primate populations of four species: Rhesus macaque (*Macaca mulatta*), Assamese macaque (*Macaca assamansis*), golden langur (*Trachypithecus geei*), and capped langur (*Trachypithecus pileatus*). Loss of natural habitat and increased conflict between humans and nonhuman primates were found to be major threats for the temple primates of the region. The study suggests the need for a special conservation program with community initiatives to mitigate these problems.

Key Words: Northeast India, temple, primates, habitat loss, human-primate conflict

Introduction

Northeast India has as many as 11 species of primates, surpassing all other areas of India in terms of primate diversity. They include the rhesus macaque (*Macaca mulatta*), Assamese macaque (*Macaca assamensis*), stump-tailed macaque (*Macaca arctoides*), northern pigtailed macaque (*Macaca leonina*), Arunachal macaque (*Macaca munzala*), golden langur (*Trachypithecus geei*), capped langur (*Trachypithecus pileatus*), Phayre's leaf monkey (*Trachypithecus phayrei*), slow loris (*Nycticebus bengalensis*), western hoolock gibbon (*Hoolock hoolock*), and eastern hoolock (*H. leuconedys*). A number of studies have been carried out to ascertain their status, distribution, and demography (for example, Mukherjee and Saha 1974; Mukherjee 1978; Choudhury 1989; Gupta 1994; Mukherjee and Southwick 1997; Srivastava *et al*. 2001; Chetry *et al*. 2002, 2003; Das *et al*. 2003a, 2003b). Some studies on behavior and ecology have also been carried out (Sarkar 2002; Das 2003; Biswas 2004; Chetry 2004; Medhi 2004). Besides populations in the wild, there are primates on the premises of a number of temples, living in association with human populations. The status, diversity, and demography of these temple primates have yet to be documented. Here we report on a survey of temple primates in four states in northeast India: Assam, Arunachal Pradesh, Manipur, and Tripura.

Methods

A survey was carried out from April 2003 to October 2003 to register the temples in the states of Assam, Arunachal Pradesh, Manipur and Tripura with primate populations. At each site we made direct counts of group sizes and age-sex composition for each of the species. Ethnological data were collected using both interviews and questionnaires. A questionnaire was designed to record information on the past histories and present status of the groups, their interactions with people, and the attitudes of the people towards the primates. Traditional beliefs, which indirectly help to protect these primates, were also recorded, along with information on the problems the monkeys cause to the surrounding communities (for example, crop raiding, orchard raiding, damage to household objects, and physical attacks).

Results

Diversity of temple primates

The study identified populations of four species in the temples: rhesus macaque (*Macaca mulatta*), Assamese macaque (*Macaca assamensis*), golden langur (*Trachypithecus geei*), and capped langur (*Trachypithecus pileatus*) (Table 1).

Temples with primate populations

We recorded 16 temples in seven states in northeastern India that were inhabited by nonhuman primate populations. A number of temple sites were formerly occupied, but today have no primates living in them (Table 2). At the time of the survey we found temple primates only in the states of Assam (16) and Manipur (2).

Status and demography of temple primates

All except one of the temple primate populations registered were free-ranging, and the groups traveled extensively in the adjacent areas (Table 3). In all cases, except for the Umananda temple, the primates were native to the area. The Umananda temple is on a small island of 4.9 ha in the Brahmaputra River near Guwahati, Assam. The golden langur population there is confined to the island, and it is the only existing provisioned and semi-free-ranging population of the species. Other temple primate populations that reside in the temples and depend on provisioning for their survival include the Assamese macaques in Tukreswari temple and the rhesus macaques in Negheriting Shiva Dol and Mahabali temples. The sizes of these four populations are shown in Table 4. The remaining temples were occupied by groups that are transitory — they visit the temples at times but do not reside in them permanently.

Foods of the temple primates

All the temple primate populations, irrespective of species and locality, are semi-provisioned. They eat naturally occurring food items from the surrounding vegetation and other food items provided by people visiting the temples. The natural food items vary with season, and include young and mature leaves, leaf buds and petioles, flowers and flower buds, seeds, unripe and ripe fruits, twigs, and stem cortex. In Mahabali Negheriting, Tukreswari, and Umananda, primates are regularly fed with diverse foods, both raw (for example, banana, gram, soaked gram, pulses, and uncooked rice) and processed (for example, cake, biscuits, cream rolls, and sweets). The Assamese macaques in Tukreswari temple even feed on the blood of the animals (pigeons, goats, and buffalo) that are slaughtered in front of the deity. At other sites visitors offer food to the monkeys.

Human perceptions of primates

The Hindus believe that both the golden langur and the capped langur are descendants of the Lord Hanuman, and because of this they believe in conservation measures on behalf of these species. Their attitudes toward rhesus macaque are negative mainly because of the damage the macaques cause to their crops.

Threats to the temple primates

The study identified three major threats to the temple primates of the region. First, the loss of natural habitat through

Figure 1. Assamese macaques (*Macaca assamensis*) at the Temple of Tukreswari, District of Goalpara, Assam. Photo by Dilip Chetry.

Table 1. Species of primates in temples and their conservation status.

Common name	Scientific name	IWPA 1972[1]	CITES	IUCN (2006)[2]
Rhesus macaque	*Macaca mulatta*	Schedule-II	Appendix-II	LC
Assam macaque	*Macaca assamensis*	Schedule-II	Appendix-II	VU
Golden langur	*Trachypithecus geei*	Schedule-I	Appendix-I	EN
Capped langur	*Trachypithecus pileatus*	Schedule-I	Appendix-I	EN

[1] IWPA= Indian Wildlife (Protection) Act, 1972

[2] VU = Vulnerable, LC = Least Concern. EN = Endangered

Table 2. Past and present records of temple primate in northeast India.

State	Numbers of temples with primates		Species	
	Past	Present	Past	Present
Assam	20	16	RM, AM, GL, CL. HG	RM, AM, GL, CL
Arunchal Pradesh	2	None	RM, CL	None
Manipur	2	2	RM, CL	RM
Meghalaya	None	None	None	None
Mizoram	None	None	None	None
Nagaland	None	None	None	None
Tripura	2	None	RM, CL, PL	None

RM = rhesus macaque, AM = Assamese macaque, CL = capped langur, GL = golden langur, HG = hoolock gibbon, PL = Phayre's leaf monkey human settlement in and around the temple sites is evidently the primary threat for the temple primate populations in most cases. The resulting loss of food sources from the natural habitat leads to increased conflicts through crop raiding, and the greater persistence of the monkeys near to humans, their habitations and places of worship. Second, people in more remote parts reported increasing incidences of human-primate conflicts. The monkeys raid crops, orchards and households; attacking, fouling, and destroying property and household objects are the most common manifestations of this conflict. Third, people's attitudes toward the monkeys are changing. The traditional beliefs are becoming weaker and, with burgeoning conflicts and inconveniences, attitudes are becoming less benign. Some people even expressed their wish to have the monkeys removed from the area and taken elsewhere. Ironically many of these same people feed the animals. The golden langurs in Umananda, the Assamese macaques in Tukreswari temple, and the rhesus macaques in the temples of Mahabali and Negheriting Sivadol are, on the other hand, highly revered.

Table 3. Population sizes of temple primates in northeast India.

Temple	Species	Number	Status[1]
Assam			
Nabagraha	Rhesus macaque	150	FR
Kamakhya	Rhesus macaque		FR
Basistha	Rhesus macaque		FR
Daul Gobinda	Rhesus macaque	25	FR
Umananda	Golden langur	7	C
Lankeswar	Rhesus macaque	20	FR
Hajo Haigrib	Rhesus macaque		FR
Tukreswari	Assamese macaque, capped langur	90, 8	FR
Surya pahar	Rhesus macaque, capped langur	75,10	FR
Baba Than	Rhesus macaque		FR
Nighreting Sivadol	Rhesus macaque	59	FR
Gupteswar	Rhesus macaque	70	FR
Biswanath ghat	None		
Mahabhairav	None		
Padumoni	None		
Basudev	None		
Durga	None		
Sivdham Tinsukia	Rhesus macaque	50	FR
Mahamaya	Rhesus macaque	35	FR
Kali Mandir	Rhesus macaque	30	FR
Manipur			
Mahabali	Rhesus macaque	59	FR
Arunachal Pradesh			
Malinithan	None		
Parsuram kunda	None		
Tripura			
Kaisabha kalibari	None		
Udaipur Matabar	None		

[1]FR = free-ranging, C = confined

Discussion

A number of primates live permanently or occasionally in temples; an association between monkeys and humans that is an age-old phenomenon in the region. The changing values of society are, however, creating conservation problems for the temple primates. Earlier studies have identified habitat loss as the primary threat for the natural populations of all the nine species in the region (Choudhury 1989, 2002; Srivastava *et al*. 2001; Chetry *et al*. 2002; Das *et al*. 2003) and this is true even for the temple primate populations that are unable to find enough food merely from incidental or irregular provisioning and the trash left by the visitors and tourists. Along with habitat loss, hunting is another major threat to the primates of the region (Choudhury 1989; Chetry *et al*. 2003; Das *et al*. 2003). For temple primates it is not hunting but increased human-primate conflict that is the most critical threat. Despite the long association between humans and other primates in northeastern India, the rapid loss of natural habitat and the increase in human populations is leading to a greater association between animals and humans, to the discomfort of many human communities and to the detriment of the langurs, macaques and gibbons, which are in decline. The temple primates are disappearing — they are neglected and there have been no efforts on behalf of their conservation and management. Management predictably will be one of crisis as the tendency of a burgeoning presence in the temples and increasing hunger will precipitate more and more serious conflict. The following measures are recommended to ensure their future existence and survival.

