ISSN 1093-8966

AFRICAN PRIMATES

The Journal of the Africa Section of the IUCN/SSC Primate Specialist Group

Volume 6, Numbers 1&2 *2002–2003*

CONSERVATION INTERNATIONAL

SPECIES SURVIVAL COMMISSION

NATIONAL MUSEUMS OF KENYA

ZOO ATLANTA

This issue of *African Primates* was kindly sponsored by the Margot Marsh Biodiversity Foundation.

African Primates is produced and distributed by Zoo Atlanta and the National Museums of Kenya's Institute of Primate Research and Centre for Biodiversity. The Chairman and Editors extend their thanks to Zoo Atlanta and the National Museums of Kenya for this generous support.

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ARTICLES

GALAGID TAXONOMY AND THE PLACEMENT OF THE NEEDLE-CLAWED GALAGO (*EUOTICUS*): BASED ON CYTOCHROME *b*, 12S AND 16S PARTIAL SEQUENCES

Abstract: *Galagidae includes four genera, seven subgroups, and 16 to 18 species (Groves, 2001). Although several morphological types exist, species within generic groupings are often cryptic. This has inhibited taxonomic evaluation. Recently, molecular characters have been used in systematic treatment within Galagidae and in characterising the history of this radiation. Data from partial sequences of the12S rRNA, 16S rRNA, and cytochrome b mitochondrial genes of* Euoticus elegantulus *were pooled with previous molecular data from exemplar taxa within Galagidae. The molecular data support the galagid clade (which includes* Galago *and* Euoticus*). This study presents tenuous support for* Euoticus *as an exclusive genus, rather than within* Galago*, and also as the most basal radiation within Galagidae.*

Résumé: *Galagidae inclut quatre genres, sept sous-groupes et de 16 à 18 espèces (Groves, 2001). Quoique plusieurs types morphologiques existent, les espèces au sein de groupes génériques sont souvent difficiles à déterminer. Ceci a ralenti leur évaluation taxonomique. Des caractères moléculaires ont récemment été utilisés au sein des Galagidae pour évaluer l'histoire et la taxonomie de cette radiation. Des données de séquences partielles des gènes 12S rRNA, 16S rRNA et du cytochrome b mitochondrial d'*Euoticus elegantulus *ont été contrastées aux données moléculaires existantes de taxons typiques de Galagidae. Ces données moléculaires appuient le clade galagid (qui inclut* Galago *et* Euoticus*). Cette étude démontre provisoirement qu'*Euoticus *doit être considéré comme un genre exclusif, plutôt qu'au sein de* Galago*, et représente la radiation de base des Galagidae.*

Introduction

Needle-clawed galagos (Galagidae: *Euoticus*) are restricted to the humid forests between the Niger and Zaire (Congo) Rivers of Central Africa. Initially thought to be monotypic (Malbrant & Maclatchy, 1949), two species are currently recognised (Groves, 2001). Both species are restricted to what is known as the West African Forest Block (Malbrant & Maclatchy, 1949). The southern needle-clawed galago *Euoticus elegantulus* (Le Conte, 1857) is known from Gabon, Equatorial Guinea, Congo and Cameroon, occurring west of the Sangha River, north of the Zaire (Congo) River and south of the Sanaga River. Its northern limits are characterised by fragmented forests grading into savannah mosaics at approximately 6° N in the Cameroon Highlands (Sarmiento & Oates, 1999). The northern needle-clawed galago *Euoticus pallidus* (Gray, 1863) is known from Bioko (Fernando Po) Island, eastern Nigeria, and western Cameroon from the mouth of the Niger River and Cross River south to the Sanaga River (figure 1) (Groves, 2001).

Molecular characters have been used to characterise systematic relationships within Galagidae, but have neglected to include *Euoticus* (DelPero *et al.*, 2000). The recent collection and acquisition of new *E. elegantulus* tissues has improved sampling for molecular data in new generic level taxonomies. The peculiar collection locality of one of the *E. elegantulus* specimens should be noted: In 1996, Darrin Lunde collected four specimens of *E. elegantulus* while night-hunting along forest trails on the eastern bank of the Sangha River, just outside the Dzanga-Sangha Forest Reserve, in extreme south-western Central African Republic (figure 1) (Lunde, pers. comm.). The collection locality is considerably isolated from previous collection localities and represents the easternmost limit of the range of *E. elegantulus* as represented by museum collections. This indicates that *E. elegantulus* occurs in the forest block east of the Sangha River and south of the Ubangi River (Malbrant & McLatchy, 1949).

This study compares partial mtDNA sequences of *E. elegantulus* with previously published molecular data for up to 11 other galagid taxa (DelPero *et al.*, 2000; Yoder *et al.*, 2001; Roos *et al.*, 2004) to determine the phylogenetic affinity of *Euoticus* within the Galagidae, and to resolve relationships among galagid taxa.

Materials and Methods

Isolation and Sequencing

Genomic DNA of *E. elegantulus* was extracted from dried tissue of museum study skeleton AMNH107154 and from specimen AMNH109045 preserved in ethanol using standard tissue protocol (Qiagen). Genomic DNA of *E. elegantulus* was accessioned in the Ambrose Monell Cryo Collection (American Museum of Natural History, NY, AMNH 107154, AMNH 109045). Mitochondrial primers from DelPero *et al.* (2000) were used for successful amplification of protein coding cytochrome *b*, and ribosomal 16S and 12S rRNA coding regions.

Genomic DNA was amplified with puReTaq PCR beads (Amersham Biosciences 2002) for final concentrations per reaction of 2.5u puReTaq DNA polymerase, 10mM Tris-HCl, 50mM KCl, and 1.5mM

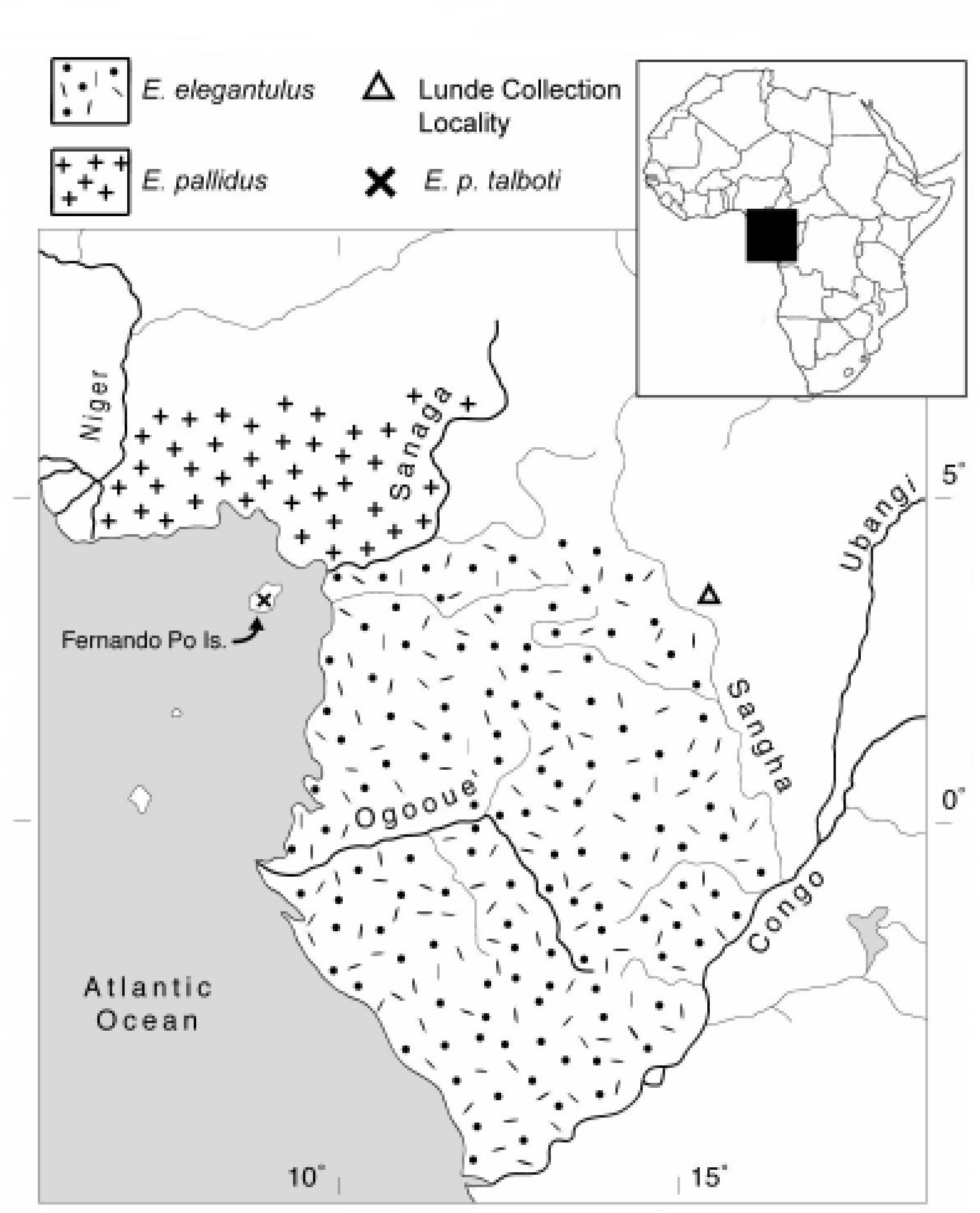

Figure 1. Range map of Euoticus *extrapolated from Malbrant & MacLatchy (1949). The triangle denotes the Lunde collection locality from which the* E. elegantulus *tissue samples used in this study were obtained. The remaining* E. elegantulus *sample used in this study was collected east of the Sangha River. No* E. pallidus *tissues were included in the analysis.*

$MgCl_2$, 0.200uM of each of four deoxynucleotide phosphates, 0.4uM for each primer. PCR conditions began with an initial denaturation (96C), followed by 35 cycles of denaturation (95°C), annealing (56°C), and extension (72°C), with a final extension (72°C) before stabilisation (4°C). Amplifications were vacuum-cleaned with Array-It filters (TeleChem International, Inc., CA) and products were re-suspended in de-ionized water. Single stranded sequencing reactions were performed with Big Dye v1.1 chemistry (Applied Biosystems). Cycle sequence conditions included an initial denaturation at (96°C), followed by 30 cycles of denaturation (94°C), annealing (56°C), and extension (60°C), before stabilisation (4°C). Products were precipitated with alcohol and resuspended in Hi-Di Formamide (Applied Biosystems). All sequencing was performed on ABI 3700 and ABI 3730 capillary sequencers at the Molecular Systematics facilities of the American Museum of Natural History (NY).

Data Collection

Single stranded sequence files were imported directly into Sequencher v.4.1.2 (Gene Codes Corp. 2000) and manually corrected for ambiguous base calls. Published sequences (AF212942–AF212971, DelPero *et al*. 2000; AF271409, Yoder *et al*. 2001; AY441467–AY441468, Roos *et al*. 2004) were imported and aligned with generated sequence data for further analyses. All sequences were manually aligned with Se-Al v.1.d1 (Rambaut, 1995), with alignment corrections made parsimoniously by eye. Alignments were exported to PAUPv4.0b10 (Swofford, 2002), and phylogenetic reconstructions were performed with both maximum parsimony [MP] and maximum likelihood [ML] optimality criterion. Two Asian lorises, *Loris tardigradus* and *Nycticebus coucang*, were used as outgroup taxa.

Parsimony searches were performed with a branch and bound search algorithm and equal weighting of characters, with gaps classified as missing data. Search parameters for the ML criterion were estimated by Modeltest v3.04 (Posada & Crandall, 1998). With this software, increasingly complex models of character evolution are tested, using likelihood ratio test statistics, via consecutive step-wise comparison to simpler (null) models. The least complex, but most likely, model of character evolution was implemented in PAUP using a heuristic search algorithm through 100 random addition replicates.

Topological similarities under variable optimality criteria and between data partitions were noted and bootstrap [BP] (Felsenstein, 1985) confidence estimates were calculated through 100 [ML]–1000 [MP] replicated data sets, with 10 random addition sequence replicates per bootstrap replicate. A 50% majority rule consensus tree was used to combine all bootstrap reconstruction support values. Decay indices (Bremer, 1988), indicating step-wise costs for alternate topologies, were checked using TreeRotv.2 (Sorenson, 1999).

For consistency, taxonomic designations were used as seen in DelPero *et al*. (2000); and Roos *et al*., (2004). It should be noted that the most current taxonomy (Grubb *et al*., 2003) includes the distinction between Zanzibar (*Galagoides zanzibaricus*) and Kenyan (*G. cocos*) forms, and also groups *Galagoides alleni* and *Galago gabonensis* into one genus, *Sciurocheirus*.

Results

Galagidae is monophyletic, (figures 2 & 3) with ML and MP converging on similar topologies and relative nodal support. Analysis of 198 parsimony informative characters gave two MP reconstructions that were not significantly different from each other (Wilcoxon sign rank $p > 0.5$; Templeton, 1983). A strict consensus is presented of both MPRs (figure 2; both trees, length = 571 steps, CI = 0.65, RI = 0.59). *Euoticus* (BP = 100/100) and *Galago* (BP = 100/100) are well-supported clades using both (MP and ML) criteria. Alternatively, *Otolemur* (BP < 5) and *Galagoides* (BP = 14/30) do not show consistent support for consideration as individual generic units. Further, weakly supported and short internodes do not resolve intrafamilial relationships among the galagid genera.

With both MP and ML criteria, *Euoticus* show some support as a basal group [BP = 63/64] within the galagid clade [BP = 90/100]. In MP and ML criteria, long branches characterise the basal radiation of this group within Galagidae (111 steps in MPR). MP and ML topologies weakly support more recent common ancestry of other galagid genera, with *Euoticus* excluded. Alternative topologies, placing *Euoticus* within the *Galago*, *Galagoides*, and *Otolemur* group would require eight additional steps on the most parsimonious reconstruction.

Our data show that the *Galago* clade is monophyletic (figures 2 & 3), although their position relative to other galagid genera is not well resolved in comparing topologies between the MP and ML criteria. Robust support [BP = 100] and long branch lengths characterise the divergence of the *Galago* clade (figures 2 & 3). *Galago gallarum* and *Galago senegalensis* are a strongly supported clade [BP = 98/87]. *Galago moholi* is placed basally [BP = 100] within the lesser bushbaby group (figures 2 & 3). These results were also found in DelPero *et al*. (2000).

Otolemur is not a well-supported genus. The tree collapses under bootstrap analyses to a polytomy at the base of the node diagnosing *Otolemur*, *Galago*, and *Galagoides* relationships (figures 2 & 3). The internode uniting *Otolemur garnettii* and *Otolemur crassicaudatus* is short, and would collapse to a polytomy with one extra step on the MPR. These results contradict the support of *Otolemur* (BP = 87) in DelPero *et al*. (2000). Nodal values supporting a relationship between *Galago* and *Otolemur* also collapse with robust analyses.

Phylogenetic reconstructions (ML) from partial cytochrome *b* sequences using data from this study in combination with published sequences (DelPero *et al*., 2000; Yoder *et al*., 2001; Roos *et al*., 2004) both resolve and conflict interpretations of relationships among galagid taxa (*figure* 4). Monophyly of *Galago senegalensis*, *Galago gallarum*, and *Galago moholi* is supported (BP = 61); however bootstrap values show strong support (BP = 94) for monophyly of the clade *Galago matschiei*, *G. senegalensis*, *G. gallarum*, and *G. moholi* (figure 4). Additionally, *Galagoides zanzibaricus* (Kenyan form) and *Galagoides granti* are a strongly supported clade (BP = 98), and *Galagoides* (*Sciurocheirus*) *alleni* and *Galago* (*Sciurocheirus*) form a strongly supported clade (BP = 99). Intergeneric alliances remain best represented as an unresolved polytomy with these data.

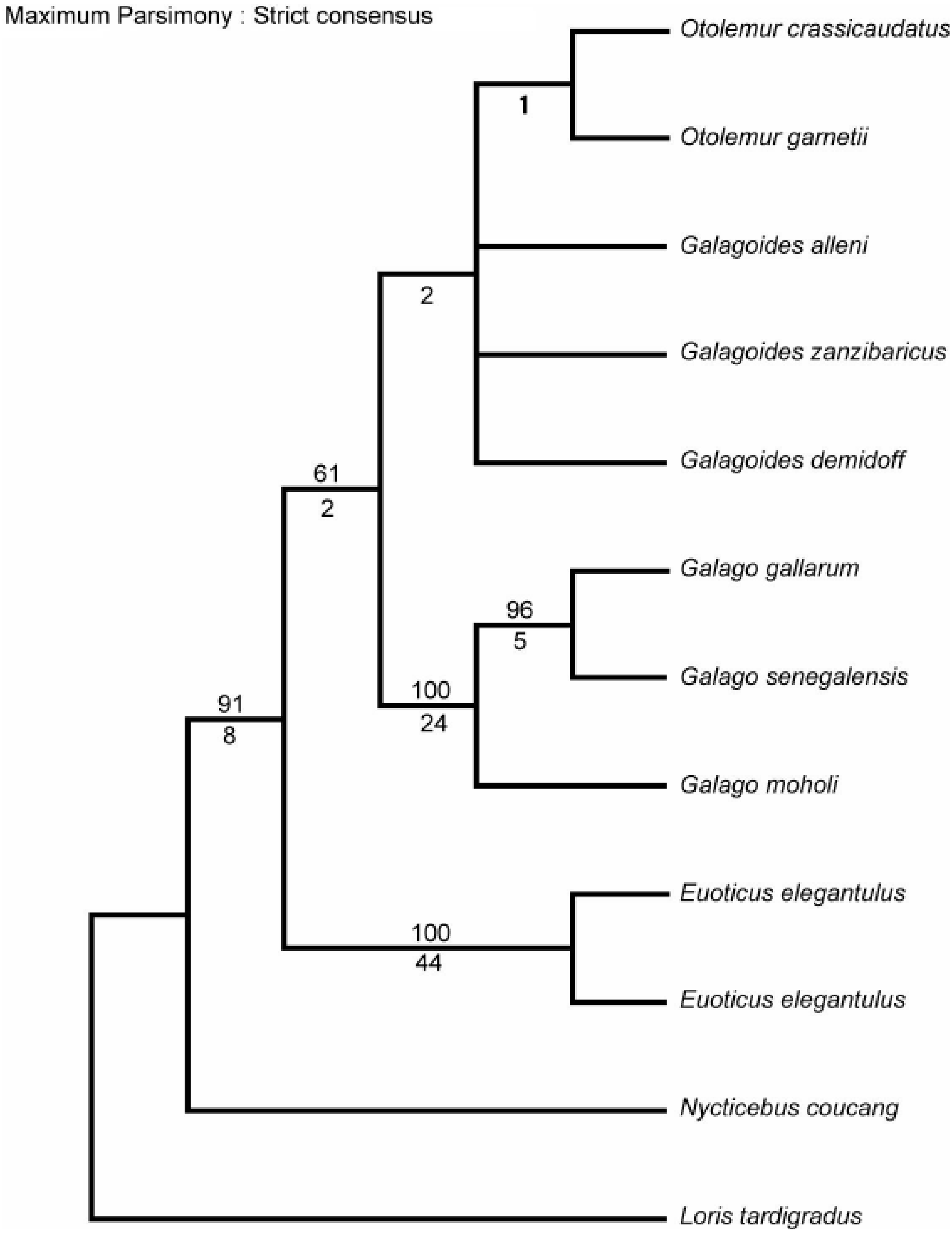

Figure 2. A strict consensus of the two most parsimonious trees is presented. Heuristic searches were performed on 198 parsimony informative characters with gaps as missing data (for both trees, length = 571 steps, CI = 0.65, RI = 0.59) from cytochrome b*, 12S, and 16S mitochondrial gene regions. Bootstrap values were obtained heuristically from 1000 bootstrap replicates and 10 random addition sequence replicates per bootstrap replicate. Bootstrap values are labeled above nodes, Bremer indices are shown below nodes.*