- Establish a special conservation program for the temple primates.
- Set up conservation education programs to increase awareness of the problems of temple primates in the region.
- Set up reforestation and planting programs of native species, providing foods for both monkeys and humans.

Table 4. Group composition of resident population in temples in the states of Assam and Manipur.

State	Temple	Species	Group composition[1]							Total
			AM	AF	JM	JF	IM	IF	I?	
Assam	Turkreswari	*Macaca assamensis*	13	25	12	17	8	10	2	90
	Neghereting Sivadol	*Macaca mulatta*	9	25	10	16	9	10		79
	Umananda	*Trachypithecus geei*	2	1			3	1		7
Manipur	Mahabali	*Macaca mulatta*	10	20	8	11	4	6		59

[1]AM = adult male, AF = adult female, JM = juvenile male, JF = juvenile female, IM = infant male, IF = infant female, I? = unidentified infant

Figure 2. A golden langur (*Trachypithecus geei*) drinking water at the Umananda Temple, Guhawati, Assam. Photo by Dilip Chetry.

- Immediately incorporate the golden langur population confined to Umananda Island into an appropriately managed breeding program.

- Establish a regular monitoring program to follow demographic trends so that appropriate conservation and management plans can be formulated.

Acknowledgments

This research was carried out with support from the Primate Action Fund of Conservational International. We are grateful to the priests of the temples for their cooperation during the study. Special thanks to Mr. Vinay Sharma for helping in carrying out the study in Manipur, and to the head of the Department of Zoology, Gauhati University, Assam, for his support. We acknowledge the logistic support of the Primate Research Centre (PRC) in pursuing our primatological research projects. Our sincere thanks to all our informants for their kind support.

Literature Cited

Biswas, J. 2004. Ecology and social behaviour of golden langur, *Trachypithecus geei* (Khajuria, 1956), in Assam, India. PhD thesis, Gauhati University, Guwahati, Assam.

Chetry, D. 2004. Socioecology of stump-tailed macaque, *Macaca arctoides* (I. Geoffroy, 1831). PhD thesis, Gauhati University, Guwahati, Assam.

Chetry, D., R. Medhi and P. C Bhattacharjee. 2002. A report on primates of Nokrek National Park, India. *Tiger Paper* 29(3): 30–32.

Chetry, D., R. Medhi, J. Biswas, D. Das and P. C. Bhattacharjee. 2003. Non-human primates in the Namdapha National Park, Arunachal Pradesh, India. *Int. J. Primatol.* 24(2): 383–388.

Choudhury, A. U. 1989. Primates of Assam: their distribution, habitat and status. PhD thesis, Gauhati University, Guwahati, Assam.

Choudhury, A. U. 2002. Golden langur, *Trachypithecus geei*, threatened by habitat fragmentation. *Zoo's Print J.* 17(2): 699–703.

Das, J. 2003. Socioecology of hoolock gibbon: *Hylobates hoolock hoolock* (Harlan, 1836) in response to habitat change. PhD thesis, Gauhati University, Guwahati, Assam.

Das, J., M. M. Feeroz, M. A. Islam, J. Biswas, P. Bujarborua, D. Chetry, R. Medhi and J. Bose. 2003a. Distribution of hoolock gibbon (*Bunopithecus hoolock*) in India and Bangladesh. *Zoo's Print Journal* 18(1): 969–976.

Das, J., J. Biswas, R. Medhi, J. Bose, D. Chetry, P. Bujarbarua and F. Begum. 2003b. Distributional status of hoolock gibbon (*Bunopithecus hoolock*) and their conservation in southern Assam, India. *Tiger Paper* 30(4): 26–29.

Gupta, A. K. 1994. Status and conservation of non-human primates in Tripura, India. In: *Current Primatology, Volume 1: Ecology and Evolution*, B. Thierry, J. R. Anderson, J. J. Roeder and N. Herrenschmidt (eds.), pp.101–111. University. Louis Pasteur, Strasbourg, France.

IUCN. 2006. *2006 IUCN Red List of Threatened Species*. IUCN – The World Conservation Union, Species Survival Commission (SSC), Gland, Switzerland, and Cambridge, UK. Website: http://www.redlist.org/. Accessed 10 May 2006.

Medhi, R. 2004. Behaviour of golden langur, *Trachypithecus geei* (Khajuria, 1956) in a riverine island. PhD thesis, Gauhati University,Guwahati, Assam.

Mukherjee, R. P. 1978. Further observations on the golden langur (*Presbytis geei* Khajuria) with a note on capped langur (*Presbytis pileatus* Blyth) of Assam. *Primates* 19: 737–747.

Mukherjee, R. P. and S. S. Saha. 1974. The golden langur (*Presbytis geei*, Khajuria, 1956) of Assam. *Primates* 15: 327–340.

Mukherjee, R. P. and C. H. Southwick. 1997. Present status of the golden langur in Assam, India. *Asian Primates* 6: 1–4.

Sarkar, P. 2002. Ecology and dynamics of social relationships of Assamese macaque: *Macaca assamensis* (McClelland, 1839). PhD thesis, Gauhati University, Guwahati, Assam.

Srivastava, A., J. Biswas, J. Das and P. Bujarbarua. 2001. Status and distribution of golden langurs (*Trachypithecus geei*) in Assam, India. *Am. J. Primatol.* 55: 15–23.

Authors' address:
Rekha Medhi, Dilip Chetry, Choudhury Basavdatta and **P. C. Bhattacharjee,** Animal Ecology and Wildlife Biology Laboratory, Department of Zoology, Gauhati University, Guwahati-781014, Assam, India. E-mail of first author: <medhirekha@rediffmail.com>. E-mail of second author: <chetryd@rediffmail.com>.

Received for publication: July 2004
Revised: August 2007

Primate Conservation 2007 (22): 139–144

A Survey of Sri Lanka's Endangered and Endemic Western Purple-faced Langur (*Trachypithecus vetulus nestor*)

Rasanayagam Rudran

Science and Conservation, National Zoological Park, Smithsonian Institution, Washington, DC, USA

Abstract: The western purple-faced langur is a Sri Lankan endemic listed by the World Conservation Union (IUCN) as one of the 25 most endangered primates in the world. The extremely endangered status of Sri Lanka's endemic langur, found nowhere else on earth, is due to the fact that it is primarily a tree-dwelling, leaf-eating monkey, the range of which includes the most densely populated areas of the country. In these areas of high human density, forests have been intensively exploited for several decades, and deforestation has adversely affected its preferred habitat and sources of food. During a recent survey, the western purple-faced langur was found most often in small and widely scattered groups, indicating that it is declining and has been extirpated in a number of areas within its range. This tendency, if left unchecked, would ultimately lead to extinction throughout its range. Although it faces a perilous future, certain facts uncovered during the survey indicate that it is still possible to prevent this monkey from disappearing forever. For instance, the largest forests where it can be found today are around two reservoirs that supply water to the 1.2 million inhabitants of Colombo, Sri Lanka's capital. Because of their importance to people and relatively large size, these forests represent the last strongholds for maintaining viable populations over the long term. Furthermore, the Forest Department, responsible for these forests, has indicated interest in replanting its pine plantations with native species exploited by these langurs, and thereby increasing its preferred habitat. Another encouraging fact is that most people living within its current range are Buddhists who have a strong aversion to killing animals. The cultural sentiments of people inhabiting the range of the western purple-faced langur provide an opportunity to create awareness of this monkey's highly endangered status, and help promote its conservation. Prospects and recommendations for conserving the western purple-faced langur are also discussed in this paper.

Key words: Purple-faced langur, Sri Lanka, endangered species, endemic species, effects of deforestation, prospects for conservation, recommendations

---

Introduction

The purple-faced langur, *Trachypithecus vetulus* (Erxleben, 1777) is a Sri Lankan endemic that consists of four subspecies (taxonomy following Groves 2001). All four are endangered, but the western subspecies, *T. vetulus nestor* (Bennett, 1833) is Critically Endangered (see Molur *et al.* 2003) and has been listed by the World Conservation Union (IUCN) as one of the 25 most endangered primates in the world (Dela and Rowe 2006, 2007). The highly endangered status of this subspecies troubled me because I had previously carried out a two-year study of the eastern (*T. v. philbricki*) and highland (*T. v. monticola*) subspecies (Rudran 1970, 1973a, 1973b), and had more than a passing interest in this species. I therefore organized a 10-day vehicle and foot survey within the historical range of *T. v .nestor* during a visit to Sri Lanka in June–July 2007. The purpose of the survey was to gather information on its distribution, habitat and threats, to help ensure its long-term survival.

The survey involved nearly 1,500 km of travel by vehicle, mainly in an east-west direction through the middle one-third of *T. v. nestor*'s historical range. Other areas were surveyed less intensively due to lack of time, but I visited a total of 50 sites within about 50% of *T. v. nestor*'s historical range to locate and observe this monkey, and to interview local people. The interviews provided information about its occurrence, abundance, group size, frequency of sightings, food habits, and interactions with humans. Care was taken to ensure that interviewees did not confuse *T. v. nestor* with the toque monkey (*Macaca sinica*) that is also found in the same area. When interviews presented opportunities to locate groups, a local guide was hired to help approach the area on foot and count the number of individuals. The survey also included an assessment of habitats around survey sites, as well as discussions with government officials and others responsible for habitats that appeared suitable for the conservation of this subspecies.

Results of the Survey

The most common habitat types within the survey area were residential areas with gardens (34%), or such sites with an adjoining patch of forest (9%), a commercial area (6%), or a coconut or rubber plantation (11%). Only 19% of the survey sites consisted of forests — usually small and isolated, and which sometimes occurred next to plantations (4%) or beside residential sites. Plantations (11%) and commercial areas (4%) or sites with both habitat types (2%) made up the rest of the areas surveyed. Thus deforested and human-dominated landscapes were the most common habitats (81%) found within the survey area. This situation is even more pronounced when the entire range is considered (Fig. 1). Due to several decades of deforestation, over 90% of the known range of the western purple-faced langur in the 1930s (Hill 1934) now consists of houses, gardens, townships, temples, schools, commercial operations and other areas of human activity. This is not surprising because its historical range includes the most densely populated areas of the country, including Colombo, Sri Lanka's capital. Deforestation of these areas has drastically depleted the preferred habitat and principal sources of food of this highly arboreal and folivorous primate.

Within the deforested, human-dominated survey area, *T. v. nestor* appears to be subsisting mainly on food from gardens. Of the fifteen food plants identified during the survey only four were native wild species, exploited for their fruits (*Dillenia retusa*, *Artocarpus nobilis*) or leaves (*Melia dubia*, *Albizia* sp.). Eight of the eleven cultivated species were exploited for their fruits (jak, *Artocarpus heterophyllus*; banana, *Musa* sp.; mango, *Mangifera* sp.; lovi, *Flacourtia inermis*; jumbu, *Syzygium jumbos*; rambutan, *Nephelium lappaceum*; betelnut, *Areca catechu*; coconut, *Cocos nucifera*), and the remainder were exploited for their leaves (manioc, *Manihot esculenta*; rubber, *Hevea brasiliensis*; durian, *Durio* sp.) or seeds (rubber). A diet consisting mainly of fruits was also documented in a 19-month study of two *T. v. nestor* groups conducted by Dela (2007). Both jak and banana were recorded as food plants at more than half of the 15 survey sites where I collected diet data, while each of the native wild species was exploited at no more than two sites. Furthermore, jak, banana and mango together constituted 50% of the diet records, while the four wild species comprised only 10% (N = 48). The western purple-faced langur's heavy use of cultivated plants is likely due to deforestation reducing wild plant diversity than to an actual preference for cultivated foods. Thus, in these human-dominated landscapes it probably exploits a less diverse diet than those living in natural habitats, such as forest patches. This is supported by the fact that the eastern (*T. v. philbricki*) and highland (*T. v. monticola*) subspecies, that occupy natural habitats less diverse than those within the range of *nestor* (de Zoysa and Raheem 1990; Gunatilleke and Gunatilleke 1990; US Agency for International Development 1991; Green and Gunawardena 1993), exploited at least 32 and 33 plant species respectively within a single study site (Rudran 1970).

The nutritional consequences of feeding on a low diversity diet, especially of fruits, are not known, but likely to be detrimental over the long-term for *T. v. nestor*. This is because langurs are adapted to obtain much of their nutrients and energy from complex carbohydrates found in leaves, with the help of a highly specialized stomach and the action of symbiotic bacteria (Bauchop and Martucci 1968). However, when the diet becomes heavily dependent on cultivated fruits, loaded with simple sugars, instead of complex carbohydrates, the functioning of the gut fauna is undermined, and the ability to absorb nutrients is consequently compromised. Furthermore, fruits tend to occur seasonally, which means that *T. v. nestor* may not be able to fully satisfy its energy requirements outside the fruiting seasons of cultivated plants. When such detrimental effects have the potential to impact this langur through most of its range, its survival becomes an issue of serious concern.

Besides depleting *T. v. nestor*'s primary food source and preferred habitat, deforestation also causes other problems for this monkey's survival. For instance, when deforestation forces it to move on the ground, for which it is ill-adapted, people sometimes capture the young individuals to raise them as house pets. While on the ground it also runs the risk of being killed by village dogs or speeding vehicles. Death by electrocution is also a source of mortality when it climbs onto power lines and electricity cables. *Trachypithecus v. nestor* is occasionally shot and killed while feeding in home gardens in some parts of its range (Dela 2004). Thus deforestation indirectly leads to a wide range of human-induced fatalities.

Deforestation, and the mortality it causes, could explain the small group sizes recorded during the survey. The average size of the groups seen was 4.4 (range 1–10, N = 9), and the mean group size from 21 estimates recorded during interviews was 5.1 (range 1–15). These average group sizes were smaller than in the highland subspecies, *T. v. monticola* (mean = 8.9, range 3–14, N = 27) and the eastern subspecies, *T. v. philbricki* (mean = 8.4, range 3–15, N = 33) that I had studied earlier (Rudran 1970, 1973a). Nevertheless, group sizes at four survey sites were estimated to be more than 20 individuals. The existence of these relatively large groups could not be confirmed, but their occurrence was noted only in about 13% of the survey sites where *T. v. nestor* was seen or recorded as present (N = 30). At the other sites group size reduction appeared to have the potential to disrupt the social organization of the groups.

Deforestation may also be having an effect even more serious than group size reduction, disruption of social organization, loss of diet diversity and increased mortality. This effect can be illustrated by comparing its current status at the sites surveyed in relation to its historical range (Fig. 1, inset).

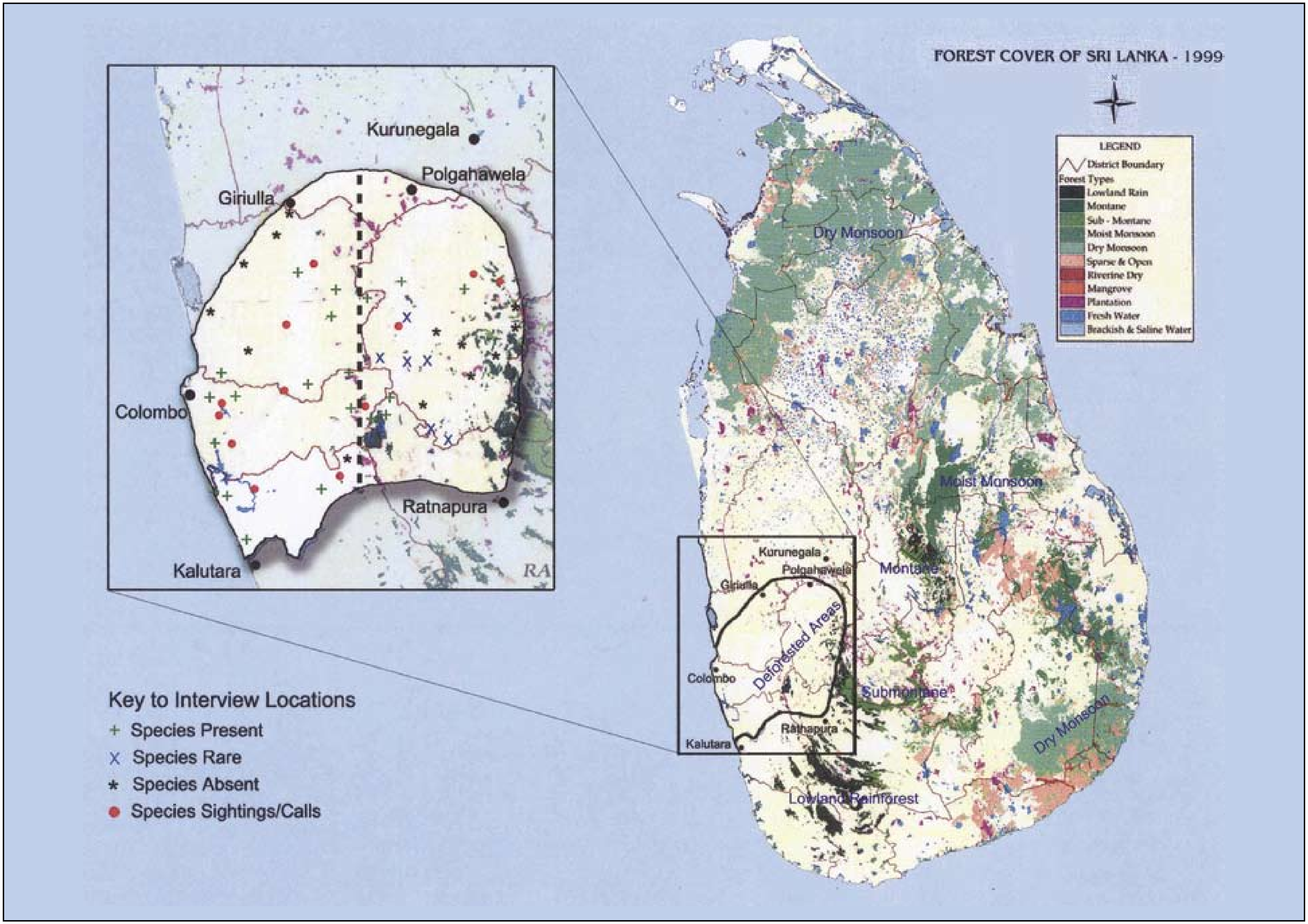


Figure 1. A recent forest cover map of Sri Lanka produced by the country's Forest Department showing the extent of deforestation within the historical range of the western purple-faced langur (as described by Hill 1934). Note that Hill (1934), Phillips (1935), and Hill and Burn (1941) suggest, but do not confirm, that the range may have extended further north-east up to Kurunegala. The inset indicates the results of the survey of the western purple-faced langur in the western and eastern half of its historical range.

The western purple-faced langur was seen or recorded as present only in 43% of the sites surveyed in the eastern half of its historical range (N = 23), and 78% of the survey sites in the western half (N = 27). At other sites in both halves, *T. v. nestor* was recorded as rare or absent. Thus range reduction seemed to be taking place more rapidly in the eastern than the western half, and these reductions suggest the occurrence of local extinctions. For instance, although Hill (1934) mentioned *T. v. nestor*'s presence several decades ago at localities such as Kitulgala and Ruwanwella, it was recorded as absent at these sites during the survey. Moreover, the sites in the eastern half where it was seen or recorded as present during interviews were interspersed between areas where it was absent or rare. Hence, the status of *T. v. nestor* at the sites surveyed (i.e., present, absent or rare) also suggests the occurrence of local extinctions. Local extinctions in the western half appeared to be mostly along the north-east boundary where it may have occurred in low numbers in the first place, but local extinctions in the eastern half appear to have progressed well inside its former haunts (Fig. 1, inset).