Discussion

In this study, the addition of molecular characters, from *Euoticus*, to previously sequenced taxa (DelPero *et al*., 2000; Yoder *et al*., 2001; Roos *et al*., 2004;) give an alternate interpretation of phylogenetic relationships of Galagidae and this result raises questions about interpretations of their evolutionary history. Our

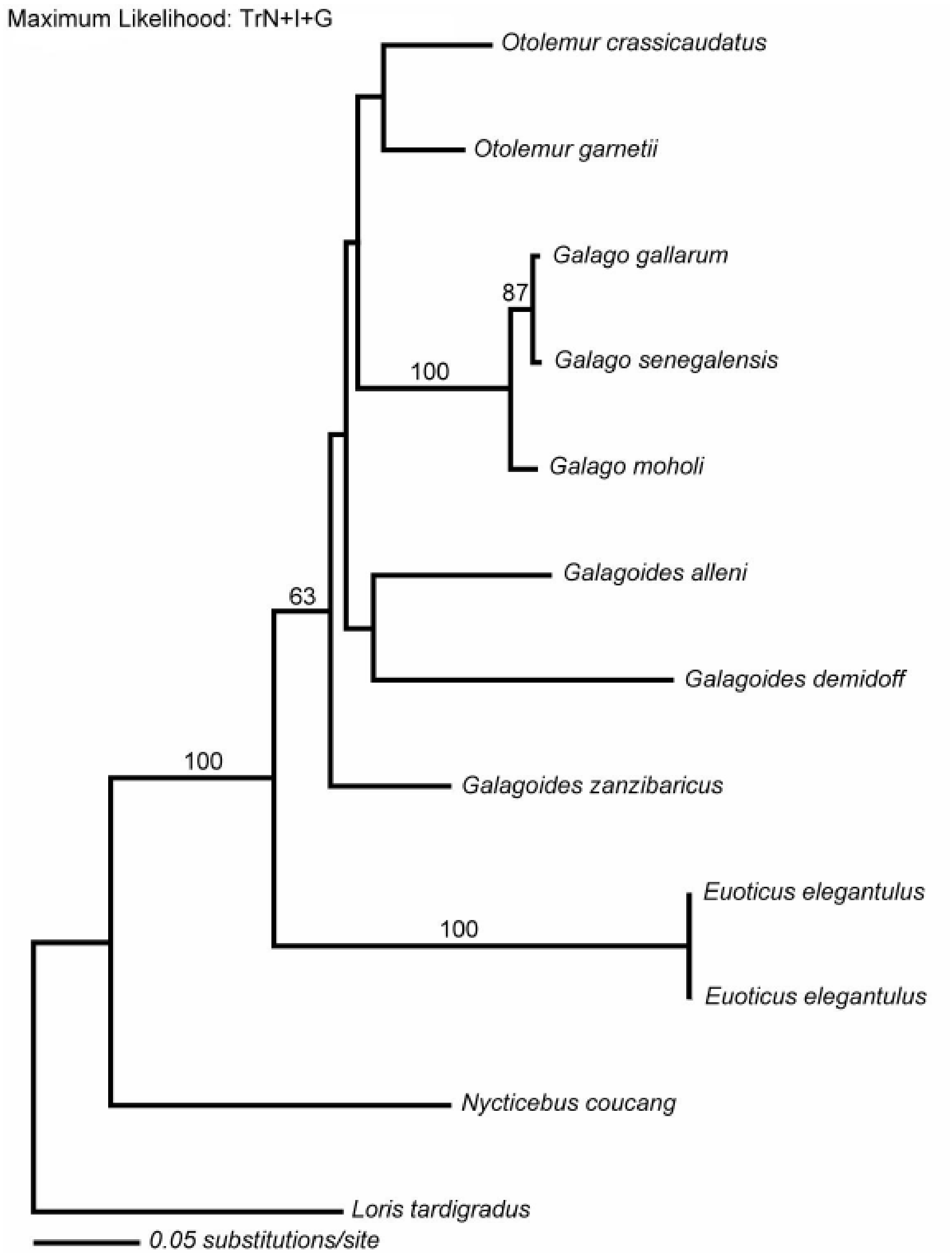

Figure 3. The maximum likelihood reconstruction was obtained by using the Tamura and Nei model (1993) of sequence evolution, with invariant sites, and gamma shape parameter. Data reflect cytochrome b*, 12S and 16S mitochondrial gene regions. Bootstrap values (above nodes) were obtained heuristically from 100 bootstrap replicates and 10 random addition sequence replicates per bootstrap replicate. Here, branch length is indicative of evolutionary radiation within Galagidae.*

molecular evidence suggests that *Galago* and *Euoticus* are two separate clades. This result contrasts findings from cheek tooth and skull morphology (Schwartz & Tattersall, 1985; Masters & Brothers, 2002). In this scenario, the uncertainty regarding the placement of *Euoticus* may be due to its plesiomorphic morphology

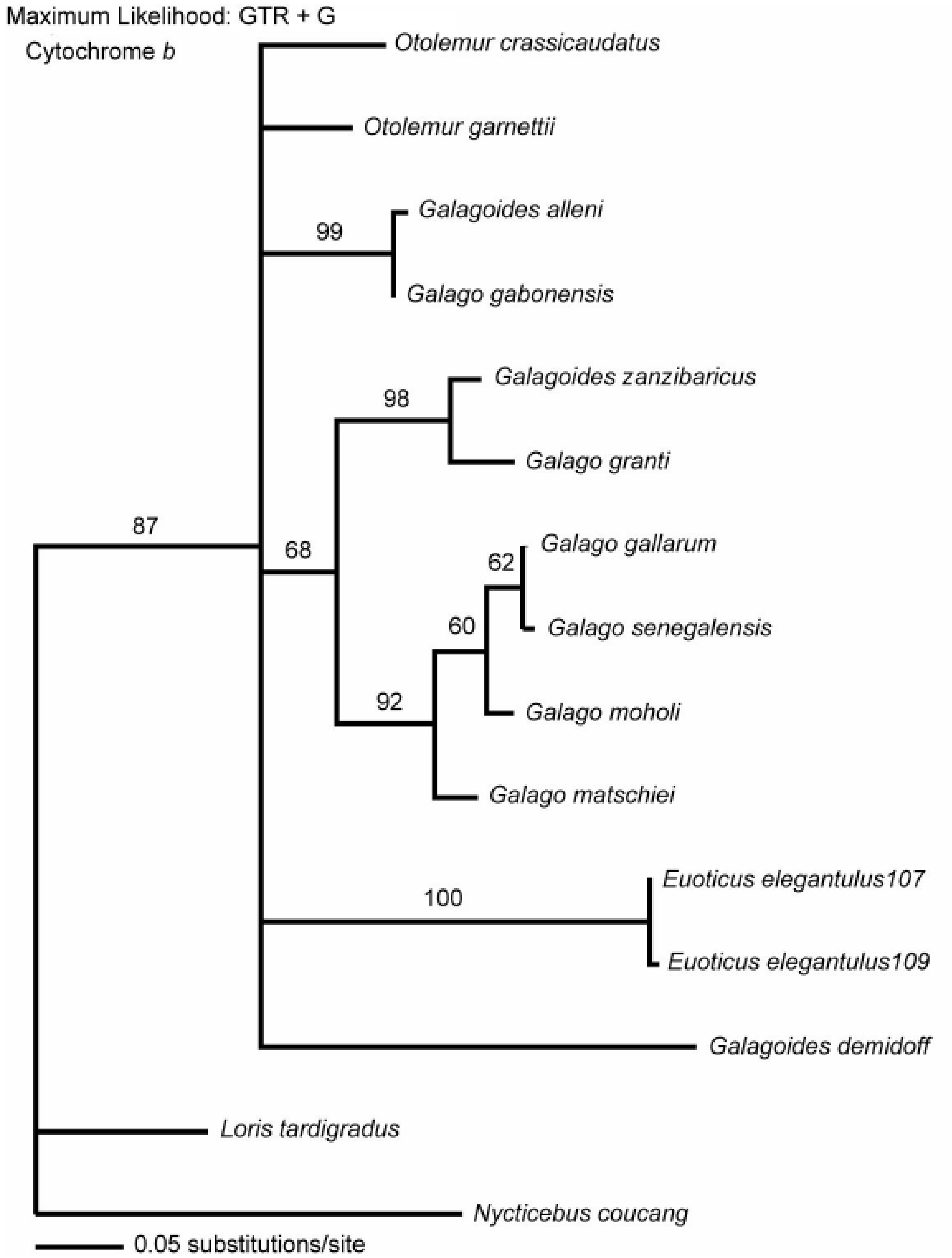

Figure 4. The maximum likelihood reconstruction was obtained by using the GTR + G model of sequence evolution. Data reflect pooled cytochrome b *partial sequences from this study, DelPero* et al. *(2000), Roos* et al. *(2004), and Yoder* et al. *(2001). Bootstrap values (above nodes) were obtained heuristically from 100 bootstrap replicates and 10 random addition sequence replicates per bootstrap replicate.*

when compared with more derived *Galago* taxa (Masters & Brothers, 2002).

Generic support for *Galago* is consistent with the findings of recent molecular (DelPero *et al.*, 2000; Roos *et al.*, 2004) and morphological (Masters & Brothers, 2002) studies. Masters & Brothers (2002) suggest at least four synapomorphic morphological characters diagnosing a relationship between *G. moholi*, *G. senegalensis*, *G. gallarum*, and *G. matschiei*. The partial cytochrome *b* sequence data corroborate this alliance and strongly support a clade of common ancestry for these taxa.

With our addition of *Euoticus* to the DelPero *et al*. (2000) data set there is still no support for *Galagoides* as a natural group. All *Galagoides* taxa are connected to the base of a polytomy of the galagid tree with respect to bootstrap support with MP and ML analyses. *Otolemur*, however, is a well-supported genus in the DelPero *et al*. (2000) phylogeny, and is positioned as sister to *Galagoides alleni*. Our study does not strongly support the genus *Otolemur*, nor does *G. alleni* have any recognised affinity to *Otolemur* in either MP or ML topologies. However, combined evidence with other data sets, including karyological (de Boer, 1973), morphological (Olson, 1979) and vocalisation (Zimmermann, 1990) characters, may retain support for *Otolemur*.

The relationship of *G. alleni* has been contested in the literature (Schwartz & Tattersall 1985; Masters *et al*., 1994; DelPero *et al*., 2000; Masters & Brothers, 2002). The addition of *G. gabonensis* to this study (partial cytochrome *b* data) produced a strongly supported sister relationship with *G. alleni*. Roos *et al*. (2004) do not include *G. alleni* in their taxonomic sampling, but suggest strong support for *G. gabonensis* allied with *Otolemur*. More taxonomic sampling is necessary for further phylogenetic interpretation of relationships among these taxa.

Galagoides topology suggests that this is not a natural group and that two exclusive genera characterise the Zanzibar and non-Zanzibar groups (DelPero *et al*., 2000; Grubb *et al*., 2003). Support for this recommendation is shown in the basal divergence of *G. zanzibaricus* relative to the greater and dwarf bushbabies. Additionally, long branches under the ML criterion are suggestive of divergent species within *Galagoides*. MP analyses also do not support common ancestry of this group. Again, internodes are short and weakly supported with current molecular data, but the possibility should be subject to more rigorous testing.

DelPero *et al*. (2000) suggests that the association of *G. zanzibaricus* and *Galagoides demidoff* in a single genus creates a "wastebasket taxon of plesiomorphic species." While this study does not support that *G. zanzibaricus* or *G. demidoff* possess plesiomorphic character states for galagids, the wastebasket analogy is consistent with our results. Inclusion of partial cytochrome *b* data from *G. granti* suggests a strong alliance with *G. zanzibaricus*. Future analyses should include sampling of *Galagoides thomasi* and current putatively related taxa. This may provide increased resolution of interspecific relationships within *Galagoides*.

Reconstructions of galagid radiation in the current study are characterised by short internodes between bifurcation events. This increases the likelihood that the mitochondrial gene tree and species tree will be incongruent (Nei, 1987; Pamilo & Nei, 1988; Wu, 1991). However, with regard to lineage sorting, the incongruence of mitochondrial markers in the species tree would likely be further exacerbated with a small sample of nuclear genes (Moore, 1995), so it is possible that the mitochondrial data do provide a reasonable, though unresolved, estimate with respect to rapid radiation in Galagidae. We suggest reconstructions from multiple independent molecular characters to test for the effect of lineage sorting (Nei, 1987; Pamilo & Nei, 1988; Wu, 1991).

Collapsing weak nodes gives intrafamilial relationships that are characterised by a polytomy with the potentially divergent *Euoticus* group emerging from the base of the galagid phylogeny in the current study. Although many studies have identified and discriminated between bushbaby taxa, the historical radiation of the living group is mostly unknown. Masters (1988, 1998) attributes the radiation of bushbabies primarily to events that took place in the Plio-Pleistocene, with some few events occurring in the last 1 Mya. Patterns of radiation can be reflected in an intrafamilial phylogeny, but inconsistent and incomplete taxonomic sampling across studies may be the most serious impediment to the complete characterisation of the galagid phylogeny based on molecular and morphological characters.

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HUNTING PRESSURE ON THE DRILL *MANDRILLUS LEUCOPHAEUS* IN KORUP PROJECT AREA, CAMEROON

Abstract: *In the IUCN/SSC* Action Plan for Primate Conservation *(Oates, 1996), the drill* Mandrillus leucophaeus *is among the highest-ranked species for conservation action, being considered one of the most threatened primate species in Africa. This study aimed (1) to add information on the drill's status in the Korup Project Area, especially the Support Zone of Korup National Park, and (2) to assess the role of the species in the bushmeat trade of this region. We were also interested in (1) disparities in hunting patterns between villages situated near or inside the National Park and villages in the northern Support Zone, (2) the relative importance of subsistence and commercial hunting, and (3) the existence of an international trade. According to our interviews with hunters, the drill is distributed throughout the Korup Project Area. The rate of consumption and trade in drills is certainly far from being sustainable based on the hunters' own* *statements that drill numbers are still declining due to excessive hunting with the use of dogs. We conclude that the villages between the Korup National Park and Nta Ali Forest Reserve need to be included in a wildlife management program which should include a complete hunting ban for threatened primates.*

Résumé: *Dans son Plan d'Action IUCN/SSP pour la Conservation des Primates (Oates, 1996), le drill* Mandrillus leucophaeus *fait partie des espèces les plus importantes pour des actions de conservation, cette espèce étant considérée comme une des plus menacées de toute l'Afrique. Cette étude a pour objectif (1) de fournir des informations additionnelles sur le statut du drill dans la Zone du Projet Korup, particulièrement dans la zone d'Appui du Parc National de Korup et (2) d'établir le rôle de cette espèce dans le commerce de la viande de brousse de la région. Nous étions également intéressés à (1) la disparité dans les types de chasse entre les villages situés près ou au sein du Parc National de même que dans les villages au nord de la zone d'Appui, (2) l'importance relative de la chasse de subsistance et commerciale et (3) l'existence d'un commerce international. Nos entrevues avec les chasseurs ont démontré que les drills sont présents partout dans la Zone du Projet Korup. Les taux de consommation et de commerce des drills sont loin d'être durables si l'on considère les propos mêmes des chasseurs en quoi le nombre de drills continue de diminuer à cause de la chasse excessive utilisant des chiens. Nous concluons que les villages entre le Parc National de Korup et la Réserve Forestière Nta Ali doivent être inclus dans un programme d'aménagement de la faune sauvage, programme qui doit bannir complètement la chasse des primates en danger.*

Introduction

Wildlife in Africa is traditionally considered a more or less freely accessible resource (bushmeat) to be used by local people, and its economic exploitation is widespread. Bushmeat (meat from hunted wild animals) is accessible to the poorer segments of the rural population, its procurement requiring almost no input other than time. In urban settings, those who can afford it pay remarkably high prices for bushmeat (Hofmann *et al*., 1999). In the 1980s, meat from the Korup National Park (KNP, 1253 km^2) in Cameroon was worth US$ 437,000 per year (Infield, 1988). This illustrates the economic importance of the trade at a regional level. In addition to being a source of income and protein, subsistence hunting also serves to protect cultivated areas from damage by wild animals. Infield (1988) estimated that in the Korup Project Area (KPA) (figure 1), approximately 38% of the total village income is derived from hunting. The average hunter in the KPA 'gathers' approximately 860 kg of meat per annum for consumption.

Declines in African wildlife populations have been typically related to human population growth and habitat destruction. However, a growing body of evidence shows that hunting of forest primates for meat has greatly increased due to shifts in social and economic practices resulting in a high demand of meat from outside markets. Infield (1988) estimated that 80% of the commercial carcasses harvested within the KPA are sold.

If current rates of exploitation continue, the commercial bushmeat trade will eliminate some threatened West African species. Ogork and Brown (1996) report from the Korup Support Zone (KSZ) that the giant pangolin *Manis gigantea* has not been seen for 5 years or more by 58 interviewed hunters. Due to hunting, Preuss' red colobus *Piliocolobus pennantii preussi* and mainland drill *Mandrillus leucophaeus leucophaeus* are locally extinct in many parts of the KSZ (Infield, 1988; Waltert *et al.,* 2002).

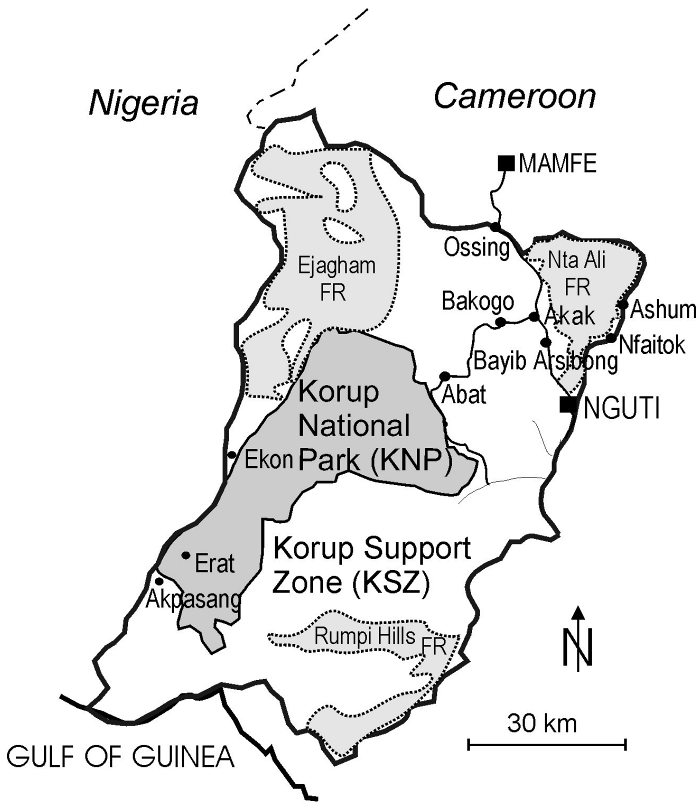

Figure 1. The Korup Project Area (KPA) including the Korup National Park (KNP) and the three forest reserves (FR). Interviewee's villages are marked with a dot. Major villages are marked with squares.