Figure 2. A garden — the predominant habitat type within the current range of the western purple-faced langur, *Trachypithecus vetulus nestor*.

Figure 3. A juvenile western purple-faced langur, *Trachypithecus vetulus nestor*, resting in a coconut palm.

Prospects for the Conservation of the Western Purple-faced langur

Although facing a perilous future, certain facts revealed during the recent survey indicate that it is still possible to save this monkey from disappearing forever. For instance, the largest forests that it inhabits now are found around two reservoirs (Kalatuwawa and Labugama) that supply water to the 1.2 million inhabitants of Sri Lanka's capital, Colombo. Because of their importance to people and their relatively large size (about 21 km² in total), these forests represent the last and most secure strongholds for maintaining viable populations over the long-term. Furthermore, the Forest Department, which is responsible for these forests, has indicated interest in replanting the pine plantations found within them with native species exploited by *T. v. nestor*. Such an initiative would certainly increase *T. v. nestor's* preferred habitat, but it would first require a study of this langur's little known dietary preferences in forested habitats.

Another important fact that surfaced during the survey was that the Forest Department has plans to promote forest conservation and generate income for communities living around its forests through environmental education and ecotourism programs. Such plans that benefit local communities also create opportunities to promote the conservation of the western purple-faced langur and its habitat. For instance, this langur could be used as a model in environmental education programs to disseminate information on the effects of habitat destruction on species survival. For such programs to be truly effective, experts in education, such as school teachers, must be trained to help school children and the rural public to clearly understand the significance of scientific concepts such as ecological niches, species-habitat interactions, minimum viable populations, and local extirpation and complete extinction. Training young people to become nature guides is also in line with the Forest Department's plans to develop ecotourism. Ecotourism has the potential to generate income, and therefore provides a powerful incentive to local people to protect their natural resources, including *T. v. nestor*. Numerous projects such as those based on fireflies in Malaysia (Othman and Othman 1998) and gorillas in Uganda (Butynski 1998) are attempting to strengthen species protection through ecotourism's potential to generate income.

The training in nature guiding and public education must provide information on the local fauna and flora, particularly their benefits to humans, so that those who undergo the training could impart this knowledge to rural people and tourists. Information on the fauna and flora within *T. v. nestor*'s range is scarce, and collecting it creates opportunities for scientific research, which must also include other investigations such as the study of its little known diet in forested areas. Thus the Forest Department's plans to promote conservation and ecotourism provide ample opportunities to develop programs in scientific research, personnel training and public education.

Another promising aspect is that the survey showed that most people living within this langur's range are Buddhists, who have a strong aversion to killing animals. Thus shooting and trapping animals is uncommon, and besides the killing reported by Dela (2004) I was able to record only one other similar incident during the survey. It seems that about four years ago, six albino langurs were killed, presumably for their skin. In contrast to these events, interviews at two thirds of the survey sites (N = 21) indicated that people were either tolerant or protective of these animals. Two of the sites that protected langurs were Buddhist monasteries, where the incumbents strictly enforced the principles of their faith. At sites where *T. v. nestor* was neither tolerated nor protected, it was chased, with people throwing stones at them, or otherwise frightened off with fire crackers, when it raided home gardens. The Buddhist taboo against killing may explain why it has survived as long as it has in such a densely populated area, despite its reputation as an agricultural pest and a nuisance causing damage to roofing tiles of houses.

Recommendations for the Conservation of the Western Purple-faced Langur

Given the above-mentioned facts and findings of the survey, the following preliminary measures are recommended to help ensure the future survival of *T. v. nestor*.

1) The survey indicated that the best site available for *T. v. nestor*'s long-term survival is the forest around the Labugama and Kalatuwawa reservoirs. This forest is not only the largest remaining habitat for this langur but is also managed by the Forest Department, which is supportive of efforts to conserve these monkeys. Therefore, these efforts should be launched in collaboration with the Forest Department and initially focus on the forests around the two reservoirs.

2) In line with the Forest Department's plans to promote conservation and ecotourism, efforts to protect western purple-faced langur over the long-term should include programs in public education and personnel training. Since the Forest Department's own plans appear to be in the early stages, the public education and personnel training efforts to promote its conservation should be launched as soon as possible, to help get things moving.

3) The public education program related to the conservation of *T. v. nestor* should emphasize Buddhist concepts of compassion and kindness towards animals. It should also highlight the deeply-rooted cultural sentiments about protecting animals, such as those expressed in the first-ever Buddhist sermon delivered in Sri Lanka more than 2,500 years ago, and devoted solely to the protection of animals. The public education program should also help rural people to understand scientific concepts such as the evolution of species, biological diversity and conservation, which are very relevant to addressing sustainable development and issues related to human needs for this and future generations.

4) Training in public education and ecotourism should be enriched through scientific research, not only on the western purple-faced langur but other species as well. Such research should help reveal biologically important facts, and also the significance and economic, medicinal, agricultural, and social values of the fauna and flora within *T. v. nestor*'s habitats. This information could be provided to trainees through courses and workshops, and to the local public and tourists via posters, brochures, and community meetings. It could also be disseminated through signage along nature trails established within the forests around the two reservoirs.

5) In addition to the forests around the two reservoirs, other secure sites with healthy langur populations should be located to help ensure this species' long-term survival. Protecting *T. v. nestor* at several sites would prevent the possibility of a catastrophe at any one wiping out the entire subspecies. It would also provide opportunities to manage subpopulations as a metapopulation, where translocation could be used as a tool to overcome any deleterious effects of small population sizes (Valladares-Padua *et al*. 2002; Medici *et al*. 2003). Further surveys are needed to locate other viable sites for the conservation of populations of this subspecies. The indications are that the "sacred groves" around Buddhist monasteries could offer the best options for establishing satellite sites for conservation. Visits to these "sacred groves" are especially important during the next phase of the survey to evaluate the possibility of replicating the programs established in the forests around the reservoirs.

Acknowledgments

I thank Mr. Nanda Senanayake, President, Ceylon Bird Club, and Mr. Ananda Wanasinghe for their assistance in arranging the logistics and conducting the survey. The many people who readily agreed to be interviewed during the survey are also thanked for their participation. I am also grateful to Mr. M. R. G. Sarathchandra and his Forest Department field staff of the Waga Range for their enthusiasm and suggestions for developing a project to help conserve the western purple-faced langur. At the Forest Department's Colombo office I met Mr. P. M. A. De Silva, (Senior Deputy Conservator of Forests) and Mr. Anura Sathurusinghe (Conservator of Forests, Research and Education), and I thank them for explaining their department's programs and providing guidance on the opportunities available for collaboration. My meeting with the Forest Department staff was arranged by Dr. D. Kariyawasam, former Director-General of the Department of Wildlife Conservation, to whom I am very grateful. The recent survey was partially funded by the Friends of The National Zoo, Washington, DC.

Literature Cited

Bauchop, T. and R. W. Martucci. 1968. The ruminant-like digestion of the langur monkey. *Science* 161: 698–700.

Butynski, T. M. 1998. Is gorilla tourism sustainable? *Gorilla Journal* 16: 1–3.

Dela, J. 2004. Protecting the endemic purple-faced langur. *Loris* 23: 14–22.

Dela, J. 2007. Seasonal food use strategies of *Semnopithecus vetulus nestor*, at Panadura and Piliyandala, Sri Lanka. *Int. J. Primatol*. 28: 607–626.

Dela, J. and N. Rowe. 2006. Western purple-faced langur, *Semnopithecus vetulus nestor* Bennett, 1833. In: Primates in Peril: The World's 25 Most Endangered Primates 2004–2006, R. A. Mittermeier, C. B Valladares-Padua., A. B. Rylands, A. A. Eudey, T. M. Butynski, J. U. Ganzhorn, R. Kormos, J. M. Aguiar and S. Walker. (compilers), pp.12–13, 24. *Primate Conserv.* (20): 1–28.

Dela, J. and N. Rowe. 2007. Western purple-faced langur, *Semnopithecus vetulus nestor* Bennett, 1833. In: Primates in Peril: The World's 25 Most Endangered Primates 2006–2008, R. A. Mittermeier *et al.* (compilers), pp.15, 28. *Primate Conserv*. (22): 1–40.

de Zoysa, N. and R. Raheem. 1990. *Sinharajah: A Rainforest in Sri Lanka*. Aitken Spence & Co. Ltd., Colombo, Sri Lanka.

Green, M. J. B. and E. R. N. Gunawardena. 1993. Conservation evaluation of some natural forests in Sri Lanka. Environmental Management in Forestry Development Projects. Report of the Sri Lanka Forestry Department, UNDP, FAO, and IUCN, Colombo.

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Gunatilleke, I. A. U. N. and C. V. S. Gunatilleke. Distribution of floristic richness and its conservation in Sri Lanka. *Conserv. Biol*. 4(1): 21–31.

Hill, W. C. O. 1934. A monograph on the purple-faced leaf monkeys (*Pithecus vetulus*). *Ceylon J. Sci.* 19(1): 23–88.

Hill, W. C. O. and Y. Burn. 1941. Monkeys — mainly from Ceylon. *Loris* II(5): 247–252.

Othman, J. and R. Othman, 1998. Economic benefits from wetland biodiversity: case of fireflies recreation, Malaysia. *Trop. Biodiv*. 5(1):65–74.

Medici, E. P., C. B. Valladares-Padua, A. B. Rylands and C. Saddy-Martins. 2003. Translocation as a metapopulation management tool for the black lion tamarin. *Primate Conserv*. (19): 10–18.

Phillips, W. W. A. 1935. *Manual of the Mammals of Ceylon*. Colombo Museum, Ceylon (Sri Lanka).

Rudran, R. 1970. Aspects of ecology of two subspecies of purple-faced langur (*Presbytis senex*). M.Sc dissertation, University of Colombo, Ceylon (Sri Lanka). 210pp.

Rudran, R. 1973a. The reproductive cycles of two subspecies of purple-faced langurs (*Presbytis senex*) with relation to environmental factors. *Folia Primatol*. 19: 41–60.

Rudran, R. 1973b. Adult male replacement in one-male troops of purple-faced langurs (*Presbytis senex senex*) and its effect on population structure. *Folia Primatol*. 19: 166–192.

US Agency for International Development. 1991. *Natural Resources of Sri Lanka: Conditions and Trends. A Report Prepared for the Natural Resources, Energy and Science Authority of Sri Lanka*. Keells Business Systems Ltd., Colombo, Sri Lanka. 280pp.

Valladares-Padua, C. B., J. D. Ballou, C. Saddy-Martins and L. Cullen, Jr. 2002. Metapopulation management for the conservation of black lion tamarins. In: *Lion Tamarins*: *Biology and Conservation*, D. G. Kleiman and A. B. Rylands (eds.) pp.301–314. Smithsonian Institution Press, Washington, DC.

Author's address:
Rasanayagam (Rudy) Rudran, Directorate of Science and Conservation, National Zoological Park, Smithsonian Institution, Washington, DC 20013-7012, USA.

Received for publication: September 2007
Revised: October 2007

Book Reviews

Primate Behavior and Ecology

Review of *Primate Behavioral Ecology* by Karen B. Strier. 3rd edition. Allyn and Bacon, Boston. 452 pp. ISBN: 0-205-44432-6. Paperback: US$65.00. 2007.

Some textbooks quickly come to be established as the 'gold standard' for their particular area of enquiry, and this is often indicated by the speed with which new editions appear, presumably in response to a buoyant market. Such is the case for the behavioral ecology of non-human primates, as this third edition follows hard on the heels of its predecessors in 2000 and 2003. (Contrast this with its equally worthy counterpart in primate ecology, *Primates in Nature,* by Alison F. Richard, which appeared in 1985, but was never revised. What a pairing it would make with this volume!)

Karen Strier is a distinguished primate behavioural ecologist at the University of Wisconsin, best known for her exemplary long-term studies of the muriqui (*Brachyteles*) in Brazil. Equally, she is known for her overall grasp of the field and her ability to take primatology to a wider audience (for example, Strier, 2003). Both of these virtues are repeatedly expressed in this latest edition.

Happily, she has not tinkered with the general structure of the book, which retains its twelve key chapters: Introduction to Primate Studies; Traits, Trends, and Taxonomy; Primates Past and Present; Evolution and Social Behavior; Evolution and Sex; Food, Foraging and Females; Female Strategies; Male Strategies; Developmental Stages through the Life Span; Communication and Cognition; Conservation. Each of these has been bolstered by new material, to varying extents, matching the appearance to new findings in the field. For example, I checked point-by-point the four-page section on 'tool use'; the newer version has the same four photographs but nine new references cited, and about 10% more text. This is a bit more than the overall increase in the number of pages, which has gone from 422 to 452, as has the number of reference sources cited in the bibliography (both at +7%). A new feature is a more user-friendly, 12-page Appendix of primate names, which now includes geographic regions and numbers of subspecies. Also, to the subject index has now been added a separate author index, making it easier to track the work of particular primatologists.

The strengths of the book remain, in that it is firmly embedded in the real world of primates in the wild, though with some, admittedly selective reference to their captive counterparts, especially in the section on cognition. The judicious and apt use of topic boxes to develop specific, instructive points is retained, e.g., primates and parasites, hybrid baboons, etc. The mix of evidence and ideas remains sensibly balanced, and examples are used tellingly to illustrate key points. Strier occasionally uses anecdotes and personal experiences to flesh out topics, but never enough for this reader, who would like even more.

Why should a conservationist specialising in non-human primates buy this book? First and foremost, it is the most comprehensive and comprehensible treatment of the topic available. Furthermore, it is timely (although the date of publication is given as 2007, it appeared in 2006, and the literature referenced covers up through 2004). When the final chapter on conservation is reached, it is solidly grounded in basic science, as is the chapter itself: it covers such threats to primates as habitat disturbance and hunting pressure, conservation policies in relation to economic incentives, public awareness, and NGOs. It also examines non-invasive research, from genetics to reproductive biology. There is an earlier section, on rehabilitation, reintroduction, and sanctuaries, and on the ethical treatment of primates. Finally, although the list price of the book is a bit expensive, even new copies can be bought on line for less than $10.

All in all, whether student or professional, any person in primate conservation should have this book close to hand on their shelves, and, even better, a spare copy to lend to colleagues. A thoroughly admirable and practical aim would be to arrange somehow for mass shipping of this book to Third World conservationists, who day-by-day are working 'in the trenches' and would find the book invaluable.

Literature Cited

Richard, A. F. 1985. *Primates in Nature.* W. H. Freeman and Co., New York.

Strier, K. B. 2003. Primate behavioral ecology: From ethnography to ethology and back. *Am. Anthropol.* 105: 16–27.

Reviewed by:
William C. McGrew
Leverhulme Centre for Human Evolutionary Studies
Department of Biological Anthropology
University of Cambridge
Cambridge CB2 3DZ, UK

Primate Genetics – Is Taxonomy a Trivial Pursuit?

Review of *Primate Cytogenetics*, edited by Stefan Müller, Ludwig Maximilian University, Munich, Germany. S. Karger, Basel, Switzerland. 268pp. ISSN: 1424–8581. 111 Figures, 56 Tables. Hardcover: 122.00 Swiss francs, Eur87.00, US$111.00. 2005. A reprint of *Cytogenetic and Genome Research*, Volume 108(1–3).

In appearance this book is like an oversize (285 mm × 215 mm), hardbound *Folia Primatologica*, but with a red spine and lettering. There are 30 articles, divided into three sections: Comparative Genomics and Molecular Evolution (13); Comparative Molecular Cytogenetics and Chromosome Evolution (14); and Primate Meiosis and Nuclear Architecture (3). Sixteen of the articles are dedicated to the human genome and the comparative genetics of humans and apes (and in one case Old World monkeys in general).

The first article (Ryder) is a most interesting essay on "conservation genomics," the relevance of studies of complete genomes for conservation measures for threatened species. A further three articles examine aspects of primate phylogeny in terms of their place in the evolution of mammals (Froenicke), the phylogenetic relationships of the major primate groups (Hominoidea, Cercopithecoidea, Platyrrhini, Tarsioidea, and Strepsirrhini) (Schmitz *et al.*), and a definition of the ancestral karyotype (chromosome morphology, and banding patterns) for primates (Ruiz-Herrera *et al*. [the copy editor should surely have spotted the adjective being used as an adverb in the title of this paper]). Schmitz *et al*. examine primate origins and their affiliations with such as the Dermoptera and Scandentia, and provide a very interesting discussion of the place of the Tarsioidea — the dichotomy of the haplorrhines, including tarsiers, and the strepsirrhine lemurs.

For their investigation of the ancestral primate karyotype, Ruiz-Herrera *et al*. used data on 36 primates, 24 of them platyrrhines, from 20 published sources, besides information from their own work on *Lagothrix* (their Table 1, p.163). What is striking looking at the table is that there is one article from 1982, another from 1992 and all the remainder are from 1996 or later. The studies are quite contemporary, but a number of the scientific names are outdated. This is curious in showing that either the authors are very conservative, or disagree with recent taxonomic arrangements or are just straight inattentive, or have been victims of a copy editor with an ancient taxonomy. This is not a problem in most cases. The species name should always identify the animal involved — whether it changes genus or is placed as a subspecies should not matter. Ruiz-Herrera *et al*., for example, listed *Ateles paniscus chamek* (of Kellogg and Goldman [1944]), citing a study of G-banding by Medeiros *et al.* (1997). Seuánez *et al.* (2001) also refer to *Ateles paniscus chamek*. Medeiros (1994) and Medeiros *et al*. (1997) in fact regarded the form *chamek* to be a subspecies of *belzebuth* not *paniscus* (as was also argued by Froehlich *et al.* [1991] and more recently by Collins and Dubach [2000]). Four of the six authors of Ruiz-Herrera *et al*. are also authors of Medeiros *et al.* (1997). Either there has been an unexplained about turn or there was an intrusive copy edit not seen by Ruiz-Herrera *et al*. Although De Boer and Bruijn (1990), Froehlich *et al.* (1991), Medeiros (1994) and Medeiros *et al*. (1997) argued that *A. paniscus* is a distinct form with no subspecies, it is listed in the table of Ruiz Herrera *et al*. as *A. paniscus paniscus*. Most odd. However, this has no particular importance besides misleading and creating confusion, because the form *chamek* has not been redefined. *Ateles paniscus chamek* is perfectly identifiable as what is considered today to be either *A. belzebuth chamek* or *Ateles chamek* (of De Boer and Bruijn [1990], Groves [1989, 1993, 2001, 2005] and Rylands *et al*. ([1983, 2000]).