High economic rents, and the combination of low population growth rates and high discount rates, characterise the situation facing many threatened species today. Under these circumstances the hunters' interest is to harvest the resources as quickly as possible rather than in an ecologically sustainable long-term manner. The establishment of protected areas favors this situation by forbidding any legal harvest, thus destroying future security in resource use. Open access results from an inability to exclude users and leads to unregulated competitive use with the resource being exploited either to extinction or to an equilibrium point of low biomass and productivity, leaving the species vulnerable to extinction (Barnes, 1996).

Historically, forest-based communities have followed rules defined by customary institutions governing the use of resources, with regard both to the land they occupied and to the forest resources they used (*e.g.* through "resource and habitat taboos", Colding & Folke, 2001). However, traditional rules regarding land tenure and natural resources have been eroded in recent decades due to new settlements, population growth, changed legal property rights by the state (*e.g.* protected areas), the demand for manufactured consumer goods, education, and "modern" health care (Jell, 1999; Rose, 1998).

The Drill's Conservation Status in the Wild

The drill has the smallest geographical range of any large primate on the African mainland, occupying only 50,000 km^2 between the rivers Cross and Sanaga (Gadsby & Jenkins, 1998). Because of hunting and habitat fragmentation, populations in unprotected areas are under high pressure and expected to be extinct soon (*e.g.*, Dowsett-Lemaire & Dowsett, 2001). In 1996, the IUCN/SSC Primate Specialist Group published the *Action Plan for Primate Conservation* (Oates, 1996). Of the 64 species included in the Plan, the drill *Mandrillus leucophaeus* was one of the highest-ranked species for action. It was classified as "Endangered" by the US Fish and Wildlife Service in 1976 and included in Appendix I of CITES in 1977 (Schaaf, 1990; Oates, 1996; Cox, 1997).

Objectives

The main objective of the study was to add information on the drill's conservation status within the Korup Project Area (southwest Cameroon), especially the Support Zone of Korup National Park. We also sought to determine differences in wild meat use patterns between villages near or inside the National Park and those far from it (northern Korup Support Zone) in order to assess the effect of road infrastructure, information that is valuable for the management of this protected area complex. Furthermore, we wanted to assess the relative importance of subsistence and commercial hunting since these factors have important consequences for wildlife harvesting.

Study Area and Methods

Details of the topography, geological conditions, climate, and vegetation of the KPA can be found in the Korup Management Plan (Ministry of the Environment and Forestry, 2003). The KPA consists of the KNP (1,253 km^2) and the surrounding KSZ (5,357 km^2), which is still covered by extensive forests and contains three forest reserves (Rumpi Hills, Nta Ali, Ejagham) situated to the south, east, and north of the Park, respectively (figure 1). In contrast to other parts of the Support Zone—and even to the National Park—the forest reserves do not contain any human settlements. At present around 50,000 people in 182 villages are living within the KPA. The global objective of the Korup Project is to protect the biodiversity of the National Park and to manage the natural resource use of the local communities in the support zone in an ecologically and economically sustainable and socially acceptable way for the benefits of the local communities.

During April and May 2000 we collected information on existing drill populations in KPA by conducting questionnaire interviews with hunters, and visiting sites where drills were recently observed. We interviewed 54 hunters from the villages of Ashum, Nfaitok, Bayib Arsibong, Akak, Bakoko, Ossing and Mwangale ("Support Zone villages", situated in the northern KSZ), and Akpasang, Erat, and Ekon ("Park villages", situated within or near the southwestern border of the KNP). Although Akpasang and Ekon are outside the National Park, the villagers use the Park as their traditional hunting grounds (which they access by foot), so interviews here were included in the KNP category. In contrast to the Park villages, The Support Zone villages have relatively good access to roads because they are situated in and around the logging concession MPL (Mukete Plantations Limited). The hunters were interviewed with the assistance of a translator speaking the local languages, and with the help of a literate inhabitant of Akpasang in the southern villages. We excluded interviews in which responses raised doubts about their reliability. The questionnaire consisted of two parts, the first was concerned with general observations on wildlife and hunting habits, and the second specifically about the drill. Every hunter was asked the same questions. In some cases hunters could not respond to some questions. Those questions remained unanswered, which explains the variations in sample size later in the results section.

In addition to these structured interviews, an informal discussion was held where the hunters were asked about their daily lives and about their wildlife management ideas. Furthermore, in the village Akak, a closed mailbox together with 100 freely available forms was fixed on a chain. This was seen as a possible first step to collect ideas of hunters and to commence a discussion about community-based wildlife management. The methodology was introduced to the community by an eminently respected agricultural advisor and supporter of the Korup Project. A meeting was held at the beginning of the survey period and thereafter every second week to explain the box's function. This anonymous way to obtain information was considered to be helpful in obtaining first-hand information from hunters which would otherwise avoid participation in questionnaires. This method helped to estimate the off-take of wildlife, judge the possibility of including hunters in a participatory wildlife management approach, and create a sense of community wildlife management. Seven hunters of the village, whose identity was kept anonymous, completed forms on their hunting success and ideas of wildlife management over 25 days in May 2000, each hunter using one form for each hunting excursion. Twenty-eight forms were found after 25 days.

Forest reconnaissance (recce) walks are a method to gather indices of abundance of mammal species and human activities. Recce walks are usually conducted along existing trails. They serve to cover very large areas in a shorter time period than possible using permanent transects, and to reduce the impact on vegetation. Recce walks cannot be used to calculate population density, and as they often follow animal or human trails, which avoid certain vegetation types and preferentially select others, they are not necessarily representative of the study area as a whole. The advantages are that observers are not slowed down by the need to cut a straight transect and will therefore be able to cover 10–15 km per day (compared to perhaps 2–5 km on transects). Since already existing trails are used, the construction of new trails or transects, which could increase access of poachers after the passage of researchers, is avoided.

A total of 152 km were walked during 9 days, comprising 3 days in the area between Abat, Bakogo and Arsibong, including a hilly area with an elevation up to approximately 700 m a.s.l. called "Nkwende Hills"; and 6 days in the southern part of KNP between the villages Erat and Ekon.

Results and Discussion

Traditional Hunting Rights, Regulations and Preferences

Although most hunters mentioned that the village has traditional hunting grounds, there were seemingly no restrictions, taboos, or limitations in exploiting wildlife, neither traditionally nor recently. These traditional hunting grounds usually surround the villages and are partly shared with adjacent villages. After the creation of the National Park and the Forest Reserves hunting grounds lying within these areas were not considered as legal hunting grounds any more. Hunting was not restricted to given localities, seasons, animal species, or persons. The only regulations cited by some hunters concerned hunter safety (see below). The protection of certain endangered species such as drill or chimpanzee *Pan troglotytes,* by law, was found to be still unrecognised in most villages. It was a tradition that meat from large animals such as elephants *Loxodonta africana* and buffaloes *Syncerus caffer* are shared both within the village and with neighboring villages. All larger mammals and birds are hunted; small animals were not hunted, as they were not worth wasting a cartridge. Grey parrots *Psittacus erithacus* may have the minimum body size of hunted animals, as their price was just above that of the cartridge (US$ 0.67).

Foreign Hunters and Commercial Trade

Hunters from both locations of the KSZ, as well as from the southeastern part of the KNP, mentioned the presence of strangers (non-community members) and that hunters not residing in the respective village (strangers) were free to hunt. However, while only 23% of the hunters (n=22) in the KSZ mentioned hunting by strangers (and none of them stated the presence of Nigerian hunters), 96% of the interviewed hunters in the KNP (n=24) reported that Nigerian hunters were regularly hunting in the area. Only one hunter (n=21) in the KSZ mentioned that the presence of strangers represents a problem for them, while six (n=25) did in the KNP. The most frequently mentioned concern regarding strangers had to do with safety (*e.g.* a stranger could disappear after hurting someone in a hunting accident). There are regulations that are established to assure the village profits from non-local hunters. These regulations also include measures by which foreign hunters can be successfully kept apart from village hunting grounds, thus reducing competition. Hunters from outside the community have to follow the following procedures: (1) they must be introduced to the village and, (2) they have to pay for the village "permit", or at least share any meat they get. The villages on the southwestern end of the KNP prefer to hunt and to sell the meat across the Nigerian border. The existence of organised commercial hunting with intensive hunting by non-locals (Gadsby & Jenkins, 1998) could not be confirmed.

Every interviewee hunted for money as well as for subsistence (table 1). The meat was sold both inside and outside the village. In the KNP, all interviewed hunters believed that the decline in wildlife would lead to poverty, whilst in the KSZ 74% believed so. The reason for this difference is that the villages in the KSZ are connected with roads, and therefore have better opportunities to sell agricultural products. In KNP, hunting was the only source of income for 76% of the hunters (n=25), whereas, only 43% (n=23) were wholly dependent on hunting in the KSZ. In the KSZ, 35% of respondents (n=23) saw declining wildlife numbers as an incentive for greater crop production, and as resulting in less crop destruction (30%), this was not the case in the KNP [4% and 0%, respectively (n=25)] (table 1).

Hunting provided an average of 63% (±37.5%) of the household income in the KSZ, but ranged from 2% to 100%. The mean amount of money earned by hunting per family member per month in the KNP ranged from US$ 3.3 to 16.7 , averaging US$ 10.6 (US$ ±3.3).

Of 47 hunters, 36 noticed a declining monkey population. Of the remainder, most were from Ekon where nine of the 10 hunters had not noticed a decline in the monkey population over the past decade.

Of 44 hunters, 26 mentioned that drills were also kept as pets, while 12 mentioned chimpanzees in this context. Usually the drill or chimpanzee orphans are kept at the hunter's home until they can be sold or they die.

Hunting the Drill

Dogs were used extensively to hunt animals in the study area. All but one hunter (97%, n=42) used dogs when hunting drills, and dogs were also used to hunt cane rat (21), porcupine (16), antelope *Tragelaphus spp*. (11), and mongoose (11). Having forced a drill group into trees, the preferred target is

Table 1. Commercialisation of the bushmeat trade and effects of decreasing wildlife in villages in southwestern Korup National Park (KNP) and Korup Support Zone (KSZ).

	Total responses	Total yes	yes %	Total responses	KSZ yes	yes %	Total responses	KNP yes	yes %
Are foreign hunters free to hunt around the village?									
Strangers	46	28	61	22	5	23	24	23	96
Nigerians	45	23	51	21	0	0	24	23	96
Commercial hunters	48	16	33	23	5	22	25	11	44
Are they a problem?	46	7	15	21	1	5	25	6	24
Subsistence or commercial hunting?									
Hunt for food	48	43	90	23	18	78	25	25	100
Hunt for money	47	47	100	22	22	100	25	25	100
Meat sold in the village	44	41	93	19	16	84	25	25	100
Meat sold outside the village	42	42	100	17	17	100	25	25	100
Only income	48	29	60	23	10	43	25	19	76
Effects of decreasing wildlife?									
No effect	48	2[x]	4	23	2	9	25	0	0
Poverty	48	42	88	23	17	74	25	25	100
Poorer diet	48	38	79	23	18	78	25	20	80
Less crop destruction	48	8	17	23	7	30	25	1	4
No response	48	0	0	23	0	0	25	0	0
More crop production	48	8	17	23	8	35	25	0	0

[x] these two hunters mentioned that they own a farm now, but only hunting enabled them to afford a farm.

always the largest male of the group because it represents a danger to hunter and dog, and because it is twice as valuable on the market than a female due to its larger body size. Hunters noted that drills live in groups of up to 25 animals with one adult male, several females and their young, but six hunters reported the existence of "super-groups" containing up to 200 individuals. The single, large, dominant male plays an important role for the social structure of groups. Its removal will likely lead to fights for a new group hierarchy, including infanticide.

Of 45 hunters, 43 stated that it is not easy to kill the dominant male without dogs, but it is easy with dogs (39 hunters). The use of dogs offers several advantages: (1) Drills spend most of the day on the ground and are not able to jump from one tree to another or to flee quickly through the forest canopy. With the use of dogs the hunters are able to fix the whole group of drills in a tree and shoot all or as many for which they have cartridges. (2) The hunter is able to select the immobilised animals and take the heaviest first. (3) Using dogs allows the drill to be easily hunted during the dry season because the hunters need not avoid the noise of the dry leaves on the forest floor. Like other mammals, and independently from the seasons, drills can also be trapped in snares.

Hunters unanimously agreed that it is extremely difficult to obtain drills without using dogs. Asked how many drills they can shoot with the help of dogs, 32 hunters mentioned a number between 2 and 25, with a mean of 7.2 animals being taken per encounter.

Estimates of the number of drills taken per village in recent years ranged from one to 21, averaging 7.6. But this number could be a severe under-estimate because individual respondents did not know about the activities and success of other hunters in the village; the given number probably represented an individual hunter's success over the last year.

According to hunter interviews, the drill was once distributed throughout the KPA, but all but two hunters (96%) believed its numbers were declining. The hunters reported a substantial decrease in encounters between 1990 and 1995. In villages in the southwestern part of the KNP, drills were reported to be still damaging crops, suggesting that the local population was higher than elsewhere. Villagers of the northern KSZ, on the other hand, mentioned that the drill was a crop pest in the past only.

Of the 46 hunters who reported declines in drill populations, 50% attributed the decline to over-hunting. Of the 15 reasons cited for this decline (table 2), only three answers (of 66 answers in total) were unrelated to hunting (two times timber exploitation and once lack of fruits). Of 47 hunters, 30 (64%) reported changes in their hunting behavior because of declines in wildlife populations (table 3). Of those who changed their hunting habits, 19 (63%) had intensified their hunting activities, while the remainder reduced their hunting, mostly due to spending more time farming. Alternatives to intensified hunting were only practiced in villages with good road infrastructure outside of the National Park (KSZ).

The mean price for an adult male drill was US$ 15.00 (±4.65) but ranged from US$ 8.30 to 33.30. There was a highly significant positive correlation between the prices obtained for a drill and the size of the village, expressed as number of inhabitants (Pearson

Table 2. Reasons given by 46 hunters in KSZ and KNP for the declining drill population, over the last 5 years. Hunters were allowed to cite more than one cause (hence, total 66).

Reason for the declining drill encounter rates	Number responses given
Too much hunting	23
Use dogs	18
Too many hunters	9
Trapping	4
Timber exploitation	2
Insufficient fruits in the forest	1
Inefficient dog	1
Hunted out close to the village	1
Drills are too far away now	1
Moved into far hills because of hunting	1
Drills move around	1
Drills are clever now	1
Hunter had no access to national park	1
The terrain is too vast and hilly	1
The forest too small and mostly swampy	1
Total	66

Table 3. Response of 47 hunters in KSZ and KNP to the decreasing wildlife, particularly drills.

Hunters response to decreased abundance of wildlife	# of responses given
Unchanged behavior	17
Hunting different animals	11
Reduced hunting	6
More agricultural production, fishing and trading	5
Spend more time, intensified hunting	3
Travel longer distances	2
Follow them* to their roost tree and attack next morning	1
Looking for a good dog	1
Use traps, because it is very hard to see them	1

Product Moment correlation coefficient $R=0.703$, $p<0.001$), and a significant correlation between the drill price and accessibility of the village expressed as ranked road infrastructure (accessible by paved or unpaved road, or footpath, Spearman Rank correlation coefficient $R=0.428$, $p<0.01$). This suggests that the price is principally determined by the access to urban markets. Road infrastructure enhances access to markets, which in turn, enhances the price and increases overall hunting pressure in the whole study area.

Results from Forms in the Anonymous Mailbox

During the 25 days of study, 123 animals of at least 11 different species were taken (see table 4). Primates accounted for 12% of the species harvested. The good participation of hunters in this exercise further suggests that they were aware of the problem of decreasing wildlife, and that anonymous "interviews" could play a role also in community-based wildlife management.

Recce Walks

Despite spending 9 days and walking approximately 52 km through suitable habitat in the northern part of KSZ (Nkwende Hills) and southern part of KNP, no sightings were made of drills. On one occasion, drill vocalisations were heard, and on three occasions, observers detected signs of a foraging drill group (broken termite mounds, and overturned dead wood and leaves). This suggests that the drill is very rare and/or very shy, because of a long history of hunting. The almost complete lack of observations of drills during bio-monitoring in the northern KSZ (Waltert *et al.*, 2002), and the difficulties of detecting them explains why the use of hunting dogs is now the only way to kill these animals regularly in these areas. A recently instigated monitoring program inside KNP, however, suggests that while drills and Preuss' red colobus have decreased over much of KPA, encounter rates have remained stable and even increased inside KNP (Okon & Dunn, in prep.), a result which should encourage the management of the National Park to maintain their efforts to protect this area. However, since the size of KNP is relatively small and we do not have any significant biological data, *e.g.* on seasonal movements of drills and other large mammals, between the Park and the surrounding Support Zone, we see a strong need for further conservation measures.

Conclusions

Community-based Wildlife Management

There is a strong need to enforce poaching control inside

Table 4. Hunting success of 28 hunts by seven hunters within 24 day-period at Akak in Korup Project Area, SW Cameroon.

Species	Number	Percentage
Porcupine	55	46
Blue duiker	25	20
Monkey	15	12
Ogilby´s duiker	10	8
Pangolin	4	3
Cane rat	4	3
Water chevrotain	3	2
Mongoose	3	2
Python	2	2
Tortoise	1	1
Nile crocodile	1	1

the KNP. However, even the best protection of wildlife inside the park might not be sufficient to maintain viable populations of threatened species such as drill and red colobus, given the small size and unfavorable geometry for conservation of KNP. Indeed, Terborgh (1999) described the National Park as a long, narrow slice of land, impossible to protect. Although we do not share this view completely, we must emphasize that viable populations of large animals in the Korup Region can only be secured by a combination of effective protection of the National Park, in combination with the protected area system and village areas around it. Threatened species are protected by the Wildlife Law of Cameroon (Infield, 1988; Gadsby, 1990, Bowen-Jones, 1998; Rose, 1998; Hofmann *et al*, 1999; Steiner 2001), yet hunting and bushmeat trading in the villages studied are practiced in an almost unregulated way. There is a lack of sufficient personnel to control the bushmeat trade in this area, and greater commitment by the authorities is needed. But increased enforcement alone will not be a successful strategy for conservation. An additional approach to preventing illegal hunting activities is needed.

- First, we advocate a stronger commitment of conservation organisations involved in natural resource management to the aims of wildlife conservation. In the last 10 years, many conservation organisations have come to realise that hunting is the major threat to wildlife across the tropics (Bennett *et al.*, 2002). There are still, however, local and regionally active NGOs that are only starting to acknowledge that wildlife conservation has to be a major component within small-scale development projects. Too often, the major focus was on land use planning and sustainable harvest of non-timber forest products.
- Second, a community-based strategy for wildlife conservation and management has to be found. It will be necessary to co-operate more effectively with those village institutions whose traditional leaders and members of the younger generation see the need for good wildlife management. There is strong interest among many villagers to be better informed about the official hunting regulations and the possibilities to manage wildlife for future generations. Activities should include awareness campaigns that consider the existing cultural values and traditional beliefs of the local communities (Colding & Folke, 2001; Infield, 2001). A complete ban on hunting of threatened species, such as drill, red colobus, and chimpanzee, especially in areas adjacent to the Park, should be the main objective of all efforts. The hunting of drills with dogs should be a matter for discussion. Since, in some villages, only a few hunters depend on commercial hunting, special solutions for those few should be sought in strong collaboration with the village councils.