The major problem arises when the definition of a given name is changed. For example, Table 1 of Ruiz-Herrera *et al*. lists studies of *Callicebus molloc* [*sic*] and *Saimiri sciureus* by Stanyon *et al*. (2000) as part of their data set. *Callicebus moloch* was one of just three species of titi monkeys recognized by Hershkovitz (1963). It was divided into seven subspecies. In Hershkovitz's 1988 and 1990 re-evaluation, *Callicebus moloch* was divided into eight species and 14 species and subspecies, as part of the "*Callicebus moloch* Group." Kobayashi (1995) split the "*Callicebus moloch* Group" into two, placing four species (five species and subspecies) into the "*moloch* Group" and the form *Callicebus cupreus* into its own group (three subspecies). Groves (2001) has eight species (13 species and subspecies) in his "*Callicebus moloch* Group," and Van Roosmalen *et al.* (2002) recognizing also a separate "*Callicebus cupreus* Group" decided on six species. Could the real *Callicebus molloc* stand up? With time passing, probably not — complicating at best and invalidating at worst any future use of the data provided by Ruiz-Herrera *et al.*

Saimiri sciureus, likewise, has, still, a highly disputed taxonomy. Silva *et al*. (1993) recognized just one species throughout the Amazon and Central America, while Costello *et al*. (1993) recognized two species, and Hershkovitz's widely accepted taxonomy (1984, 1987) listed four species and 12 species and subspecies. Thorington (1985) proposed a taxonomy slightly divergent from Hershkovitz (1984). He recognized *S. madeirae*, considered by Hershkovitz (1984) to be a synonym of *S. ustus*. It is necessary to refer to Stanyon *et al*. (2000) to know what exactly is the "*Saimiri sciureus*" listed in Table 1 of Ruiz Herrera *et al*. The identity (current name) of both the *Callicebus* and *Saimiri* according to any of the above authors can be ascertained as long as Stanyon *et al.* give the exact provenance of all the specimens they used for their ZOO-FISH analysis.

For geneticists, having the correct name and definition of the animal whose DNA they are analyzing is paramount, and they surely recognize that. So why does one perceive a certain pococurante attitude to the whole issue of taxonomy? Geneticists are after all responsible now for much reshuffling in primate taxonomy — some lumping, much splitting, discoveries of new populations which are awarded the status of "new species", and in many cases the discovery that what we thought was X (they look very alike) is in fact something different with a “Y”. These are not just new primates with new names, they are redefining species. Research on the marmoset *Callithrix jacchus* as defined by Hershkovitz in the 1970s, may well today be research on *Callithrix penicillata.*

Examining particularly Old World primates, Stanyon *et al.* show that fissions (non-Robertsonian and Robertsonian) are the main mechanism driving the evolution of progressively higher diploid numbers in the Cercopithecini, and their findings suggest an early bifurcation of lineages represented by *Cercopithecus neglectus/C. wolfi* on the one hand and *Erythrocebus patas/Chlorocebus aethiops* on the other, already suggested by a number of earlier authors. Warter *et al.* provide a review of the application of molecular cytogenetics to the phylogeny of Lemuriformes. They examined 21 species and reconstructed the presumed ancestral karyotype for all the lemurs except for the aye-aye. Their results largely confirm the ancestral karyotype proposed by Rumpler and Dutrillaux (1990), and indicate an early divergence of the Daubentoniidae, with the subsequent radiation into four families: Cheirogaleidae, Indriidae, Lepilemuridae and Lemuridae.

New World primates are well represented in this book. Seuánez *et al.* provide a most useful review of the contributions that genetics have made to our understanding of the phylogeny of the platyrrhines. They summarize classifications and phylogenies at the family level (they argue for three clades — Cebidae [including Cebinae, Callitrichinae and Aotinae], Pitheciidae [including Pitheciinae and Callicebinae] and Atelidae [including Alouattinae and Atelinae])—and then discuss each in terms of the key findings and phylogenetic issues. Nascimento *et al.* examined the cytochrome b gene in two howler monkeys, *Alouatta caraya* and *Alouatta belzebul*. They showed that *A. belzebul* was paraphyletic for individuals from Paraíba in Northeast Brazil and from the left bank of the Rio Tocantins at Tucuruí, and also confirmed their common ancestry with the brown howler, *A. guariba*. Their results (Figure 4) also indicate an early split (5.3 MYA) of clades leading to *A. caraya*, the red howlers, and *A. nigerrima* on the one hand, and *A guariba* and *A. belzebul* on the other. This may suggest that the Atlantic forest and the Amazon forests were separated at this time, to be reunited later when *A. belzebul* invaded Maranhão and the basins of the Rios Tocantins and Xingu. Most interesting in their Figure 4 is the inference that all these South American howlers shared a common ancestry with the Mesoamerican species, *A. palliata* and *A. pigra*, splitting off some 6.46 MYA.

In the last paper of the book, Solari and Rahn describe the fine structure and meiotic behavior of the male multiple sex chromosomes in *Alouatta caraya* and *A. palliata*, and summarize the studies carried out to date on this phenomenon, especially those of the Argentinean research group of which they are a part. They conclude that although a trivalent sex chromosome is found in *A. palliata*, that a quadrivalent system arose early in the evolution of howler monkeys.

Ferguson-Smith *et al.* review the contributions of chromosome sorting and painting techniques to the study of primate karyotype evolution. They summarized the different applications of this method to the New World monkeys, and concluded that they have resulted in new insights into the ancestral karyotype and their phylogenetic relationships. Wienberg also reviews the application of modern cytogenetic analysis techniques, and provides a brief and useful summary of the main results to date for Callitrichidae, Cebidae and Atelidae. Wienberg includes *Callicebus* in the Cebidae, but it seems that no work had been done or published by that time on the remaining Pitheciidae. The author concludes that “chromosome painting demonstrates that karyotypes of New World monkeys have been considerably reshuffled when compared to the ancestral karyotype of all primates,” and that the evidence argues for a monophyletic origin for all of them (p.147).

Chromosomes of three atelid species, the muriqui, *Brachyteles arachnoides* (or was it *hypoxanthus*?), and two spider monkeys, identified as *Ateles belzebuth marginatus*, and *Ateles paniscus paniscus*, were subjected to multi-directional painting by Oliveira *et al*. Including data from *Ateles geoffroyi*, *A. belzebuth hybridus*, *Lagothrix lagothricha*, *Alouatta caraya* and *Cebus apella* (outgroup), their attempt to clarify the phylogeny at the generic level was frustrated because *B. arachnoides* and *L. lagothricha* conserved what is considered to be the ancestral karyotype for the atelins. They did find evidence of a synapomorphism linking *Brachyteles*, *Lagothrix* and *Ateles* to the exclusion of *Alouatta*. Among the spider monkeys, they concluded that *A. b. hybridus* was sister to *A. geoffroyi*, and *belzebuth* was paraphyletic, with *marginatus* branching off first from a lineage which gave rise to *A. p. paniscus* and *A. b. hybridus*. Collins and Dubach (2000), analyzing mitochondrial DNA, argued that *hybridus* is a species, which would resolve that problem. Oliveira *et al.* concluded also that *A. b. hybridus* should be re-classified, since its karyotype shares no synapomorphies exclusively with *A. b. marginatus*, but does share a derived inversion of chromosome 6 with *A. geoffroyi*.

Also included in this collection of papers is a report by Neusser *et al*. on the cytogenetics of the hybrid twins born in 1998 to a male pygmy marmoset, *Cebuella pygmaea*, and a female common marmoset, *Callithrix jacchus*. The findings are what the authors refer to as a “balanced karyotype” and a healthy morphology, although fertility had yet to be ascertained. They argue that this hybridization reinforces other genetic evidence for the two marmosets to be placed in the same genus, a step sufficiently disagreeable to those who know these monkeys that, as pointed out by the authors, Rylands *et al.* (2000) resurrected the genus *Mico* for the Amazonian marmosets to avoid a paraphyly hinted at by DNA sequence comparisons (*Cebuella* phylogenetically closer to the Amazonian marmosets than the Amazonian marmosets are to the Atlantic forest marmosets) (see Groves, 2004).

I have concentrated on the articles dealing with New World monkeys but, as mentioned above, this is not the main emphasis of the book. Although I am no expert in the matter there is no doubt that it details major contributions — descriptions of research investigations and reviews, to primate molecular and chromosomal phylogeny, evolutionary dynamics of the primate genome, karyotype evolution and chromosome breakpoint analyses, meiotic studies, comparative functional genomics and nuclear architecture, as emphasized in the editor's preface. Strange to me, however, is what would appear to be a cavalier disregard for the niceties of taxonomy when numerous authors espouse the importance of genetics for our understanding of the systematics and phylogenetic relationships of the morphological, geographic and genetic entities which comprise the Order.

While citing Froehlich *et al*. (1991) who argued cogently that the spider monkey described as *marginatus* was not a subspecies of *belzebuth*, that *chamek* was not a subspecies of *paniscus*, and that *paniscus* has no subspecific forms, and knowing that nobody has disputed this since — neither morphologists, nor zoogeographers, nor geneticists — it is quirky, to say the least, that Oliveira *et al*. should continue to use these names in the title of their paper. They make no mention of the fact that Collins and Dubach (2000) (whom they cite for other reasons) had argued that *Ateles hybridus* should be a species separate from *belzebuth*, even though this concurs with and explains their findings (they mention that *A. belzebuth hybridus* needs reclassifying, as if this had not been suggested — done — before). *Ateles hybridus* is now considered to have a subspecies. Subspecies of *L. lagothricha* are now considered species, so one is left wondering whether the study of Oliveira *et al*. was on *L. peoppigii* or *L. cana* (which has a subspecies) or *L. lugens* or the nominate form. *Cebus apella* as defined by Groves (2001) is restricted to the Guiana shield. Was the tufted capuchin of Oliveira *et al*. in fact *Cebus nigritus*? Humans give names to animals that have been named previously, and their definitions of their essential differences when compared with others are, as we well know, often disputed — both within and between the disciplines. For a species to exist it must have not only a name and description but it must occur somewhere. Knowing that Oliveira *et al.*'s *Cebus apella* came from the Iguaçú National Park, for example, would complete the tripod needed to sustain its Linnean identity — its taxonomic definition. 1) the given name, 2) the person who gave it (where its name was published and by whom) and 3) its type locality (where it lives). If there is no information about where the animal came from, it is necessary to depend on the often subjective description and, often ephemeral, definition of the "species". The "occurring somewhere" is a vital parameter, and is helpful to the extent of the precision concerning where it occurs. Whereas in the past primates were labeled as having come from the "Brazils", today GPS allows for no excuses when describing a new species. The type locality of a specimen should be indisputably precise.