If a hunting ban can be achieved for threatened species, we have to commit ourselves to find a wise way of managing species that are productive enough to allow certain levels of harvesting. Of course, this is difficult to achieve given the low reproductive rates of many of the hunted species and the often high human population pressure. Even in theory it is yet unclear how forest wildlife can be harvested sustainably (Bennet *et al.*, 2002; Rowcliffe, 2002). However, there are forest edge species that are both favoured by local people and more productive than forest-interior species (Barnes, 2002).

More research is needed in order to understand the links between local protein consumption, the economic situation of individuals, and conservation objectives (Rowcliffe, 2002). It is clear that all Congo Basin countries have to find solutions at higher organisational levels in order to fulfill the protein requirements of their people (Fa *et al.*, 2003). The management of wildlife around protected areas should be treated as a special case and the conservation of populations of threatened species in these areas should be of higher importance than the country-wide economics of the bushmeat trade (Wilkie, 2003). As Milner-Gulland *et al.* (2003) point out, conservation efforts must be placed in a landscape context, so that hunted and no-take areas balance conservation with continued subsistence use, fitting also into a wider economic and institutional context. It seems that an overall strategy of poverty alleviation or economic development will likely increase the pressure on wildlife in the mid-term—instead of lowering it (Robinson & Bennett, 2002). As such wildlife management around protected areas should be buffered against the effects of country-wide economic development (Robinson & Bennett, 2002).

Roads, Logging, and Agricultural Encroachment

Logging companies and palm-oil producers have constructed and maintained roads going to remote areas of the KPA. These roads enable villagers to sell bushmeat and agricultural products more easily, and for a better price, and to buy industrial goods from the larger towns. These factors also facilitate increases in human population density, and thus increase bushmeat consumption and bushmeat price.

The communities in the villages use a wide spectrum of forest animal species. As long as they are dependent on the utilisation of wildlife, villagers will have an interest in preserving it. It was always part of the management strategy within Korup's Support Zone to enable villagers to manage resources on which they depend. Extirpation of species is not in the hunter's interest, as his livelihood is dependent on a functioning ecosystem around his village. It is necessary that projects use this fact for awareness creation. However, the situation could quickly change as soon as remote villages are able to commercialise agricultural products. Agricultural areas will be expanded if agriculture is profitable. Increased agriculture will, however, come at a cost to communities (as well as wildlife) if the forested areas, and their animals, medicinal plants, and clean water are destroyed, and their substitutes need to be purchased. Human population growth increases competition for wildlife. According to the interviews, there are many more hunters today than in the past, and 20% of the hunters interviewed mentioned the number of hunters as a cause of decreasing wildlife.

Outlook

At the local level, the only way to the reach the goals of conservation and sustainable harvest of wildlife is for villagers to participate in setting up management systems and to accept the regulations. Outside protected areas, only traditional village institutions can presently enforce wildlife regulations. The interviews, as well as the anonymous mailbox ("Akak-Box"), indicate the villagers' awareness of decreasing wildlife resources, and their potential participation in management. Some hunters mentioned the need for regulations. The possibility for subsistence hunting and gathering in the KSZ should be given more attention.

Recently, with the help of the Centre for Nature Conservation at Göttingen University, several Cameroonian students have founded an NGO called "African Nature e.V.". They acquired funds to raise environmental awareness in KSZ villages and have set up hunting regulations together with the traditional councils of six villages near and inside the Park. Locally, with the assistance of their partner organisation (CODEV), three eco-guards in each village were recruited from the teams of a community-based monitoring programme (Waltert *et al*. 2002). These people, who were former hunters, are backed by the traditional chiefs of their villages and serve as main actors in wildlife management activities.

Acknowledgements

We are grateful to Karin von Loebenstein, Vincent Ndangang, and Jochen Esser for supporting this study. We thank all staff of Korup, especially Mr. Njokagbo "Njock" John and Mr. Emanuel Abeto, for their assistance. Thanks to Steve Gartlan, Ilse Ackerman, Lien, Richard Noske, and an anonymous reviewer for comments on earlier versions of this manuscript. Special thanks for valuable information go to Mr. Roland Wolf, drill-keeper at the Zoo Hannover.

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DISTRIBUTION AND ABUNDANCE OF THE ROLOWAY MONKEY *CERCOPITHECUS DIANA ROLOWAY* AND OTHER PRIMATE SPECIES IN GHANA

Abstract: *The Critically Endangered Roloway monkey* Cercopithecus diana roloway *is found in Ghana and eastern Cote d'Ivoire. Primate surveys were conducted to assess the distribution and abundance of Roloway monkeys and other primate species in Ghana. Roloway monkeys were present in four of the nine forest areas visited, were encountered at the rate of 0.04 groups/km surveyed, and averaged 1.53 groups/km². These figures are far lower than those for most other species of primate in these forests.*

Résumé: *Le singe Roloway* Cercopithecus diana roloway, *en danger critique d'extinction, habite le Ghana et l'est de la Côte d'Ivoire. Des sondages ont été menés afin de déterminer la distribution et l'abondance du singe de Roloway et des autres primates au Ghana. Les singes de Roloway étaient présents dans quatre des neuf forêts qui ont été visitées, ont été vus à des taux de 0.04 groupe/km échantillonné, et ont montré des densités moyennes de 1.53 groupes/km². Ces densités sont parmi les plus faibles que celles obtenues pour la plupart des autres espèces de ces forêts.*

Introduction

The Roloway monkey *Cercopithecus diana roloway* is considered a subspecies of the Diana monkey *C. d. diana* (Grubb *et al.,* 2003) though its taxonomy is still unresolved (Groves, 2001; Butynski, 2002; figure 1). Roloway monkeys occur from the Sassandra River in eastern Cote d'Ivoire to south-western Ghana (Oates, 1988). This subspecies is distinguished by a broad white brow line, cream-coloured inner thighs, narrow face-mask, and long white beard, all of which are absent or less pronounced in the Diana monkey (Kingdon, 1997; Curtin, 2002).

Members of the Diana group are arboreal and found primarily in mature undisturbed forest (Booth, 1956), but also occur in secondary forest (Davies, 1987; Fimbel, 1994) as well as farmland (Jeffrey, 1974). Roloway monkeys at Bia National Park are frugivore-insectivores with a marked preference for seeds (Curtin, 2002). One study group had a 189 ha home range (Curtin, unpubl. data). Diana and Roloway monkeys both associate with other *Cercopithecus* spp. (Whitesides, 1989; Curtin, unpubl.) and with *Colobus* spp. (Olson & Curtin, 1984; Oates & Whitesides, 1990; Holenweg *et al.*, 1996; Wachter *et al.*, 1997).

Eight diurnal forest primates occur in Ghana, including two endemic species, the Critically Endangered white-naped mangabey *Cercocebus atys lunulatus,* and the Vulnerable western black-and-white colobus *Colobus vellerosus*. Miss Waldron's red colobus *Procolobus badius waldroni* is also known for this area though it may now be extinct (Oates *et al.*, 2000).

Over 40 years ago, Booth (1956) recognized *Cercopithecus diana* as the rarest monkey in the Gold Coast (now Ghana). Roloway monkeys are listed as Critically Endangered based on the estimation that populations have declined by at least 80% in the last 10 years (or three generations; Hilton-Taylor, 2000). Recently, this subspecies was listed as one of the 25 most endangered primates in the world (Konstant *et. al*, 2002). Recent surveys document the decline or absence of Roloway monkeys in parks where they once occurred (Oates *et al.*, 1997; Abedi-Lartey & Amponsah, 1999). In the 1990s, Oates *et al.* (1997) encountered Roloway monkeys in Bia and Ankasa Forests at one quarter the frequency reported in the 1970s. They failed to confirm Roloway monkeys in Bia where they were considered abundant in 1978 (Asibey, 1978).

Few studies have been undertaken to fully assess the geographic range of Roloway monkeys and other primates in Ghana, and none since 1996 (Oates *et al.*, 1997). Current information on the distribution and abundance of the Roloway monkey is essential to the conservation of

Figure 1. Roloway monkey Cercopithecus diana roloway, *at the Heidelberg Zoo, Heidelberg Germany, 2001. Photographs by Lindsay Magnuson.*

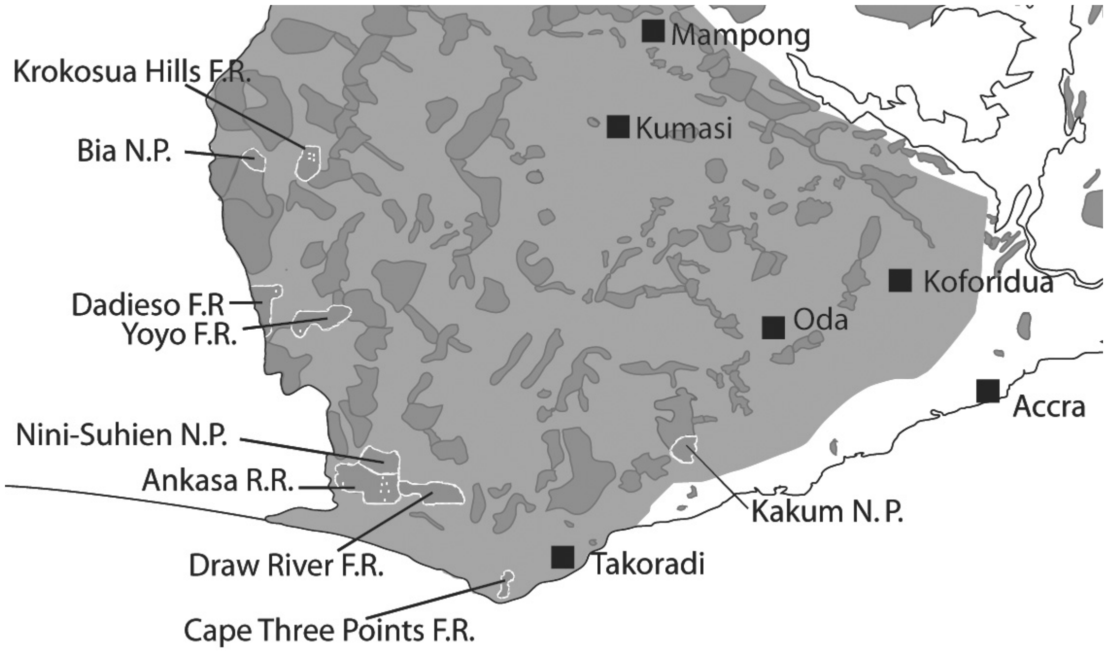

Figure 2. High Forest Zone of Ghana (shaded areas) and study sites surveyed for primates (outlined in white). Roloway monkey Cercopithecus diana roloway *group detections indicated by white dots. The abbreviations are as follows: N.P., National Park; F.R., Forest Reserve; R.R., Resource Reserve.*

this subspecies. The purpose of this study was to gather detailed information regarding the distribution and abundance of Roloway monkeys, including densities, encounter rates, and patterns of polyspecific association.

Study Area

Primate surveys were conducted from July to December 2001 throughout Ghana's high forest zone (figure 2). Ghana's forests lie in the Upper Guinean Forest region that stretches from south-eastern Guinea and eastern Sierra Leone through Liberia, Cote d'Ivoire, Ghana and into Togo. This area is considered a biodiversity "hotspot" based on the number of endemic species, loss of habitat, and the degree of threat from human impact in the area (Conservation International, 2002). All forest areas surveyed were heavily hunted and poached for resources such as wood, building materials and food (pers. obs.). Five forests were being logged for either commercial or agricultural purposes at the time of this study (table 1).

Methods

Information on local primate distribution, including Roloway monkeys, was obtained by conducting 78 interviews with local hunters ($n = 12$), farmers ($n = 50$) and Wildlife Division staff ($n = 16$). Interviews were based on a questionnaire asking age, occupation, hunting experience, and observations of primates and other animals in the forest. Most interviews were conducted with men ($n = 68$) and all interviewees were between the ages of 25 and 50. Interview data were combined with prior survey results (Oates *et al.*, 1997; Abedi-Lartey & Amponsah, 1999) and used to construct the most productive sampling routes.

Two kinds of primate surveys were conducted to determine presence, abundance and density of primate species. Ninety-eight kilometres (123.9 h) of transect were surveyed to estimate primate group densities in the Ankasa Resource Reserve and Krokosua Hills Forest Reserve (nine transects totalling 19.5 km). These areas contained the largest remaining populations of Roloway monkeys (Oates *et al.*, 1997; Oates *et al.*, 2000). Ninety-three kilometres (185.4 h) of additional trails were surveyed (in all nine forest-areas) to compute the number of primate groups encountered/km surveyed (Brockelman & Ali, 1987).

Existing trails were used for surveys when human traffic was light (*i.e.*, no evidence of recent hunting). Where existing trails were inadequate, new trails were established using low profile marking techniques such as slashing tree boles and bending branches (to discourage trail use by local hunters). Survey methodologies were identical for all surveys except transect lines were walked five times whereas non-transect surveys did not necessarily use the same trail more than once. One kilometre of transect was cut for every 33 km^2 of forest area and 1 h of additional survey time was conducted for every 10 km^2 of forest area. All surveys were separated by a minimum of 48 h.

Table 1. Survey days and description of forest condition and human use pressure at study sites in Ghana [forest type from Hall & Swaine (1981); some information from Hawthorne & Abu-Juam (1995)]. See figure 2 for site locations.

Site[1], Size and forest type[*]	Survey fays	Index[2]	Description
Ankasa RR, (343 km^2) Wet Evergreen (WE)	41	1	Relatively intact structurally, with little hunting. No recent logging. Reserve divided by wide power line track and new road. Old secondary and some mature forest.
Bia NP, (78 km^2) Moist Semi-Deciduous (MSD)	6	2–3	Intact Biosphere Reserve[3] with adjoining Resource Reserve (175 km^2, relatively degraded). Hunting moderate to heavy. Mature forest.
Cape 3 Points FR[*], (20 km^2) Moist Evergreen (ME)	4	4	Long-term logging, hunting, and illegal farming activities have degraded this Forest Reserve. Secondary forest. Mangrove system also heavily hunted for primates and all other fauna.
Dadieso FR[*], (165 km^2) ME	8	3–4	Structurally pristine Forest Reserve. Severe levels of illegal hunting and use of forest seriously threaten local fauna. Hunters from neighbouring Cote d'Ivoire may be a problem. Mature forest.
Draw River FR[*], (100 km^2) (surveyed) WE	2	3	Heavily logged and hunted Forest Reserve adjoining Ankasa Resource Reserve. Some small tracts of pristine forest remain but the area is currently being logged. Mostly secondary and old secondary forest.
Kakum NP, (14 km^2) (surveyed) Dry Semi-Deciduous (DSD)	3	2–3	Southern reserve heavily logged with only a very small tract of intact forest remaining. Hunting pressure moderate to heavy. National Park is mature forest with adjoining secondary forest areas.
Krokosua Hills FR (North)[*], (295 km^2) MSD	37	4	Very heavily hunted and logged with illegal farms and poaching inside Reserve. Small tracts of pristine forest remain but most is old secondary and secondary forest.
Nini-Suhien NP, (166 km^2) WE	7	3	Structurally pristine forest adjoining Ankasa Resource Reserve. Hunting pressure has reduced faunal populations dramatically in recent years.
Yoyo FR[*], (235 km^2) ME	4	1–2	Not logged before 2001 when most of the area was slated to be selectively logged in coming years. Hunting pressure is mild to moderate.

[1] FR: Forest Reserve—managed for production of timber, NP: National Park—managed for sustainable populations of significant species, RR: Resource Reserve—managed for sustainable populations of significant species and, development of economic activities such as tourism, logging and collection of non-timber forest products (Wildlife Division, 2001).
* Denotes GSBA: Globally Significant Biological Area—recent program that protects reserves or portions of reserves from all logging. Wildlife protection varies by site.
[2] Index of human disturbance was based on total observations of human activity during surveys: 1, little disturbance (<5 traps or shotgun cartridges found, no obvious trails); 2, moderate disturbance (5–10 traps or cartridges, few observed trails); 3, heavy disturbance (11–15 traps or cartridges, several trails); 4, very heavy disturbance (>15 traps or cartridges, numerous trails).
[3] Biosphere Reserve—International program in which forest area is protected from poaching and logging practice. Theoretically allows no human use or disturbance.

To reduce bias associated with habitat use, ranging patterns, or direction travelled by observers, the direction of travel, and the time of day (*i.e.*, morning or evening) were alternated on sequential surveys (Whitesides *et al.*, 1988). Any survey with 15 minutes of continuous rain was cancelled. All surveys began 10 minutes before sunrise and, in the afternoon, ended no later than 10 minutes after sunset. Primate observations during midday (10:30–14:30 h) were not included in statistical analyses as primate activity was much reduced during this time.

Data recorded for each primate observation included: date, time, weather, species and location (Magnuson, 2002). A primate group was defined as one or more individuals separated by 50 m or more from the nearest neighbouring conspecific (Whitesides *et al.*, 1988).

Density estimates were calculated using the program DISTANCE (Thomas *et al.*, 1998). This is based on the equation: $N=nA/a$, where N is the total number of animals in the census area, n is the number of animals recorded, A is the total census area, and a is the sample area calculated from the length and width of the transect (National Research Council, 1981). Transect width is two times the effective strip width (30.25 m for Roloway monkeys), which is estimated by examining the distribution of perpendicular distances between the transect and first animal detected (Emlen, 1971; Whitesides *et al.*, 1988). Encounter rate is the number of primate detections divided by the total number of kilometres surveyed.

Results

Roloway monkeys were detected in four of the nine forests visited ($n=18$, figure 2) and observations did not vary significantly by time of day ($X^2=0.58$, $df=1$, $P>0.05$). Roloway density was 1.53 groups/km^2 (CL= 0.75–3.01 groups/km^2), which was lower than all other species-group densities except for the white-naped mangabey (table 2). Most Roloway monkey detections were in the Ankasa Resource Reserve ($n=10$).

During non-transect surveys, Roloway monkeys were encountered at the average rate of 0.04 groups/km surveyed. The Lowe's mona monkey *Cercopithecus lowei*, lesser spot-nosed monkey *Cercopithecus petaurista*, and olive colobus *Procolobus verus*, were the most often encountered monkeys; the western black-and-white colobus was encountered as often as Roloway monkeys (table 2). Roloway monkeys were detected in association with Lowe's mona monkeys more often than with any other species ($n=9$). They were also often detected travelling alone ($n=6$) or in association with lesser spot-nosed monkeys ($n=4$).

Discussion

Primates in the study area are not habituated to humans and are heavily hunted (Oates *et al.*, 2000; pers. obs.). This influenced primate detections negatively as monkeys rarely vocalized and fled quickly. Roloway monkeys are a vocal species and generally call in the morning, evening, and after any disturbance (Curtin, pers. comm.; Kingdon, 1997). Only once during this study did Roloway monkeys alarm call (after disturbance), and rarely did they call in the morning or evening (except at Ankasa Resource Reserve where they often vocalized in the evening in association with Lowe's and lesser spot-nosed monkeys).

Roloway monkeys were detected in only four forests. They are likely extirpated from Bia National Park, Cape Three Points Forest Reserve, Draw River Forest Reserve, and probably Nini-Suhien National Park (Magnuson, 2002). In October 2001, hunters reported that Roloway monkey groups were often observed near the border of the Nini-Suhien National Park (in Ankasa) but indicated that severe hunting pressure in Nini-Suhien restricted their movement into this Park. In August and September 2001, Wildlife Division staff reported two Roloway monkeys at Kakum National Park, and an infant in 1999 in eastern Kakum. This study and previous research (Oates *et al.*, 1997) failed to confirm these

Table 2. Primate groups detected in Ghana.

Primate species detected	Total detections[1]	Transect surveys			Non-transect surveys		
		No. groups	Groups/ km^2	ESW[2] (m)	No. groups	Groups/km	Range[3] (groups/km)
Roloway	18	9	1.5	30.3	5	0.04	0–0.15
Lowe's mona	96	41	13.0	16.2	37	0.39	0–0.85
Lesser spot-nosed	30	12	7.3	8.5	10	0.11	0–0.77
Olive colobus	13	9	2.8	14.7	3	0.03	0–1
Western black-and-white colobus	9	6	4.9	6.3	3	0.03	0–0.12
White-naped mangabey	3	1	0.3	20.0	2	0.02	0–0.08
Unknown species	27	8	2.7	13.4	18	0.14	0–0.59
All species	195	86	24.3	12.9	78	1.05	0–2.24

[1] Includes detections made during transect surveys, non-transect surveys, and non-survey observation (*i.e.*, sub-optimal time of day or weather conditions).
[2] ESW: The Effective Strip Width (detection distance) of the transect for each species.
[3] The range of encounter rates observed between the nine forest areas visited.

reports. Based on interviews with hunters and prior survey results (Oates *et. al,* 2000) it is possible that Roloway monkeys still exist in several areas not visited during this study, including the Boin River, Boi Tano, Sui River, and Bia Tributaries North Forest Reserves, as well as the Amansure mangroves. Thus, there are nine possible sites for Roloway monkey populations in Ghana encompassing roughly 1,500 km^2 of suitable habitat for this species.

This survey found densities of 1.53 Roloway monkey groups/km^2 in Ghana. This is less than the 2.2–5.1 groups/km^2 for the Diana monkey in Tiwai Forest, Sierra Leone (Whitesides, 1991), and 3.5 Diana monkey groups/km^2 at Taï National Park, Cote d'Ivoire (Holenweg *et al.*, 1996). There may be differences in the grouping behaviours or mean group size of Diana and Roloway monkeys, accounting for this difference in density estimates. Taï National Park is far better protected from human disturbance than any forests visited in Ghana during this study. Transects for Ankasa and Krokosua were cut in areas most likely to harbour Roloway groups. Therefore, estimates of Roloway group density from this study were likely inflated and should not be extrapolated to other forest habitats in Ghana.

Overall, Roloway monkeys were encountered at the average rate of 0.04 groups/km surveyed during this survey (table 2). Oates *et al.* (1997) found 0.04 Roloway groups/km in the Ankasa Resource Reserve. I found 0.03 groups/km in Ankasa. The average encounter rate for groups of all species of primates was 1.05 groups/km surveyed. This falls within the range of previously reported encounter rates (Oates *et al.*, 1997; Oates *et al.*, 2000).

Based on rates of encounter, this study confirmed that Lowe's, lesser spot-nosed, and olive colobus monkeys are the most common primates, and that the Roloway, western black-and-white colobus, and the white-naped mangabey are the rarest of the eight diurnal forest primate species in Ghana. I estimate that the number of Roloway monkeys in Ghana has been reduced to less than 1,000 individuals and possibly as low as 500. In the late 1970's, Roloway monkeys were abundant in both Bia National Park and Ankasa (Asibey, 1978), and white-naped mangabeys were a common pest to farms in Bia (Rucks, 1976). Current data and recent field surveys (Oates *et al.*, 1997; Abedi-Lartey & Amponsah, 1999; Oates *et al.*, 2000) indicate that Ghana's three endemic primate species have experienced a dramatic population decline over the last two decades, and are facing extirpation in this country.

Conservation Recommendations

Considering the high rate of deforestation in Ghana (Cleaver, 1992), it is important that future studies gather information on primate ranging patterns, polyspecific associations, and adaptations to hunting and habitat degradation. It is also important to focus conservation efforts on those forests most likely to support endangered species, such as the Roloway monkey.

Primate conservation in Ghana must focus on local community involvement and education, as well as implementation of conservation measures in the field. Previous attempts at community based conservation measures have enjoyed some success (Asibey, 1978; Lindsay, 1996; Ashie, pers. comm.), however, such programs must be implemented on a much larger scale throughout conservation areas to be truly successful.

It is necessary to monitor and protect the forest areas that offer the best chance of survival for the Roloway monkey and other threatened primate species. The Krokosua Hills Forest Reserve and the Ankasa Resource Reserve are of highest conservation priority for Roloway monkeys and other primates. Krokosua has the highest diversity of primates in Ghana and the greatest probability of containing a population of Miss Waldron's red colobus. Ankasa has the highest density of Roloway monkeys and is the best protected of all forests visited.

Regular primate surveys should be conducted by Wildlife Division staff to gather more information regarding distribution and status of primates both in Krokosua and Ankasa. All surveys should be presented in comprehensive reports at the reserve, regional and national levels on a regular basis (Magnuson, 2002). The Yoyo Forest Reserve has a surprisingly high primate species diversity and density. Unfortunately, the majority of this reserve was slated for selective logging in 2001. Fifty square kilometres in south-western Yoyo Forest Reserve is a Globally Significant Biological Area and will be fully protected from logging. Surveys should be conducted in Yoyo to gather information regarding the reaction of forest primates to selective logging.

All primate surveys must be combined with extensive and intensive systematic anti-poaching patrols in all protected areas. Patrols should cover a wider area including trails not specifically designated for anti-poaching efforts. I strongly recommend that patrols be conducted every day traversing old, new and poorly constructed trails in search of poaching activity around each patrol camp.

Educational programs such as CREMA (Community Resource Management Area) have great potential to encourage conservation on a local scale and should be made available to as many villages as possible near conservation areas. Education meetings should be followed by brief discussion sessions, which address the concerns and suggestions of local residents in order to encourage their participation and support in conserving Ghana's wildlife.

Acknowledgements

I am grateful for financial assistance provided by grants from the Whitley Awards Foundation, Conservation International, Primate Conservation Incorporated, and West African Primate Conservation Action. Permission and logistical support were provided by the Wildlife and Forestry Divisions of the Forestry Commission of Ghana. I gratefully acknowledge the numerous Wildlife Division officials that offered their support. Thanks to Trista Thompson, Samuel Ndah, Phillip Mensah, and John Atingah for their assistance in the field. Special thanks also to Kupambazua Furaha, and my committee members at Humboldt State University—Drs. David W. Kitchen, Mary E. Glenn, and T. Luke George—for their support throughout this endeavour.

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ZAMMARANO'S MONKEY *CERCOPITHECUS MITIS ZAMMARANOI* DE BEAUX, 1923: THE FORGOTTEN MONKEY OF SOMALIA

Abstract: *This paper reviews the presence of* Cercopithecus mitis *in Somalia. Morphological features and biogeographical considerations led to the rejection of the hypothesis that Zammarano's monkey* Cercopithecus mitis zammaranoi *of the Jubba and Shabeele Rivers is a synonym of* C. m. albotorquatus. *Zammarano's monkey is one of the most threatened primate taxa in Africa.*

Résumé: *Cet article présente un bilan de la présence de* Cercopithecus mitis *en Somalie. Les données morphologiques et des considérations biogéographiques nous amènent à rejeter l'hypothèse que le singe de Zammarano* Cercopithecus mitis zammaranoi *des rivières Jubba et Sheebeli est un synonyme de* C. m. albotorquatus. *Le singe de Zammarano est probablement un des taxons d'Afrique les plus menacés.*

Historical Overview

In 1923 (not 1924 as usually stated in the literature), the Italian zoologist Oscar de Beaux described a new subspecies of *Cercopithecus mitis* (*albogularis* group) from the forests along the Jubba and Shabeele Rivers of southern Somalia. His description was based on materials collected by Vittorio Tedesco Zammarano and deposited at the Museo Civico di Storia naturale of Milan. According to de Beaux (1923), Zammarano's monkey *Cercopithecus mitis zammaranoi* is mainly distinguished from other mitis forms by smaller size and less reddish coat. Subsequently, Schwarz (1928) put *zammaranoi* in synonymy with Pousargues's white-collared monkey *Cercopithecus mitis albotorquatus*. This latter taxon was described from a menagerie specimen known only to be from East Africa (Rode, 1938:19), but Napier (1981) accepted this as the available name for specimens from the Tana River, giving *Cercopithecus rufotinctus* Pocock, 1907 (from "Mombasa") as a synonym. So the difficult taxonomic history of Zammarano's monkey began.

Being found in Italian Somalia, with Italy maintaining 'protectorate' status over the country until 1957, it is probable that most non-Italian taxonomists overlooked *zammaranoi* due to the lack of available specimens. Strong evidence for the validity of *zammaranoi* was presented in a subsequent paper by de Beaux (1937) on the mammals collected in 1934 during the zoological expedition of Marquis Saverio Patrizi in the then southern Italian Somalia (Oltregiuba). This collection includes two specimens of *zammaranoi* from the Jubba River and (for the first time in Somalia) two specimens of a larger white-throated monkey that de Beaux identified as *C. m. albotorquatus*. The new materials permitted a close comparison of the two taxa. Two black and white photos of the skins (ventral and dorsal) clearly show the small size (see table 1) and reduced white zone of the throat of *zammaranoi* compared to *albotorquatus* (de Beaux, 1937). The two specimens of *albotorquatus* were collected in a gallery forest at Olà Uagèr, along the Bubasci River. This site is ca. 30 km from the border with Kenya in what is now referred to as the 'Holawajir Depression'. Patrizi (1935) states that this forest is isolated by 150 km of arid bushland from the Jubba riverine forest. He was aware that the monkey he killed was "...a kind well-distinct from the white-throated guenon of the Jubba for its greater size and greater white throat patch" (p. 21).

Subsequently, Dandelot (1971: 21), one of the few taxonomists to have direct experience with Somali specimens, made the following statement concerning *zammaranoi*: "A good race, smallest of all *mitis* (*sensu lato*), confined to riverine forest of southern Somalia". Rahm (1970) also recognised the validity of *zammaranoi* and presented a map that shows the geographic hiatus between *zammaranoi* and *albotorquatus*. A similar hiatus is more recently shown by Lernould (1988). Napier (1981), citing de Beaux (1923; she listed the date as 1924) and a personal communication from Dandelot, recognised *zammaranoi* as a valid subspecies, and in this she was followed by Groves (2001). Nonetheless, in the most recent overviews of the taxonomy and conservation of the *Cercopithecus mitis albogularis* subgroup, Grubb (2001), Butynski (2002) and Grubb *et al.*, (2003) did not list *zammaranoi* as a valid subspecies. Considering the important implications of taxonomic classifications to conservation efforts, it may be useful to collate and review all the bibliographic materials concerning *zammaranoi*, particularly the relevant Italian literature.

Taxonomic Status of *C. m. zammaranoi*

In Italy, known specimens of Zammarano's monkey are stored in Florence and Genoa. The type series of the Museo Civico di Storia Naturale of Milan were probably lost during World War II (Cagnolaro, 1976). A flat skin of a juvenile female from Bidi Scionde N. 1446 Paratype (de Beaux, 1923) is now in the Museo di Storia Naturale Giacomo Doria of Genoa (MSNG 17892) (G. Doria, pers. comm.).

Table 1. Skull measurements (mm) of adult males of *Cercopithecus. mitis albotorquatus* and *Cercopithecus mitis. zammaranoi* in the Museo Civico di Storia Naturale di Milano and Museo di Storia Naturale 'G. Doria' di Genova (from de Beaux, 1937).

Specimens	*albotorquatus* Genoa 32930	*albotorquatus* Genoa 32931	*zammaranoi* Genoa 32928	*zammaranoi* Milan 2575	*zammaranoi* Milan 2576
Greatest length without incisors	106	106	96	96	95
Basal length	78	80	69.5	72	
Zygomatic width	70	70	69	66	69
Nasal length	21	21	18.5	15	18.5

Apparently not aware of de Beaux's latter paper, Hill (1966) followed Schwarz (1928) and Allen (1939) in considering *zammaranoi* as a synonym of *albotorquatus*. Hill's description of *albotorquatus* (p. 417) is mainly based on *zammaranoi* on the premise, first advanced by Schwarz, that the types of *albotorquatus* and *rufotinctus* are affected by erythrism and albinism. Hill did, however, include some notes by P. Dandelot (*in litt.*) on three Zammarano's monkeys living in Paris, saying, "Rather small in size, they presented a completely olive-green back without trace of rufous tint. The white collar was smaller than in the type of *albotorquatus* and the under parts ashy grey".

Part of Zammarano's collection was previously given to the Colonial Museum in Rome but only one skin with skull inside (no locality) has been recently identified among the material of the former Colonial Museum now in the Museo Civico di Zoologia of Rome. A female and a juvenile in bad condition are conserved as mounted specimens in the private collection of Vittorio Tedesco Zammarano Jr.

I observed and compared all the skins of Somalian specimens of *C. mitis* in the Museo di Storia Naturale-Sezione di Zoologia of Florence (n=10). These are the result of several biological expeditions in Somalia between 1957 and 1970, during one of which two living Zammarano's monkeys were acquired by J. Roche and exhibited at the Jardin des Plantes in Paris (where Dandelot observed them). Specimens from southern Somalia (Olà Uagèr 1°11"S; 41°34'E) are distinguishable from those of the Jubba River by their larger size, white ventrum [but see De Beaux (1937) for one specimen with 'neutral gray' ventral area], wider extension of the white patch around the neck, and reddish back, especially near the tail. Some labels include measurements of the specimens taken in the field. Two *zammaranoi* males from Gelib (2970 and 3011) have head and body length of 390 and 435 mm, and tail length of 575 and 640 mm. Three *albotorquatus* males from Ola Uager (3514, 3521 not seen, donated to Paris Museum, and 5736) have head and body length of 620, 600 and 510 mm, and tail length of 750, 765 and 790 mm, respectively (see figure 1). All these data agree with the conclusions of de Beaux (1923) about the distinctiveness of *zammaranoi* from *albotorquatus*. A deeper systematic revision of eastern African members of the *mitis* group is, however, required to fully understand the degree of differentiation between the several described subspecies. Available evidence indicates that *C.m. zammaranoi* is a valid taxon that cannot be put in synonymy with *C.m. albotorquatus*.

Concerning Grubb's (2001) observations of skin variations, it should be noted that: 1) no *zammaranoi* observed by de Beaux or by myself (n=13) showed a red lumbar region similar to *albotorquatus* (n=5); 2) variation in the colour of the ventrum of *albotorquatus* is also reported by de Beaux (1937); 3) no red patch underneath the tail was observed in *zammaranoi*; and 4) the dimensions of the white collar were never used to discriminate *zammaranoi* from other mitis subspecies in the original description of de Beaux (1923). This character does, however, appear noteworthy when comparisons with neighbouring *albotorquatus* are made. From figure 2, a male (# 2913) mounted at the Florence Museum, it can be appreciated how inconspicuous the white collar is, explaining Dandelot's observation on living animals.

Biogeographical Aspects

Studies of the biogeography of Somalia highlight a somewhat more complicated pattern than simply a recent northward colonisation of *C. mitis* from the south, which is what is implied by synonymising *zammaranoi* with *albotorquatus*. Uncertainty about the validity of some mammal subspecies described as endemic to the riverine forests of southern Somalia (*i.e.*, Bottego's duiker *Cephalophus harvey bottegoi* de Beaux, 1924) does not allow for solid conclusions to be made based on a comparative biogeographical approach about the former connections between the Tana River forests and those forests along the Somali rivers. Certainly the Tana region is characterised by the presence of two primate taxa of Central Africa affinities, the Tana mangabey *Cercocebus galeritus* and the Tana red colobus *Procolobus rufomitratus*, while *C.m. albotorquatus* appears so distinctive as to lead Schwarz (1928)—who certainly had much experience with the other white-throated monkeys—to consider the type an aberrant individual. Kingdon (1971: 75) suggested that the coastal forests north of Mombasa may have suffered a longer isolation than those to the south. As far as the Somali rivers are concerned, it is puzzling that de Beaux (1923), in agreement with Neumann (1902), recognised two different forms of *Chlorocebus* in the Jubba and Shabeele regions. According to his opinion, in the upper and medium Shabeele (but not in the lower) *C. pygerrythrus hilgerti* Neumann is found, while in the lower Jubba a different local race, *C. pygerythrus* aff. *rufoviridis* Neumann, is reported. Although the taxonomy and distribution of *Chlorocebus* is out of the scope of this paper, this too seems to imply different times and routes of colonization of the riverine forest mammals of southern Somalia. It is worth mentioning that the presence of *C.m. zammaranoi* on both the Jubba River and Shabeele River is further evidence of the old origin of the taxon, as the two rivers are not nowadays physically connected nor does a forest corridor exist between them. That the Jubba and Shabeele forests cannot be considered simply an impoverished northern subset of the Tana forests is suggested by the absence in the Tana forests of some species of mammals that are present in southern Somalia (ground pangolin *Smutsia temminckii*, and, although not a riverine species, bush hyrax *Heterohyrax brucei*) (Kingdon, 1971; Agnelli *et al.*, 1990).

A Review of Distribution

The localities of origin of specimens of *zammaranoi* stored in Italian and other European museums, as well as sight records, are listed in table 2. According to Zammarano (1930), Zammarano's monkey was found along the forest of the Shebeele between Balaad and Mahaddei, and along the course of the Jubba up to 4° N (Lugh Dolo 04°10'N; 42°05'E), near the border with Ethiopia. Funaioli (1957) said that *zammaranoi* was especially common along the Jubba between Yonte and Gelib, and along the Shebeele between Afgoi and Mahaddei Uen. According to Douthwaite (1987), less than 20 km^2 of forest remained at that time along the Jubba, and less than 7 km^2 along the Shabeele. In the same years, Varty's (1988) estimate is of 10 km^2 along the Jubba. The greatest contiguous areas of forests was in the Shoonto Reserve (267 ha) and in the (less pristine) Barako Madow Reserve (140 ha) (Varty, 1988). The same author encountered Zammarano's monkey in both forests,

Figure 1. Skin of adult male Cercopithecus mitis zammaranoi *on the left (3011) compared with one* Cercopithecus mitis albotorquatus *(3514) at the Museo Zoologico "La Specola", Florence. Photo by S. Gippoliti.*

as well as in the Balcad Reserve, the only remaining sizeable forest along the Shabeele (figure 3). A detailed botanical study of the forests was conducted by Madgwick (1989,1990). The situation is now certainly worse owing to lack of political stability in the region and the reported extensive export of charcoal to Arabian countries.