Rylands and Brandon-Jones (1998) explained at length that *Simia straminea* Humboldt, 1812 is a synonym of *Alouatta caraya* and therefore unavailable for the red howlers, *Alouatta seniculus*. The name *Alouatta macconnelli* Elliot, 1910 may be the next available for the red howlers of the Guianas, but this requires that other candidates, such as *Mycetes laniger* and *Mycetes auratus*, both of Gray (1845), be discounted first. Bonvicino *et al.* (1995) resurrected *A. macconnelli*, first described from Georgetown, Guyana, arguing that it is distinct from *S. straminea*, based evidently on a cursory reading of Hill (1962), and/or an uncritical interpretation of his provisional subspecific distribution map. The name was taken out of its coffin and applied to animals on the left bank of the lower Rio Trombetas in Brazil, at least 1000 km from Georgetown. The name *macconnelli* may well be the correct one but a careful revision of the red howler monkeys is required first. Bonvicino *et al.* (2001), Nascimento *et al*., Oliveira *et al.* (2002), Ruiz Herrera *et al*., Seuánez *et al*., Solari and Rahn, and Wienberg continue to use the name *stramineus* for those west of the Rio Trombetas. The name *stramineus* is not available for red howlers — the holotype is a female *Alouatta caraya*. Besides this particular example, there are numerous mentions of *Cebus nigrivittatus*, which has long been recognized as a junior synonym of *C. olivaceus* (see Rylands, 1999). The name *Callithrix emiliae* was wrongly applied to the marmosets described by Vivo (1985) from Rondônia (see Rylands *et al*., 1993, 1995), but continues to be used by Seuánez *et al.* and numerous other geneticists. Wienberg includes *Callicebus* in the Cebidae. *Callicebus moloch* continues to be used *sensu* Hershkovitz (1963). Seuánez *et al*. manage to review the classification and taxonomy of Neotropical primates with no reference to Groves (1993, 2001).

This book illustrates well the developments in, and the importance of, the use of cytogenetic (and molecular genetic) analyses in improving and refining our understanding of primate diversity, evolution and phylogeny, but also illustrates the pitfalls of paying little heed to the niceties of names and their histories. Taxonomy is not trivial — it identifies the owner of the chromosomes, hopefully for eternity; it underpins the comparative method; it labels and defines what is being compared. The short shrift it receives from many geneticists is illogical and potentially ruinous.

Literature Cited

Bonvicino, C. R., M. E. B. Fernandes and H. N. Seuánez. 1995. Morphological analysis of *Alouatta seniculus* species group (Primates, Cebidae). A comparison with biochemical and karyological data. *Hum. Evol*. 10: 169–176.

Costello, R. K., C. Dickinson, A. L. Rosenberger, S. Boinski and F. S. Szalay. 1993. Squirrel monkey (genus *Saimiri*) taxonomy: a multidisciplinary study of the biology of the species. In: *Species, Species Concepts, and Primate Evolution*, W. H. Kimbel and L. B. Martin (eds.), pp.177–210. Plenum Press, New York.

De Boer, L. E. M. and M. De Bruijn. 1990. Chromosomal distinction between the red-faced and black-faced black spider monkeys (*Ateles paniscus paniscus* and *A. p. chamek*). *Zoo Biol*. 9: 307–316.

Ferguson-Smith, M. A., F. Yang, W. Rens and P. C. M. O'Brien. 2005. The impact of chromosome sorting and painting on the comparative analysis of primate genomes. *Cytogenet. Genome Res*. 108: 112–121.

Froehlich, J. W., J. Supriatna and P. H. Froehlich, P. H. 1991. Morphometric analyses of *Ateles*: systematic and biogeographic implications. *Am. J. Primatol*. 25: 1–22.

Froenike, L. 2005. Origins of primate chromosomes—as delineated by Zoo-FISH and alignments of human and mouse draft genome sequences. *Cytogenet. Genome Res*. 108: 122–138.

Gray, J. E. 1845. On the howling monkeys (*Mycetes*, Illiger). *Ann. Mag. Nat Hist.* 16: 217–221.

Groves, C. P. 1989. *A Theory of Human and Primate Evolution*. Oxford University Press, New York.

Groves, C. P. 1992. Titis, New World monkeys of the genus *Callicebus* (Cebidae, Platyrrhini): a preliminary taxonomic review. *Fieldiana, Zoology, New Series*, (55): 1–109. Hershkovitz, P. 1990. *Int. J. Primatol*. 13: 111–112. (Review).

Groves, C. P. 1993. Order Primates. In*: Mammal Species of the World: A Taxonomic and Geographic Reference*, 2nd Edition, D. E. Wilson and D. M. Reeder (eds.), pp.243–277. Smithsonian Institution Press, Washington, DC.

Groves, C. P. 2001. *Primate Taxonomy*. Smithsonian Institution Press, Washington, DC.

Groves, C. P. 2004. The what, why and how of primate taxonomy. *Int. J. Primatol.* 25(5): 1105–1126.

Groves, C. P. 2005. Order Primates. In: *Mammal Species of the World: A Taxonomic and Geographic Reference*, 3rd Edition, Volume 1, D. E. Wilson and D. M. Reeder (eds.), pp.111–184. Johns Hopkins University Press, Baltimore.

Hershkovitz, P. 1963. A systematic and zoogeographic account of the monkeys of the genus *Callicebus* (Cebidae) of the Amazonas and Orinoco River basins. *Mammalia* 27: 1–80.

Hershkovitz, P. 1984. Taxonomy of squirrel monkeys, genus *Saimiri*, (Cebidae, Platyrrhini): a preliminary report with description of a hitherto unnamed form. *Am. J. Primatol*. 4: 209–243.

Hershkovitz, P. 1985. A preliminary taxonomic review of the South American bearded saki monkeys genus *Chiropotes* (Cebidae, Platyrrhini), with the description of a new subspecies. *Fieldiana, Zoology, New Series* (27): iii + 46.

Hershkovitz, P. 1987. Uacaries, New World monkeys of the genus *Cacajao* (Cebidae, Platyrrhini): a preliminary taxonomic review with the description of a new subspecies. *Am. J. Primatol*. 12: 1–53.

Hill, W. C. O. 1962. *Primates Comparative Anatomy and Taxonomy V. Cebidae Part B*. Edinburgh University Press, Edinburgh.

Kellogg R. and E. A. Goldman. 1944. Review of the spider monkeys. *Proc. U. S. Natl. Mus.* 96: 1–45.

Kobayashi, S. 1995. A phylogenetic study of titi monkeys, genus *Callicebus*, based on cranial measurements: I. Phyletic groups of *Callicebus*. *Primates* 36: 101–120.

Medeiros, M. A. A. 1994. Citogenética, evolução cromossômica, radiação e especiação dos macacos-aranha (*Ateles*, Primates). Master's Thesis, Universidade Federal do Pará, Museu Paraense Emílio Goeldi, Belém, Pará. 137pp.

Medeiros, M. A. A., R. M. S. Barros, J. C. Pieczarka, C. Y. Nagamachi, M. Ponsà, M. Garcia, F. Garcia and J. Egozcue, J. 1997. Radiation and speciation of spider monkeys, genus *Ateles*, from the cytogenetic viewpoint. *Am. J. Primatol*. 42: 167–178.

Nascimento, F. F., C. R. Bonvicino, F. C. D. da Silva, M. P. C. Schneider and H. N. Seuánez. 2005. Cytochrome b polymorphisms and population structure of two species of *Alouatta*. *Cytogenet. Genome Res*. 108: 106–111.

Neusser, M., M. Münch, G. Anzenberger and S. Müller. 2005. Investigation of marmoset hybrids (*Cebuella pygmaea* x *Callithrix jacchus*) and related Callitrichinae (Platyrrhini) by cross-species chromosome painting and comparative genomic hybridization. *Cytogenet. Genome Res*. 108: 191–196.

Oliveira, E. H. C. de, M. Neusser, W. B. Figueiredo, C. Y, Nagamachi, J. C. Pieczarka, I. J. Sbalqueiro, J. Wienberg and S. Müller. 2002. The phylogeny of the howler monkeys, (*Alouatta*, Platyrrhini): reconstruction by multicolor or cross species chromosome painting, *Chromosome Res*. 10: 669–683.

Oliveira, E. H. C. de, M. Neusser, J. C. Pieczarka, C. Y. Nagamachi, I. J. Sbalqueiro and S. Müller. 2005. Phylogenetic influences of Atelinae (Platyrrhini) based on multi-directional chromosome painting in *Brachyteles arachnoides*, *Ateles paniscus paniscus* and *Ateles b. marginatus*. *Cytogenet. Genome Res*. 108: 183–190.

Ruiz-Herrera, A., F. Garcia, L. Mora, J. Egozcue, M. Ponsà and M. Garcia. 2005. Evolutionary conserved chromosomal segments in the human karyotype are bounded by unstable chromosome bands. *Cytogenet. Genome Res*. 108: 161–174.

Rumpler, Y. 2002. Chromosomal and molecular primatology. *Evol. Anthropol*. 11: 145–149.