Conservation Implications

The first reference to the conservation situation of Zammarano's monkey is in the second edition of the *IUCN/SSC African Primates Action Plan* (Oates, 1996). *C.m. albotorquatus*, with *zammaranoi* as a synonym, was listed as "Data Deficient" in the 2003 *Red List* (IUCN, 2003). Even considering the now chronic political instability in Somalia, the conservation status of *zammaranoi* seems to have received scant interest by the conservation community. Zammarano's monkey must today be one of the most threatened primate taxa in Africa. Assuming an average density of 1 animal/hectare within the species' range (Lawes *et al.*, in prep.), it is likely that there are nowadays no more than 200–500 Zammarano's monkeys in very small fragments of riverine forest. Accordingly, *Cercopithecus mitis zammaranoi* should be classified as a Critically Endangered taxon. This has been

Figure 2. Mounted Cercopithecus mitis zammaranoi *(2193) at the Museo Zoologico "La Specola", Florence. Photo by P. Agnelli.*

effectively accorded during a meeting of the IUCN/SSC Primate Specialist Group in January 2005.

Conservation action relies on sound taxonomy, and taxonomic changes can greatly affect the identification of taxa and geographic areas of conservation relevance (Cotterill, 2005). Therefore, I suggest that taxonomists be careful to not overlook described taxa only because there are few museum specimens. Otherwise, we risk not recognising those rare and/or restricted range taxa that are most in need of conservation action.

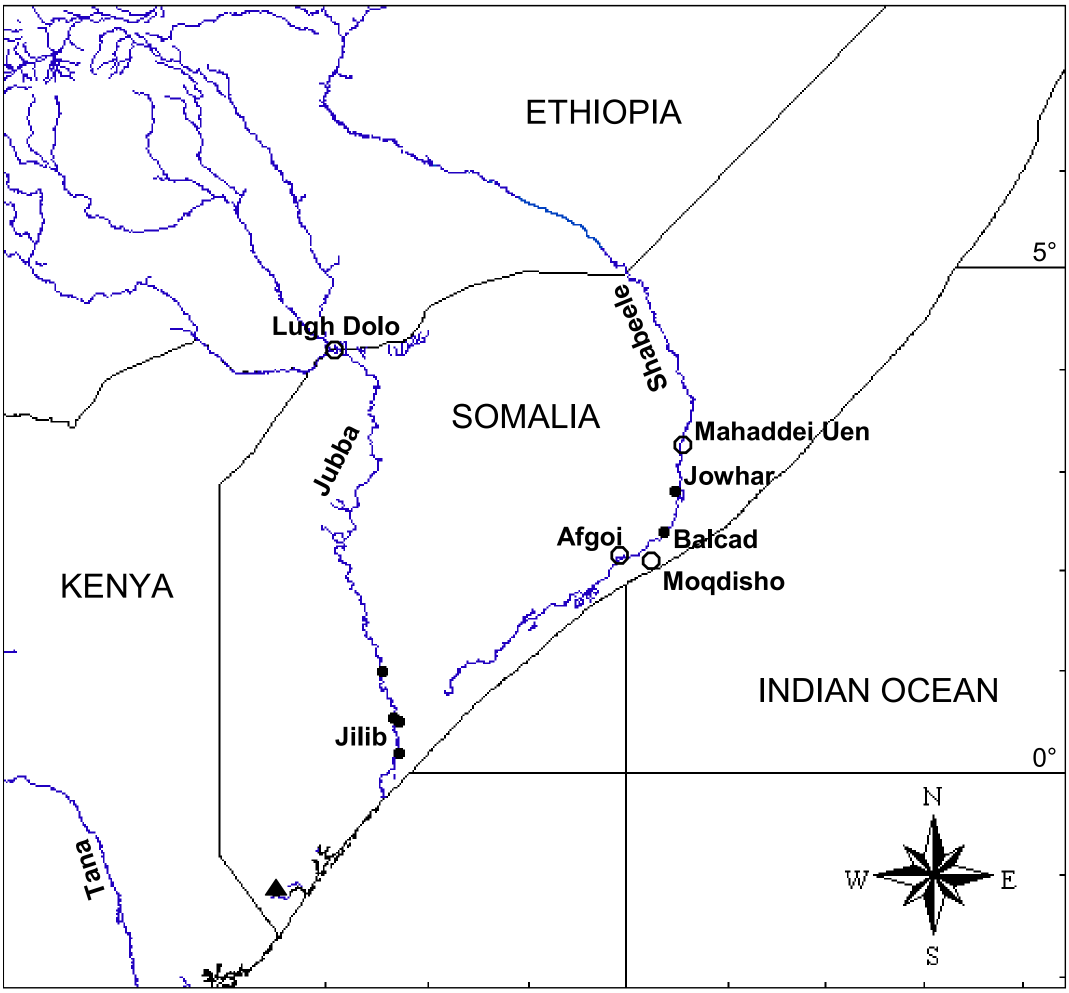

Figure 3. Known collecting localities of Cercopithecus albogularis *in Somalia: Filled circles for* zammaranoi, *filled triangle for* albotorquatus.

Table 2. Localities of *Cercopithecus mitis zammaranoi* specimens based on museum records.

Villabruzzi (Florence) = Jowhar	02°46'40"N, 45°30'20"E
Isola Alessandra - Gelib (Florence, Paris) = Jilib	00°29'30"N, 42°46'30"E
Foresta di Mobilén (Alessandra) (Genoa)	0°32'N, 42°44"E
Belet Amin - Beled Amiin (Genoa)	0°11°40"N, 42°46'30" E
Bidì Scionde (Milan) = Bidi	00°59'N, 42°37'50"E
Balad - Uebi (Milan) = Balcad	02°21'N, 45°23'30"E
Lugh Dolo = Doolow (Zammarano, 1930)	04°10'N, 42°05'E

Even considering the precarious political situation in Somalia, raising the profile of this endemic primate could further encourage the Somali people engaged in the battle against environmental degradation in the Jubba Valley, and attract the attention of the international environmental community.

Acknowledgements

I express my gratitude to all colleagues and friends who provided information about Somalia and/or Zammarano's monkey specimens in their care: P. Agnelli (Florence), R. Asher (Berlin), T. Butynski (Nairobi), A. M. Simonetta (Florence), G. Veron (Paris), and V. T. Zammarano Jr (Rome). I am indebted to P. Franchini for preparing the map. C. P. Groves (Canberra) and Cathi Lehn greatly improved the paper with their reviews.

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DECLINE OF PRIMATE POPULATIONS IN THE MBAÉRÉ-BODINGUÉ RESERVE, CENTRAL AFRICAN REPUBLIC

Abstract: *A pilot study to evaluate the possibility of habituating great apes in the Mbaéré-Bodingué Reserve in Central African Republic was conducted from November 2000 to August 2001. Overall, 1077 km of forest transects were surveyed to quantify direct (visual and auditory) and indirect (traces, nests, etc.) contacts by a team of two to three people. With the objective to evaluate the small primate (Cercopithecidae) populations in that zone, we made a population count on a 4 km long forest transect (covered 36.5 times, for a total of 146 km). We used an identical protocol to counts made in 1994 and 1998 on the same transect.*

We recorded only 13 direct contacts (four visual, nine auditory) with gorillas and nine direct contacts (one visual, eight auditory) with chimpanzees. The mean encounter rate with all four species of Cercopithecidae decreased by 28.1% relative to 1998, and 63.6% relative to 1994. Poaching evidence was noted everywhere in the study area.

The continuous decline of small monkey populations, associated with poaching evidence, suggests that this study area is facing serious hunting pressure which could explain the few encounters with great apes. The Mbaéré-Bodingué Reserve does not provide conditions for a great ape habituation project. Actions against poaching are recommended.

Resumé: *Une étude de faisabilité d'un projet d'habituation des grands singes dans la Réserve Mbaéré-Bodingué en République Centrafricaine a été réalisée du mois de Novembre 2000 au mois d'Août 2001. Au total, 1077 km de layons ont été parcourus à la recherche de contacts directs (visuels et auditifs) et indirects (traces, nids, etc) par une équipe composée de deux ou trois personnes. Parallèlement, pour évaluer l'évolution des populations de petits primates (Cercopithecidae) dans la zone, nous avons réalisé un dénombrement sur un layon de 4km (parcourus 36.5 fois, soit 146 km) en utilisant un protocole identique aux dénombrements réalisés en 1994 et 1998 sur ce même layon.*

Nous n'avons enregistré que 13 contacts directs (4 visuels, 9 auditifs) avec les gorilles et 9 contacts directs (1 visuel, 8 auditifs) avec les chimpanzés. Le taux moyen de rencontre avec les quatre espèces de Cercopithecidae observées a diminué de 28.1% par rapport à 1998 et de 63.6% par rapport à 1994. Dans toute la zone d'étude, de nombreux indices de braconnage ont été notés.

Le déclin continu des populations de petits singes associé aux indices de braconnage suggèrent que le site d'étude fait l'objet d'un forte pression de chasse qui pourrait être à l'origine du faible nombre d'observations des grands singes. La Réserve Mbaéré-Bodingué ne constitue actuellement pas un site approprié pour un projet d'habituation des grands singes et la mise en place d'actions anti-braconnage est recommandée.

Introduction

The development of great ape-based tourism has been proposed by the ECOFAC program as a means to protect and add value to the Mbaéré-Bodingué Reserve, Central African Republic (which is about to be gazetted as a national park). A census carried out from November 1998 to March 1999 found that great apes occurred in low densities: 0.40 and 0.37 weaned individuals/km^2 for gorillas *Gorilla gorilla gorilla* and chimpanzees *Pan troglodytes troglodytes*, respectively (Brugiere, Sakom & Sinassonasibe, 1999; Brugiere & Sakom, 2001). Regarding monkeys, a decrease of 49% in the encounter rate with groups was recorded between August 1994 and June 1998 (Gautier-Hion, 1994; Brugiere Sakom & Sinassonasibe, 1999). This decline was attributed to poaching. In light of these findings, a preliminary study was undertaken in the Reserve to evaluate whether the current situation was compatible with a project to habituate the great apes for viewing by tourists. The results of this study are presented here.

Study Area and Methods

The Mbaéré-Bodingué Reserve (872 km^2) is a triangular area located between the Mbaéré and Bodingué Rivers in the Ngotto Forest (03°48'–03°50'N; 16°06'–17°20'E). There are three main habitat types:

- *terra firma* forest, characterised by a richness of tree species in the Meliaceae and Sapotaceae, and a scarcity of herbaceous vegetation (in particular Marantaceae species);
- small patches of herbaceous savannah;
- flooded forest along the two main rivers.

The study site (50 km^2) was located in *terra firma* forest in the north of the Reserve. Censuses were conducted by two or three teams (comprised of one guide and one observer) during November 2000–February 2001 (dry season) and during March–August 2001 (wet season). Teams moved along 16 transects that varied in length from 3 to 6 km, and that joined to form loops that varied in length from 8 to 14 km. A total of about 1077 km were walked: 380 km during the dry season and 697 km during the wet season. Each team covered between 8 and 14 km/

day. All direct contacts (visual and auditory) and indirect contacts (print, nests, dung, food remains) with apes were recorded.

Each visual observation of monkey groups was recorded. The 4 km long C1 transect was censused in the morning 19 times during the dry season and 17.5 times during the wet season, yielding a total censused distance of 146 km. All signs of human activity were also recorded (*e.g.*, tracks, shotgun cartridges, camps, poached animals). To make the comparison valid with the results of the previous censuses conducted on that transect in 1994 and 1998, the same trackers and procedures for data collection and analysis were used.

Results

A total of nine and 13 direct contacts with chimpanzees and gorillas, respectively, were made. These yield encounter rates of 0.008/km and 0.012/km, respectively (table 1). To obtain a visual contact with groups of gorillas and with groups of chimpanzees, the observers had to walk 270 km and 1100 km, respectively. Indirect contacts occurred at the rate of 0.008/km for chimpanzees and 0.041/km for gorillas.

Table 1. Number of contacts with gorillas and chimpanzees along 1,077 km of transects in Mbaéré-Bodingué Reserve, CAR (2000 – 2001).

	Direct contacts		Indirect contacts *
	Visual	Auditory	
Pan troglodytes	1	8	8
Gorilla gorilla	4	9	44

* tracks, nests, dung, food remains

Four species of monkeys were observed: putty-nosed monkey *Cercopithecus nictitans nictitans*, crowned monkey *Cercopithecus pogonias grayi*, white-nosed moustached monkey *Cercopithecus cephus ngottoensis,* and grey-cheeked mangabey *Lophocebus albigena albigena* (table 2). During the wet season, the encounter rate of all species pooled was 0.91 groups/km for the whole site, and 0.85 groups/km for transect C1. Encounter rates decreased during the dry season to 0.85 groups/km for the whole site and 0.64 groups/km for transect C1. The encounter rate along transect C1 during this study was 28% lower than that of Brugiere, Sakom & Sinassonasibe (1999) in June 1998 (wet season) (table 2).

Much evidence of poaching was found during this study. A total of 27 gun shots were heard, and 20 poacher camps and 40 empty cartridges were found.

Discussion

Gorillas and chimpanzees might naturally occur at low population densities on the study area. Brugiere & Sakom (2001) suggest that the low abundance of herbaceous vegetation (in particular Marantaceous and Zingiberaceous species) in the *terra firma* forest of the study site could account for the low density of gorillas.

The high dietary flexibility of chimpanzees and the good representation of trees producing fleshy fruits at Ngotto (Lejoly, 1995) suggest, however, that the study site could support a moderate to high population density of this species. In spite of adequate habitat, previous censuses also found relatively low densities of gorillas and chimpanzees at this site, and a high level of poaching (Brugière & Sakom, 2001). I conclude that a high level of hunting is responsible for the low density of chimpanzees, and probably also contributes to the low density of gorillas. Based on these results, I believe that the study site is currently not suitable for a great ape tourism project.

A dramatic decline in encounter rates with monkeys occurred between 1994 and 1998 (Gautier-Hion, 1994; Brugiere, Sakom & Gautier-Hion, 1999). The further decline documented by this study confirms that over-hunting continues in the area. Actions need to be undertaken to greatly reduce the level of hunting in the Mbaere-Bodingue Reserve.

Acknowledgements

This study was funded by the European Union (DG VIII) via the ECOFAC project. I thank A. Penelon, G. Ngasse and J. Maro for permission to work in the Ngotto Forest and for logistical support. I also thank G. Yangoundjara, all the trackers and other field staff for their work. I am indebted to C. Aveling, A. Gautier-Hion, and particularly D. Brugiere for their advice and comments on the manuscript. T. Butynski and one reviewer greatly improved the manuscript.

Table 2. Groups of monkeys observed/km along transect C1 during the wet season in Mbaéré-Bodingué Reserve, CAR.

	Groups encountered/km			Change in encounter rate		
Year	1994	1998	2001	1994-1998	1998-2001	1994-2001
Km censused	75	51	146			
Cercopithecus nictitans nictitans	0.93	0.63	0.47	-32.4%	-25.4%	-49.5%
Cercopithecus pogonias grayi	0.59	0.28	0.13	-53.0%	-53.6%	-78.2%
Cercopithecus cephus ngottoensis	0.48	0.24	0.17	-50.8%	-27.5%	-64.4%
Lophocebus albigena albigena	0.32	0.06	0.07	-81.6%	-20.3%	-77.8%
Total	2.33	1.18	0.85	-49.3%	-28.1%	-63.6%
Source	Gautier-Hion, 1994	Brugiere, Sakom & Sinassonasibe., 1999b	This study			

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DISTRIBUTION, ABUNDANCE, AND BIOMASS ESTIMATES FOR PRIMATES WITHIN KAHUZI-BIEGA LOWLANDS AND ADJACENT FOREST IN EASTERN DRC

Abstract: *Africa's tropical forests have been subjected to alarming rates of forest clearing in the last two decades. Baseline data are critical to understanding the impacts of large-scale habitat loss and fragmentation. This report describes the distribution and relative abundance of anthropoid primates in 1994–95 within and adjacent to Kahuzi-Biega National Park lowland sector, eastern Democratic Republic of Congo. This is a region for which few empirical data exists. Density and biomass estimates derived from transect sampling are discussed for both adjacent settlement and remote sampling zones where minimum biomass estimates are 436 kg/km² and 663 kg/km², respectively. With the exception of red colobus* Procolobus badius *in sampling zone KB 4, hunting pressures do not appear to have been excessive. The owl-faced guenon* Cercopithecus hamlyni *is widely distributed and relatively abundant throughout the survey areas.*

Résumé: *Les forêts tropicales d'Afrique ont été soumises à des taux de défrichement alarmants depuis les deux dernières décennies. Des données référentielles sont nécessaires pour comprendre les impacts dus à la fragmentation et à la perte d'habitats à grande échelle. Ce rapport présente la distribution et l'abondance relative des primates anthropoïdes entre 1994 et 1995 au sein et aux alentours du Parc National de Kahuzi-Biega à l'est de la République*

Démocratique du Congo. Peu de données empiriques existent pour cette région. Les estimations de densité et de biomasse sont présentées pour les zones éloignées et les zones d'habitation où les estimations minimales de la biomasse atteignent respectivement 436 kg/km² et 663 kg/km². À l'exception du colobe rouge Procolobus badius *dans la zone échantillonnée KB 4, les pressions dû à la chasse ne semblent pas excessives. La guenon à face de hibou* Cercopithecus hamlyni *est largement répandue et relativement abondante partout dans les zones échantillonnées.*

Introduction

In recent years there have been many calls to protect the world's vanishing rain forests. In spite of the attention and politics surrounding rain forests, vast tracts of forest remain relatively unknown. The Democratic Republic of Congo (DRC, formerly Zaire) possesses over 50% of Africa's moist tropical lowland forest. Eastern DRC maintains a fauna and flora of global importance for conservation, including a number of large mammals endemic to the area (Stuart & Adams, 1990). The region neighboring Rwanda and Burundi has experienced a 4% annual human population growth rate since 1950 and large tracts of forest have been converted to pasture and farmland (Institut National de la Statistique, 1984; Hart & Hall, 1996). However, biological knowledge of the region is poor and research is at the level of basic biological explorations (*e.g.*, Mwanza & Yamagiwa, 1989; Yamagiwa *et al.*, 1989; Hart & Sikubwabo, 1994; Hart & Hall, 1996). Given the need of the ever increasing human population for land, there is a critical need for ecological information to help make informed decisions and guide development (Hart & Hall, 1996).

This report describes a survey of unhabituated anthropoid primates conducted in eastern DRC during 1994–95. The results presented here compliment information previously reported on large mammals in the survey region (East, 1996; Hall *et al.*,1997; Hall *et al.*,1998a; Hall *et al.*,1998b; Saltonstall *et al.*,1998; Inogwabini *et al.* 2000).

Study Site

This survey was conducted in a region of tropical moist forest in the North Kivu, South Kivu, and Maniema Districts (figure 1; 1°8'–2°29'S, 26°51'–28°51'E). Data were collected in two areas: (1) Kahuzi-Biega National Park lowland sector (KB, January–September 1994), and (2) Kasese area (K), to the west and north-west of the Park (April–August 1995). Vegetation in both survey sites is broadly classed as mixed mature lowland rain forest, but is highly variable both within and between areas (see Hall *et al.*, 1998b). The Kahuzi-Biega lowland sector ranges in altitude from 700–1800 m, while the Kasese survey area varies between 600–1400 m. In the 1950s, villages were evacuated from the deep forest throughout the region and much of the region has been the site of large-scale as well as low-technology mining activities.

Methods

Survey Design

The primary objective of the survey was to determine the distribution and abundance of Grauer's eastern gorilla *Gorilla beringei graueri* and robust chimpanzee *Pan troglodytes schweinfurthii*. Variable strip-width line transect sampling was used to collect systematic information within sampling zones in both survey areas (Norton-Griffiths, 1978; Buckland *et al.*, 1993; White, 1994). Transect lines were sited perpendicular to, and at random intervals along, a baseline placed parallel to major drainage features. Along transects, data were collected on habitat type, human signs, gorilla and chimpanzee nest sites, elephant *Loxodonta africana* and ungulate dung/pellets, as well as all mammal sightings (Hall *et al.*,1997; Hall *et al.*, 1998b). Monkey vocalisations and approximate locations within the survey region were recorded by one observer to assess the distribution and relative abundance of primates throughout the survey areas.

Because animals detect and react to humans cutting transects through the forest, these initial transects were deemed appropriate only for sampling indirect mammal sign. However, rewalking previously cut transects avoids this detection problem and is a generally accepted method for estimating the density and abundance of diurnal primates (Whitesides *et al.*, 1988; Buckland *et al.*, 1993; Plumptre & Reynolds, 1994; White 1994).

Transect Sampling Methods

Two Kahuzi-Biega zones—KB 1 and KB 2—were surveyed using transect sampling methods. In each zone, three previously cut, 6 km transects were surveyed totalling 11 (KB 1) and 12 (KB 2) replicates, respectively. To assure inter-observer reliability, observers walked transects in teams where observers rotated such that detection abilities and estimates of distance were standardised; a 2-day interval passed between surveys along a given transect. Data were recorded following Whitesides *et al.* (1988), including perpendicular distance from the transect to the first individual detected, perpendicular distance to the theoretical group centre (where possible), number of individuals seen by species, and number of individuals

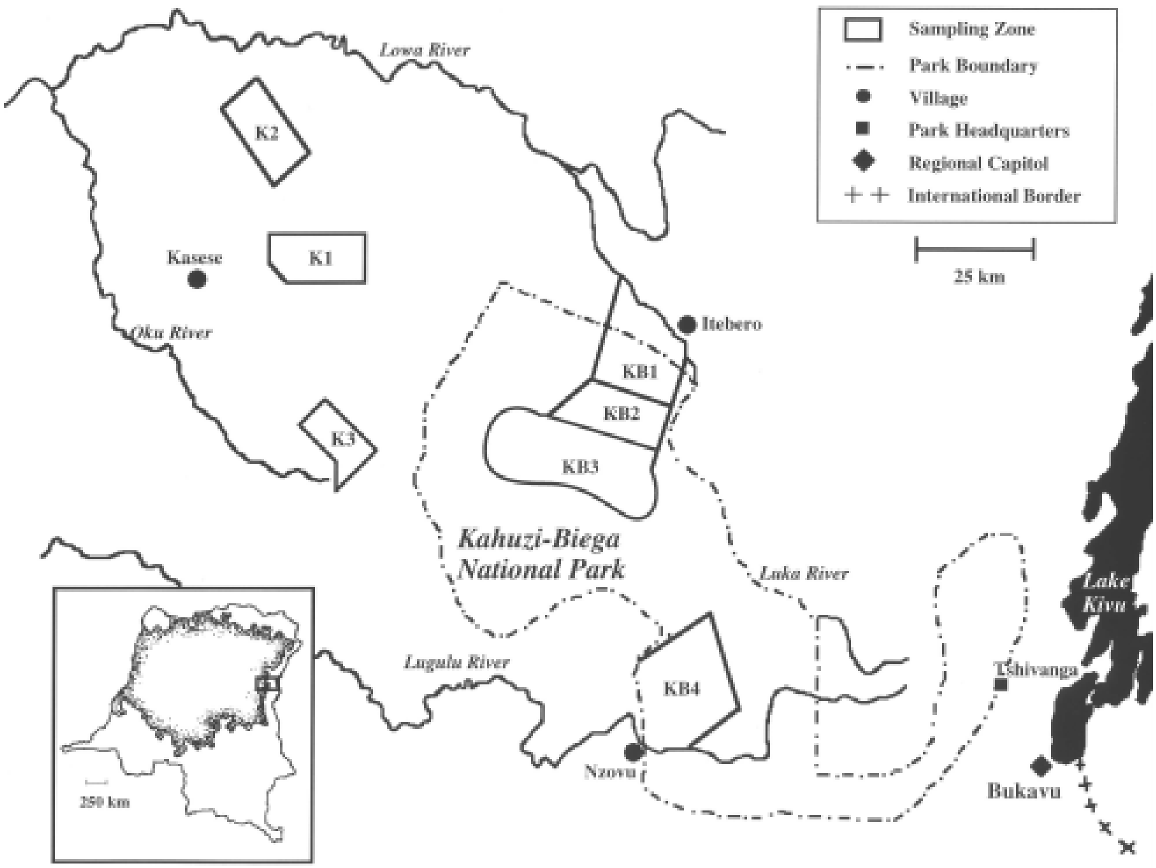

Figure 1. Sampling zones for distribution, abundance and relative biomass estimates of primates within Kahuzi-Biega National Park lowlands and adjacent forest in eastern DRC (1° 8'–2° 29' S, 26° 51'–28° 51'E; 1994–95).

believed to be within the group by species. Distance sampling methods (Buckland *et al.*, 1993) and the DISTANCE computer program (Laake *et al.*, 1994) were used to complete the analysis of transect data. DISTANCE calculates group densities based on perpendicular distance to cluster (for this study: group) centre and where the distance is the observation (see Buckland *et al.*, 1993).

Data were analysed and compared in two ways. First, group density estimates were compared between those made using the perpendicular distance to the theoretical group centre and those to the first individual detected in the subset of observations where observers could accurately determine theoretical group centre. This comparison was made to assess the relationship between the data for the first individual seen (FIRST) and those for perpendicular distance to group centre (GC). Group densities were then calculated based on the complete first individual detected data set.

Biomass Estimates

Anthropoid biomass was calculated for KB 1 and KB 2 using group densities and mean group size calculated on transects. Gorilla and chimpanzee densities were taken from Hall *et al.* (1998b). Body weight for the average individual was calculated as in White (1994), following Oates *et al.* (1990), where the average body weight was calculated as 75% that of an adult female. Adult female body weight was taken from Gevaerts (1992) except where stated otherwise.

Results

Distribution of Anthropoid Primates

Ten species of anthropoid primates were observed within the survey region (figure 1, table 1). With the exception of *P. badius*, L'Hhoest's monkey *Cercopithecus lhoesti*, and olive baboon *Papio anubis*, all were either detected through indirect sign (*i.e.* nest site), vocalisations and/or observation in all seven sampling zones. *P. badius* vocalisations were recorded in all but the KB 4 sampling zone while *C. lhoesti* was only detected, through direct observation, in KB 2 and KB 3. *P. anubis* was observed and vocalisations recorded in KB 1.

Table 1. Relative abundance of anthropoid primates within sampling zones in the Kahuzi-Biega National Park lowland sector and adjacent forest in eastern DRC (1994–95)[a].

Species	KB 1	KB 2	KB 3	KB 4	K 1	K 2	K 3
Cercopithecus mitis	+++	++++	+++	++	+++	++	++
Cercopithecus ascanius	++	+++	++	+	+	+	++
Cercopithecus denti	++	++	++	++	++	++	++
Cercopithecus hamlyni	+++	+++	++	++	+++	+++	++
Cercopithecus lhoesti	?	+	+	?	?	?	?
Lophocebus albigena	++	++	++	+	++	++	++
Procolobus badius	++	+++	+	-	+	+++	++
Papio anubis	++	?	?	?	?	?	?
Gorilla beringei	+++	++++	+++	++	++	++	++
Pan troglodytes	++++	++	++	++++	++	++	++

[a]Based on interpretation of vocalisation rates, observations, and indirect sign
++++ very abundant
+++ abundant
++ common
+ rare
- absent
? unknown

Transect Sampling

Determination of the theoretical group centre for these primates proved problematic. Researchers recorded this parameter for less than 50% of the groups encountered (46-group centre vs. 127-all groups). Comparisons of the perpendicular distance to the first individual detected (FIRST) vs. the perpendicular distance to the theoretical group centre (GC) within this subset of the data resulted in no significant differences (z test, $p<0.05$; table 2). However, because all group densities based on FIRST were markedly higher than those based on GC, data based on the FIRST likely overestimate the actual density. As the only complete data set available to calculate group densities was the FIRST data set, these densities were adjusted by multiplying species group densities based on FIRST by the ratio of GC to FIRST densities for the subset of data where both parameters were available (tables 3a and 3b).

The unadjusted group density based on the FIRST data set was significantly higher for all groups combined in KB 2 than in KB 1 (KB 1=6.00 groups/km^2, KB 2=9.83 groups/ km^2; $z=-2.06$, $p<0.05$); however, when segregated by species, only blue monkey *Cercopithecus mitis* ($z=-4.42$, $p<0.05$) had a significantly higher density.

Group Size

Limited data were available to calculate species specific group sizes. When observers were able to estimate group size, these data are presented in table 4. Because observers were more likely to estimate group sizes for smaller, more cohesive groups, these estimates represent a minimum mean group size.

Table 2. Comparison of group densities in Kahuzi-Biega National Park lowland sector, DRC, as determined from group centre and first individuals detected in KB 1 and KB 2 for subset of data where group centre could be estimated (1994–95).

Species	First Individual Detected		Group Centre		Z value
	Mean (group/km^2)	SE[a]	Mean (group/km^2)	SE[a]	
a) Kahuzi-Biega 1					
Cercopithecus mitis	1.44	0.50	0.82	0.36	-1.01
Cercopithecus ascanius	0.86	0.45	0.61	0.33	-0.45
Cercopithecus denti	0.57	0.39	0.41	0.28	-0.35
Lophocebus albigena	0.57	0.57	0.41	0.41	-0.24
Procolobus badius	0	0	0	0	
b) Kahuzi-Biega 2					
Cercopithecus mitis	3.71	0.96	2.63	0.75	-0.89
Cercopithecus ascanius	2.12	0.73	1.69	0.61	-0.45
Cercopithecus denti	0.79	0.41	0.56	0.30	-0.45
Lophoocebus albigena	0.53	0.36	0.38	0.26	-0.35
Procolobus badius	1.06	0.59	0.56	0.30	-0.75

[a]Standard Error

Table 3a. Anthropoid biomass for sampling zone KB 1 in Kahuzi-Biega National Park lowland sector, DRC (1994–1995).

Species	Encounter Rate (group/km)	Adjusted Group Density (group/km^2)	Individual Density (ind./km^2)	Average Body Weight (kg/ind.)	Total Biomass (kg/km^2)
Cercopithecus mitis	0.18	1.54	10.43	2.87	29.95
Cercopithecus ascanius	0.15	1.61	16.29	2.09	34.08
Cercopithecus denti	0.12	1.29	12.55	2.07	25.98
Cercopithecus hamlyni		2.50	6.68	2.76	18.42
Cercopithecus lhoesti					
Lophoocebus albigena	0.06	0.64	13.79	4.01	55.35
Procolobus badius	0.03	0.24	11.16	6.00[a]	66.96
Papio anubis	0.02	0.29	2.012	21.60[b]	43.42
Gorilla beringei			1.73	78.10[c]	135.11
Pan troglodytes			0.69	38.70[c]	26.70
Total					435.97

[a]From Haltenorth & Diller (1984)
[b]From Fa & Purvis (1997)
[c]From White (1994)

Table 3b. Anthropoid biomass for sampling zone KB 2 in Kahuzi-Biega National Park lowland sector, DRC (1994–95).

Species	Encounter Rate (group/km)	Adjusted Group Density (group/km^2)	Individual Density (ind./km^2)	Average Body Weight (kg/ind.)	Total Biomass (kg/km^2)
Cercopithecus mitis	0.51	5.34	36.02	2.87	103.47
Cercopithecus ascanius	0.25	3.00	30.38	2.09	63.57
Cercopithecus denti	0.17	1.78	17.34	2.07	35.90
Cercopithecus hamlyni		2.00	5.34	2.76	14.74
Cercopithecus lhoesti					
Lophocebus albigena	0.07	0.74	15.88	4.01	63.73
Procolobus badius	0.06	0.44	20.57	6.00[a]	123.42
Papio anubis					
Gorilla beringei			3.21	78.10[b]	250.70
Pan troglodytes			0.20	38.70[b]	7.74
Total					663.27

[a]From Haltenorth & Diller (1984)
[b]From White (1994)

Discussion

Distribution of Anthropoid Primates

All of the species discussed here were either previously reported or expected to be found within the region (Colyn, 1988; Yamagiwa *et al.*, 1989). However, it seems that these represent the first observations of *C. lhoesti* by researchers in the lowland sector of Kahuzi-Biega National Park (see, Yamagiwa *et al.*, 1989; Steinhauer-Burkart *et al.*, 1995). Further, while *C. hamlyni* has been characterised as either rare or uncommon in eastern DRC and Rwanda (Thomas, 1991; Hart & Sikubwabo, 1994), it is both widespread and relatively abundant throughout the Kahuzi-Biega and Kasese survey areas. No evidence was found suggesting the presence of

Table 4. Mean group size for anthropoid primates in Kahuzi-Biega National Park lowland sector, DRC (1994–95).

Species	Mean Group Size	Standard Error	Number of Groups
Cercopithecus mitis	6.8	1.02	28
Cercopithecus ascanius	10.1	1.22	17
Cercopithecus denti	9.8	2.04	12
Cercopithecus hamlyni	2.7	1.2	3
Cercopithecus lhoesti	unknown	-	0[a]
Lophocebus albigena	21.4	4.33	7
Procolobus badius	46.3	8.49	8
Papio anubis	7.0[b]	-	1
Gorilla beringei[c]	6.4	0.93	38
Pan troglodytes[c]	2.0	0.24	61

[a]Observed twice but no determination of group size possible
[b]Represents minimum number for group observed
[c]From Hall *et al.* (1998b)

Angolan black and white colobus monkeys *Colobus angolensis*. Because this species is readily detectable, the survey area clearly falls within the zone where this species does not exist.

The apparent absence of *P. badius* in KB 4 may be due to hunting and/or the altitude of this zone. This species is particularly vulnerable to hunting as it is vocal, large bodied, and both slower moving and less visually alert than cercopithecines (Oates, 1996). Hall *et al.* (1998b) report very high encounter rates of human sign on transects in this zone. Also, KB 4 has as much as 15% of its area above 1,500 m altitude, and *P. badius* and grey-cheeked mangabey *Lophocebus albigena* generally are not found above this altitude (Haltenorth & Diller, 1984).

Transect Sampling Results

Transect sampling has been widely used to estimate the abundance of primate populations (Brockelman & Ali, 1987; Plumptre & Reynolds, 1994; White 1994). Whitesides *et al.* (1988) compared transect sampling to sweep methods and found that the two methods give similar results. Nevertheless, they recommend using a combination of methods where possible. To calculate the perpendicular distance to the theoretical group centre, Whitesides *et al.* (1988) recorded the perpendicular distance to the first individual and then added one half the average group spread. In this study, observers were unable to obtain sufficient observations of complete groups to calculate an average group spread. Thus, two group density estimates were compared for groups where observers were able to estimate a perpendicular distance to the theoretical group centre. While results for these two approaches in this study were not significantly different, densities did appear to be consistently overestimated by using the first individual detected. To present the most conservative estimates, densities for the latter were adjusted (see Results). The present findings are also consistent with studies by Whitesides *et al.* (1988) and Brockelman & Ali (1987), in which they found that using only the first individual detected overestimates group abundance.

The statistically significant differences for mixed species groups between KB 1 and KB 2 might be explained by increased hunting pressure in this adjacent settlement zone (KB 1) as compared to the more remote KB 2. However, when assessed by species, this difference is due entirely to the very large differences for *C. mitis*. Because there was no significant difference between densities for *P. badius*, a species that might be expected to be the first to be reduced due to hunting pressure (Oates, 1996), this seems unlikely. An alternative explanation might be that differences were due to variation in habitat quality.

Biomass

Minimum estimates of anthropoid biomass for KB 1 and KB 2 are 436 kg /km^2 and 663 kg/km^2 respectively (table 4). Due to limitations in calculating group size, results reported here should be considered preliminary (table 4). Because researchers were more likely to calculate group size for smaller groups, these data probably represent an underestimation of group size. For example, group sizes of *C. mitis* and red-tailed monkey *Cercopithecus ascanius* were markedly lower than those reported by Butynski (1990) and Struhsaker (1988) for Kibale Forest, Uganda. In addition, observed group sizes for both *C. ascanius* and Dent's monkey *Cercopithecus denti* were lower than those observed by McGraw (1994) in the Lomako Forest, DRC. While the mean group size for *P. badius* reported here is not small (see Struhsaker, 1975), many very large groups were left out of this sample for lack of ability to estimate group size. Therefore, *P. badius* mean group size is probably also larger than presented here.

The results of the gorilla and chimpanzee survey yielded markedly higher densities than previously predicted (Hall *et al.*, 1998b). However, when combined with other anthropoid primates and compared to other forests within Africa, total anthropoid primate biomass estimates are markedly lower than for many areas. Struhsaker (1975) reported anthropoid biomass estimates between 2317–3622 kg/km^2 for Kibale Forest, Uganda. Oates et al. (1990) reported between 1229–1529 kg/km^2 on Tiwai Island, Sierra Leone. Anthropoid biomass estimates are 1010 kg/km^2 and 1034 kg/km^2 for Tai National Park, Côte d'Ivoire and the Lomako Forest, DRC, respectively (Bourlière, 1985; McGraw, 1994). In contrast, results reported for this study are higher than those reported by White (1994) for Lopé, Gabon (374 kg/km^2). The results reported here are conservative; if the larger group sizes found for *C. mitis*, *C. ascanius*, and *C. denti* in other studies as well as a group size believed to be more representative of actual *P. badius* group sizes (*c.* >65) were used, anthropoid biomass could be higher in the KB 2 sampling zone than for all studies cited above except Tiwai Island and Kibale Forest.

Conclusions

1. The ten anthropoid primate species described here have a generally widespread distribution in Kivu and Maniema Districts, however, a higher species richness was observed within Kahuzi-Biega than within Kasese. *C. hamlyni*, a species often described as rare, is both widespread and relatively abundant throughout the survey area.

2. The presence of *C. lhoesti* was confirmed within

this region.

3. Hunting could play a role in determining the differential abundance of *P. badius* between sampling zones but habitat composition and heterogeneity may be more important in explaining the relative abundance of other primate species found during this survey.

4. Preliminary estimates of anthropoid biomass are well within estimates made in other African forests but actual results for the KB 2 sampling zone are probably over 1000kg/km^2 as group sizes employed in calculations were likely underestimates.

5. No *C. angolensis* were recorded in this survey area. It is most probable that this species is absent from the area.

Acknowledgments

This research was financed by the Wildlife Conservation Society (WCS) in collaboration with the Institut Zairois (now Congolais) pour la Conservation de la Nature (ICCN). Additional support came from Bergorilla und Regenwald Direkthilfe. Logistical support provided by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). C. Fimbel, K. Freeman, K.P. Kiswele, H.S. Morland, and K. Saltonstall participated in the collection of field data. K. Saltonstall, P. Mehlman, T. Butynski, E. Sermiento and four anonymous referees reviewed drafts of the manuscript. We thank M. Mankoto and A. Vedder for their support throughout this project as well as all the guides, porters, field staff and guards who made field work possible.