Rumpler, Y. and B. Dutrillaux. 1990. *Chromosomal Evolution and Speciation in Primates*. University of the Basque Country, Vol. 23. Springer Verlag, New York.

Ryder, O. A. 2005. Conservation genomics: applying whole genome studies to species conservation efforts. *Cytogenet. Genome Res*. 108: 6–15.

Rylands, A. B. 1999. The name of the weeper or wedge-capped capuchin in the Guianas. *Neotrop. Primates* 7(3): 89–91.

Rylands, A. B. and D. Brandon-Jones. 1998. The scientific nomenclature of the red howlers from the northeastern Amazon in Brazil, Venezuela and the Guianas. *Int. J. Primatol.* 19: 879–905.

Rylands, A. B., A. F. Coimbra-Filho and R. A. Mittermeier. 1993. Systematics, distributions and some notes on the conservation status of the Callitrichidae. In: *Marmosets and Tamarins: Systematics, Behaviour, and Ecology*, A. B. Rylands (ed.), pp.11–77. Oxford University Press, Oxford.

Rylands, A. B., R. A. Mittermeier and E. Rodríguez-Luna. 1995. A species list for the New World primates (Platyrrhini): distribution by country, endemism, and conservation status according to the Mace-Lande system. *Neotrop. Primates* 3(suppl.): 113–160.

Rylands, A. B., H. Schneider, A. Langguth, R. A. Mittermeier, C. P. Groves and E. Rodríguez-Luna. 2000. An assessment of the diversity of New World primates. *Neotrop. Primates* 8(2): 61–93.

Schmitz, J., C. Roos and H. Zischler. 2005. Primate phyologeny: molecular evidence from retroposons. *Cytogenet. Genome Res*. 108: 26–37.

Seuánez, H. N., C. R. Lima, B/ Lemos, C. R. Bonvicino, M. A. M. Moreira and F. C, Canavez. 2001. Gene assignment in *Ateles paniscus chamek* (Platyrrhini, Primates). Allocation of 18 markers of human syntenic groups 1, 2, 7, 14, 15, 17 and 22. *Chromosome Res*. 9: 631–639.

Seuánez, H. N., C. R. Bonvicino M. A. M. and Moreira. 2005. The primates of the Neotropics: genomes and chromosomes. *Cytogenet. Genome Res*. 108: 38–46.

Silva, B. T. F., M. I. C. Sampaio, H. Schneider, M. P. C. Schneider, E. Montoya, F. Encarnación, S. M. Callegari-Jacques and F. M. Salzano. 1993. Protein electrophoretic variability in *Saimiri* and the question of its species status. *Am. J. Primatol*. 29: 183–193.

Solari, A. J. and M. I. Rahn. 2005. Fine structure and meiotic behavior of the male multiple sex chromosomes in the genus *Alouatta*. *Cytogenet. Genome Res*. 108: 262–267.

Stanyon, R., S. Tofanelli, M. A. Morescalchi, G. Agoramoorthy, O. A. Ryder and J. Wienberg. 1995. Cytogenetic analysis shows extensive genomic rearrangements between red howler (*Alouatta seniculus* Linnaeus) subspecies. *Am. J. Primatol.* 35: 171–183.

Stanyon, R., Consigliere, S., Muller, S., Morescalchi, A., Neusser, M. and Wienberg, J. 2000. Fluorescent *in situ* hybridization (FISH) maps chromosomal homologies between the dusky titi and the squirrel monkey. *Am. J. Primatol*. 50: 95–107.

Stanyon, R., S. Consigliere, F. Bigoni, M. Ferguson-Smith, P. C. O'Brien and J. Wienberg. 2001. Reciprocal chromosome painting between a New World primate, the woolly monkey, and humans. *Chromosome Res.* 9: 97–106.

Stanyon, R., R. Bruening, G. Stone, A. Shearin. and F. Bigoni. 2005. Reciprocal painting between humans, De Brazza's and patas monkeys reveals a major bifurcation in the Cercopithecini phylogenetic tree. *Cytogenet. Genome Res*. 108: 175–182.

Thorington Jr., R. W. 1985. The taxonomy and distribution of squirrel monkeys (*Saimiri*). In: *Handbook of Squirrel Monkey Research*, L. A. Rosenblum and C. L. Coe (eds.), pp.1–33. Plenum Press, New York.

Van Roosmalen, M. G. M., T. van Roosmalen and R. A. Mittermeier. 2002. A taxonomic review of the titi monkeys, genus *Callicebus* Thomas, 1903, with the description of two new species, *Callicebus bernhardi*, and *Callicebus stephennashi*, from Brazilian Amazonia. *Neotrop. Primates* 10(suppl.): 1–52.

Vivo, M. de. 1985. On some monkeys from Rondônia, Brasil (Primates: Callitrichidae, Cebidae). *Pap. Avulsos Zool., São Paulo* 4: 1–31.

Warter, S., M. Hauwy, B. Dutrillaux and Y. Rumpler. 2005. Application of molecular cytogenetics for chromosomal evolution of the Lemuriformes (Prosimians). *Cytogenet. Genome Res*. 108: 197–203.

Reviewed by:

Anthony B. Rylands
Center for Applied Biodiversity Science
Conservation International
2011 Crystal Drive
Arlington, VA 22202 USA

Regional Newsletters

The IUCN/SSC Primate Specialist Group also produces regional newsletters/journals which publish short articles and notes on general and specific aspects of primate ecology, taxonomy, distributions, behavior and conservation, tropical forest ecology and conservation, forest destruction, and protected areas. Also please send information on projects, research groups, events, recent publications, courses, funding sources, activities of primatological societies and NGOs, and other newsworthy items of interest to primate conservationists, directly to the editors at the addresses below.

Madagascar - *Lemur News*

Jörg Ganzhorn
Institute of Zoology, Ecology and Conservation
Martin Luther King Platz 3
20146 Hamburg
Germany.
E-mail: <ganzhorn@zoologie.uni-hamburg.de>.

Neotropical Region - *Neotropical Primates,* Mesoamerica

Ernesto Rodríguez-Luna
Instituto de Neuroetología
Universidad Veracruzana
Apartado Postal 566
Xalapa
91000 Veracruz
México.
E-mail: <errodriguez@uv.mx>

Neotropical Region - *Neotropical Primates,* South America

Erwin Palacios
Conservación Internacional Colombia
Carrera 13 # 71-41
Bogotá DC
Colombia.
E-mail: <epalacios@conservation.org>

Asian Region - *Asian Primates*

Jatna Supriatna
Conservation International Indonesia
Jl. Pejaten Barat No.16A,
Kemang Jakarta 12550
Indonesia.
E-mail: <jsupriatna@conservation.org>

African Region - *African Primates*

Carolyn L. Ehardt
Department of Anthropology
University of Texas at San Antonio
One UTSA Circle
San Antonio
TX 78249-1644
USA.
E-mail: <Carolyn.Ehardt@utsa.edu>

Instructions to Contributors

Articles submitted to Primate Conservation

Manuscript Format
All manuscripts should be typewritten, double spaced with generous margins, and accompanied by the text on diskette in Word format or by e-mail in RTF or as a Word document. Please indicate on a separate cover page the author to which correspondence should be sent, including fax number and e-mail, the month and year the manuscript was completed, up to six key words, and a short running title. Abstracts are not published. Footnotes are to be avoided (except for tables and figures). Subdivision titles, for example, Methods, Conclusions, etc. are not necessary. Please give all measurements in metric units. Please accent all foreign words carefully. The literature cited should be in the following style:

Example – journal article:
Struhsaker, T. T. 1972. Rain-forest conservation in Africa. *Primates* 13: 103–109.

Example – chapter in book:
Goodall, A. G. and C. P. Groves. 1977. The conservation of eastern gorillas. In: *Primate Conservation*, H. S. H. Prince Rainier of Monaco and G. H. Bourne (eds.), pp.599–637. Academic Press, New York.

Example – book:
Soulé, M. E. 1987. *Viable Populations for Conservation*. Cambridge University Press, Cambridge, UK.

Example – dissertation:
Homewood, K. M. 1976. Ecology and Behaviour of the Tana Mangabey (*Cercocebus galeritus galeritus*). PhD thesis, University College, London.

Maps
Maps should always be made as concise as possible and should include an inset showing the location of the area discussed in relation to its home country or continent.

Photographs
Black-and-white prints are ideal. Original color slides from which we can make prints are also acceptable. However, please send only sharply-focused, high quality slides and photographs. Please label each slide or photograph with the photographer credit and number the identifying caption. Captions should be listed on a separate sheet, or after "Literature Cited." We are always interested in receiving high quality photographs for our covers, especially those of little known and rarely photographed primates, even if they do not accompany an article.

All Figures
Please indicate on all figures the title and author of the manuscript to which they belong and package them carefully to avoid damage in the post. Figures will only be returned at the special request of the author. Electronic high resolution files (300 dpi) of maps, photographs and figures can be sent in any one of the following types of files: EPS, TIF, or JPG. Please, however supply a hard copy of all drawn maps or figures, preferably in the size in which they should be published.

Please send your contribution to:

Anthony B. Rylands
Center for Applied Biodiversity Science
Conservation International
1919 M Street, NW, Suite 600
Washington, DC 20036
USA.
E-mail: <a.rylands@conservation.org>.

Back cover: A greater bamboo lemur (*Prolemur simus*), Ranomafana National Park, Madagascar. This lemur has been listed on the Top 25 Most Endangered Primates since 2002. The greater bamboo lemur is threatened by slash-and-burn agriculture, illegal logging, the cutting of bamboo, and hunting with slingshots. See p. 4 for a complete description. *Photo*: © CI–Haroldo Castro

IUCN
The World Conservation Union