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THE WORLD'S TOP 25 MOST ENDANGERED PRIMATES—2002

In January 2000, Conservation International released a report entitled '*The World's Top 25 Most Endangered Primates*', a list of threatened prosimians, monkeys and apes whose survival beyond the present century will depend heavily on actions taken now by our own species. The impetus for the original report was two competing realities, one being the lack of any documented primate extinctions during the 20th century—a remarkable record in light of recorded losses among other groups of animals during the same period—and the other being the results of an assessment that identified approximately 120 of the world's estimated 638 types of primate as being in serious danger of extinction within the next few decades. The Top 25 that we named in 2000 were merely the tip of the iceberg.

Two years later, we have decided to release a new report based upon updated information, especially with regard to Asian primates. Since the original report, the Species Survival Commission (SSC) of IUCN-The World Conservation Union launched a program of ongoing conservation status assessments for the world's threatened plant and animal species. As many experts had feared, the number of species threatened with extinction continues to rise despite our best efforts to ensure their survival. This new report considers preliminary results from primate workshops and assessments that have recently been conducted in India, Indonesia, Madagascar and Vietnam, and that recommend listing as many as 195 primate species and subspecies as "Endangered" or "Critically endangered". According to the IUCN, a primate is

1. *Endangered (EN)* if the extent of its occurrence is estimated to be less than 1,930 mi^2 (5,000 km^2), if its population is estimated to number less than 2,500 individuals, and/or if quantitative analysis shows the probability of extinction in the wild to be at least 20% within 20 years or five generations.

2. *Critically Endangered (CR)* if the extent of its occurrence is estimated to be less than 38.6 mi^2 (100 km^2), if its population is estimated to be less than 250 individuals, and/or if quantitative analysis shows the probability of extinction in the wild to be at least 50% within 10 years or five generations.

These two categories represent what we refer to as the *most endangered* species, at significantly greater risk of extinction than those evaluated by IUCN and categorised as "Vulnerable", "Near Threatened", or "Not at Risk". New assessments suggest that, from approximately 20% only a few years ago, we should now consider more than 30%—close to one in every three—of all primate taxa to be seriously threatened with extinction. The increase from 120 to almost 200 taxa largely reflects new information available from Asian countries. Therefore, it is not surprising that Asia now accounts for almost 45%—only slightly less than half—of the world's most endangered primates, or not many less than the three other major regions where primates occur—the Neotropics, Africa and Madagascar—combined (table1).

Table 1. Numbers of Critically Endangered (CR) and Endangered (EN) primates (Hilton-Taylor, 2002).

Region	CR	EN	Total
Neotropics	17	17	34
Africa	10	33	43
Madagascar	10	21	31
Asia	18	69	87
Totals	55	140	195

Within these regions, a total of 49 countries harbor wild populations of the world's most endangered primates: eight countries in the Neotropics, 24 in Africa, 16 in Asia, and Madagascar (which is considered a major primate region as well as being a country). According to the most recent assessments, the top 10 nations, in terms of endangered primates, are as follows:

Madagascar and Brazil have long led the list of countries having the highest number of endangered primates, but both have now been overtaken by Indonesia, based on the results of a workshop held by the IUCN Conservation Breeding Specialist Group (CBSG) in January 2001. Included on the new list of threatened primates are six endangered tarsier species found only in Indonesia. Tarsiers are small, nocturnal, insectivorous primates with large, owl-like eyes, long propulsive hind legs, and a thin, snake-like tail that they use to prop themselves up against stems and tree trunks. Prior to the Indonesian workshop, none had been considered endangered. However, all six of the newly-added species represent small, isolated island populations; three of the six are new to science and, as yet, un-named. Firmly in the middle of the pack of nations are China, India and Vietnam, each with 15 endangered primate species and subspecies. Such significant levels of primate endangerment have been recognised for China and Vietnam for a number of years, but India's elevated standing stems from another recent CBSG workshop that focused on South Asian primates. Workshop results also placed Sri Lanka on the Top 10 list, as that island nation's primates are largely endemic and highly threatened. Four Sri Lankan lorises, in fact, represent the only members of the primate family Loridae that are categorised as endangered at this time (table 2).

Table 2. Top ten countries in terms of numbers of Critically Endangered (CR) and Endangered (EN) primates (Hilton-Taylor, 2000).

Country	CR	EN	Total
Indonesia	4	31	35
Madagascar	10	21	31
Brazil	10	9	19
China	5	10	15
India	2	13	15
Vietnam	5	10	15
Equatorial Guinea	0	11	11
Nigeria	1	9	10
Sri Lanka	1	8	9
Cameroon	1	7	8

The larger primates, especially the colobines (commonly referred to as leaf-eating monkeys) and lesser apes, represent the majority of Asia's most threatened species. Forty-eight (48) members of the Asian colobine genera *Nasalis*, *Presbytis*, *Pygathrix*, *Rhinopithecus*, *Semnopithecus*, *Simias* and *Trachypithecus* are either endangered or critically endangered, representing just over half of their 90 recognised species and subspecies. This situation parallels that of the gibbons, of which 15 of 28 recognised taxa are now considered among the world's most endangered primates.

There are only three Asian great apes, the monotypic orangutan (*Pongo abelii*) found only on the Indonesian island of Sumatra, and two subspecies of Bornean orangutan (*Pongo pygmaeus*), but all are endangered. This also holds true for all 10 species and subspecies of African apes—the four subspecies of robust (common) chimpanzee (*Pan troglodytes*), the gracile chimpanzee (or bonobo) (*Pan paniscus*), and five taxa of gorilla (*Gorilla gorilla* and *Gorilla beringei)*. We humans (*Homo sapiens*), by contrast, represent the only species in the family Hominidae that is not considered endangered. With a global distribution and a population exceeding six billion, far from it!

Our activities, in fact, are the principal cause for decline of our closest living relatives. We have long cleared forest land to support agriculture, degraded habitats to collect fuelwood, logged to extract valuable timber, and hunted to provide meat for the table. Wild primate populations—as well as many other species—have suffered as result. Live capture for the pet trade and export for biomedical research have become lesser concerns in recent decades, but still pose a threat to some species. Today, however, the most insidious threat is that of commercial hunting, which goes far beyond the subsistence needs of rural populations to supply major cities and international markets. In Central and West Africa this is being done largely to supply food, in Asia largely to produce salves, balms and potions. In both cases, over-exploitation is creating an "empty forest syndrome" and contributing to the demise of wild primates in a number of countries.

We are not surprised, therefore, in our analysis of the updated list of endangered and critically endangered primates, to find that the overwhelming majority live in the world's biodiversity *hotspots*: 25 ecoregions that have been identified by Conservation International as covering merely 1.4% of Earth's land surface but holding within them more than 60% of all terrestrial plant and animal diversity. Fifteen hotspots harbor native populations of non-human primates, and the 195 most endangered species can be found in a dozen of these. Also, according to our analysis, 48 (87%) of the 55 critically endangered primates and 124 (89%) of the 140 endangered primates are endemic to the hotspots, for a total of 172 (88%) of the current 195. Of the hotspots, six should be considered the highest priorities for the survival of the world's most endangered primates—Indo-Burma, Madagascar, Sundaland, the Guinean Forests of West Africa, the Atlantic Forests of Brazil, and the Western Ghats/Sri Lanka (table 3).

Between them, these six hotspots cover approximately 500,000 km^2—just over three-tenths of one percent of Earth's land surface—yet hold 137, or roughly 70%, of the world's most endangered primates in the tropical forests that remain.

Survival of the world's living primates is the principal mission of the IUCN/SSC Primate Specialist Group, more than 300 volunteer professionals who represent the front line in international primate conservation. The Primate Specialist Group helps to compile the *IUCN Red List of Threatened Animals* (which was last published in 2000 and is now being updated), produces regular reports on the conservation status of key species and geographic region through a series of newsletters and journals, and periodically publishes action plans for primate conservation in specific regions of the world (Africa – 1986, 1996; Asia – 1987 Madagascar – 1993).

Information from this report will help to update the *IUCN Red List of Threatened Animals*, though we realise that our assessment efforts to date have not examined all primate habitat regions sufficiently and still probably underestimate the number of endangered species, as well as the extent to which they are threatened. We recognise that new information continues to appear regarding the conservation status of threatened taxa and we do not consider any single document to be the final determinant of such a list. Also, we appreciate that our ability to safeguard primate diversity will depend not only on developing comprehensive lists of those species and subspecies we consider to be threatened, but on drawing attention to those whose situation is most critical, highlighting

Table 3. Numbers of Critically Endangered (CR) and Endangered (EN) primates (Hilton-Taylor, 2002) in six biodiversity hotspots (Myers et al.*, 2000).*

Hotspot	CR	EN	Total
Indo-Burma	11	20	31
Madagasca	10	21	31
Sundaland	5	23	28
Guinean Forests	5	20	25
Atlantic Forest	8	3	11
Western Ghats/Sri Lanka	2	9	11
Totals	41	96	137

the kinds of efforts that are being undertaken to save them, acknowledging both our successes and our failures, and continually re-examining the situation on a global scale so that we remain confident in establishing priorities for action.

The *World's Top 25 Most Endangered Primates—2002* is more than a tally of those species with the fewest numbers of individuals remaining. We also recognise the importance of:

- primate species recently discovered or rediscovered and known from only a few localities;
- species whose populations may have been considered stable only a few years ago but are now under severe pressure, in rapid decline, and under serious threat of extinction; and
- varieties of primates that traditionally have not been recognised as distinct but are likely to be so as the result of ongoing genetic and field research.

In addition, we feel that it is important to remove species from the Top 25 list, at least temporarily, as their situation becomes less urgent or we feel that sufficient efforts and resources are being directed to their survival. While their conservation status and numbers may not change appreciably because of our efforts, we may remove them in favor of other species to which we feel more attention should be given, or whose situations highlight conservation techniques or accomplishments that need to be shared with broader audiences. To arrive at the current list, we decided to drop species such as the golden lion tamarin, black lion tamarin, yellow-tailed woolly monkey and golden-crowned sifaka, since we consider that good progress has been, or is being, made to ensure the survival of each. For species that remain from the original Top 25 of 2000, we have provided details about conservation efforts on their behalf, pointed to reasons for any observed declines in their numbers, or simply acknowledged that greater attention must be paid to their plight(table 4).

The original *World's Top 25 Most Endangered Primates* was well received. We have seen cases where a species' presence on the list has been used effectively by conservation organisations to raise funds to put researchers in the field, to train and supply forest guards, to conduct local public awareness campaigns, and to create new parks and reserves. In fact, the Margot Marsh Biodiversity Foundation, which was established in 1995 and has quickly become one of the world's most important sources of support for primate conservation, actively solicits and supports proposals that focus on species appearing on this list.

The *World's Top 25 Most Endangered Primates—2002* is presented in conjunction with the International Primatological Society, which recently held it's 19th Congress in Beijing, China. Among the participants were many of the dedicated individuals whose work contributes to the continued survival of these species and other threatened primates worldwide.

Overview of African Species (table 5)

Miss Waldron's Red Colobus Procolobus badius waldroni, *Ghana and Côte d'Ivoire(?)*

This monkey is teetering on the very brink of extinction. Primatologists have been searching its known range in eastern Côte d'Ivoire and western Ghana since 1933, but have failed to see a living animal. A single skin found by Dr. Scott McGraw (Ohio State University) in possession of a hunter in southeastern Côte d'Ivoire in early 2002 has raised hopes that at least one population of Miss Waldron's red colobus still hangs on, but if it does a heroic effort will be needed to ensure its survival. Conservation International will support continued searches for living animals. The plight of this monkey highlights threats faced by red colobus generally. Several distinct forms inhabit the forests of Africa, but they have patchy distributions and are particularly vulnerable to human hunters. Many red colobus are endangered, including three other forms in West Africa: Pennant's red colobus (*Procolobus pennantii pennantii*) of Bioko Island, 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 for 30 years.

Roloway Guenon Cercopithecus diana roloway *and White-naped Mangabey* Cercocebus atys lunulatus, *Ghana and Côte d'Ivoire*

There are two subspecies of *Cercopithecus diana*, both highly attractive, arboreal monkeys that inhabit the Upper Guinean forests of West Africa. The Roloway subspecies is distinguished by its broad white brow line, long white beard and yellow thighs. 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

Table 4. The 25 Most Endangered Primates—2002.

Hapalemur simus	Greater bamboo lemur	Madagascar
Propithecus perrieri	Perrier's sifaka	Madagascar
Propithecus candidus	Silky sifaka	Madagascar
Leontopithecus caissara	Black-faced lion tamarin	Brazil
Cebus xanthosternos	Buff-headed capuchin	Brazil
Brachyteles hypoxanthus	Northern muriqui	Brazil
Procolobus badius waldroni	Miss Waldron's red colobus	Ghana and Côte d'Ivoire
Cercopithecus diana roloway	Roloway guenon	Ghana and Côte d'Ivoire
Cercocebus atys lunulatus	White-naped mangabey	Ghana and Côte d'Ivoire
Cercocebus galeritus galeritus	Tana River mangabey	Kenya
Procolobus rufomitratus	Tana River red colobus	Kenya
Cercocebus galeritus sanjei	Sanje mangabey	Tanzania
Presbytis natunae	Natuna banded leaf monkey	Indonesia
Simias concolor	Pig-tailed snub-nosed monkey	Indonesia
Trachypithecus delacouri	Delacour's Langur	Vietnam
Trachypithecus poliocephalus	Golden-headed langur	Vietnam
Trachypithecus leucocephalus	White-headed Langur	China
Pygathrix nemaeus cinerea	Gray-shanked douc	Vietnam
Rhinopithecus avunculus	Tonkin Snub-nosed monkey	Vietnam
Rhinopithecus bieti	Yunnan Snub-nosed monkey	China
Rhinopithecus brelichi	Guizhou Snub-nosed monkey	China
Nomascus nasutus	Eastern black crested gibbon	China and Vietnam
Gorilla beringei beringei	Mountain gorilla	Democratic Republic of Congo, Rwanda, Uganda
Gorilla gorilla diehli	Cross River gorilla	Nigeria and Cameroon
Pongo abelii	Sumatran orangutan	Indonesia

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. As primatologists search the tropical forests of Ghana and Côte d'Ivoire for evidence of living red colobus, they are also documenting the decline of both the Roloway guenon

Table 5. Most Endangered Primates in Africa by Country

Country	Critical	Endangered	Total
Angola	0	2	2
Benin	0	2	2
Burkina Faso	0	1	1
Cameroon	1	7	8
Central African Rep	0	3	3
Congo	1	2	3
Dem. Rep. Congo	1	6	7
Equatorial Guinea	0	11	11
Gabon	0	2	2
Gambia	0	2	2
Ghana	3	1	4
Guinea	0	3	3
Guinea-Bissau	0	2	2
Côte d'Ivoire	4	3	7
Kenya	2	1	3
Liberia	1	3	4
Mali	0	1	1
Nigeria	1	9	10
Rwanda	1	3	4
Senegal	0	2	2
Sierra Leone	0	3	3
Tanzania	0	5	5
Togo	0	1	1
Uganda	2	2	4

and white-naped mangabey, which seem to be found in and to be absent from many of the same forests. Surveys conducted in the latter half of last year by Lindsay Magnuson (Humboldt State University), for example, confirmed the presence of both species in Ghana's Ankasa Resource Reserve, Dadieso Forest Reserve, Krokosua Hills Forest Reserve, and Yoyo Forest Reserve. Their occurrence in several other forests was also considered possible based on interviews in local communities, but it is just as likely that they have been extirpated from a number of protected areas in which they formerly were recorded, including Bia National Park. The Roloway guenon is not known from any protected areas in Côte d'Ivoire, whereas the white-naped mangabey has been reported from Marahoue National Park. Ghana's Ankasa Resource Reserve and Krokosua Hills Forest Reserve probably represent the protected areas most important to the Roloway guenon's survival.

Tana River Mangabey Cercocebus galeritus galeritus *and Tana River Red Colobus* Procolobus rufomitratus, *Kenya*

The gallery forests of Kenya's lower Tana River are home to two severely threatened primates, the Tana River mangabey and the Tana River red colobus. Along with six other primate species, they inhabit a 60-kilometer stretch of forest on both sides of the river, from Nkanjonja to Mitapani. While the other monkeys have geographically broader distributions, the mangabey and red colobus are found nowhere else. These two species are offered some protection within the 169 square kilometer Tana River Primate National Reserve. Forest loss in their range, unfortunately, has increased over the course of the last decade, resulting in an approximately 30% loss of original vegetation. In addition, local communities continue to degrade the remaining forest for products used in the construction of homes and canoes, the collection of wild honey, and the topping of date palms to make palm wine. A 5-year World Bank/GEF project started in 1996 was originally designed to relocate several hundred families that presently live within the Reserve, but financial support was ultimately withdrawn before completion of the project, leaving responsibility for the protection of the Tana River's remaining forests and primates entirely to the Kenya Wildlife Service. Recent research has found a drastic decline in mean group size for the red colobus from earlier studies, with no increase in the number of groups. An accurate census of the mangabey population is needed. Because they live in a small area of forest and that forest is being destroyed, both these primates are at high risk of extinction.

Sanje Mangabey Cercocebus galeritus sanjei, *Tanzania*

The Sanje mangabey, endemic to the Udzungwa Mountains of Tanzania, is a relatively recent arrival on the list of East African mammals, only having been discovered in 1981. It differs from other closely-related mangabeys in fur coloration (being a smoky brown or fawn color with a lighter, almost buffy orange underbelly) and facial coloration (beige with white eyelids). Found only in fragmented relict forests of the Udzungwas, it may prefer riverine habitat at altitudes ranging from 400-1,600 meters, although it is probably more common above 1,000 meters. At least one sub-population resides within the recently established Udzungwa Mountains National Park, but it is also known to occur in low densities outside the protective boundaries of the park in the Udzungwa Scarp Forest Reserve, where animals are at risk from hunting pressures and habitat loss. Overall, fewer than 1,500 of these primates may exist. The University of Georgia, Duke University and Conservation International are collaborating on a field research program in the Udzungwas to determine the extent of this mangabey's distribution, and are using this information to develop a recommendation for expanding the present boundaries of the National Park.

Mountain Gorilla Gorilla beringei beringei, *Democratic Republic of Congo, Rwanda, Uganda*

The mountain gorilla is the world's largest living primate, one of the best studied, and unfortunately, one of the most endangered. Approximately 320 mountain gorillas survive in the montane tropical forests that cover the Virunga Volcanoes in east-central Africa. The Virungas are shared by three countries—Democratic Republic of Congo (formerly Zaire), Rwanda and Uganda. The gorillas and their habitat are protected to some degree within three national parks—Virunga National Park (DRC), Parc National des Volcans (Rwanda), and Mgahinga Gorilla National Park (Uganda)—but they are also entirely surrounded by dense human settlements and agricultural lands, as the volcanic soils of this region are among the richest in the world. The region also has been the site of incredibly devastating human conflicts in recent decades. Despite these threats, the International Gorilla Conservation Program (African Wildlife Fund, Fauna and Flora International, and the World Wildlife Fund) and the Dian Fossey Gorilla Fund International have maintained long-term studies of the mountain gorilla, sustained anti-poaching efforts against relentless pressure, and have successfully established this magnificent primate as one of the premier tropical forest tourism attractions on the African continent.

Cross River Gorilla Gorilla gorilla diehli, *Nigeria and Cameroon*

Up until very recently, this had been the most neglected subspecies of gorilla. It was originally named in 1904 as a distinct species, *Gorilla diehli*, based on a few specimens collected in what was then the German colony of Kamerun, close to the Nigerian border at the headwaters of the Cross River. Based on recent morphological studies, it is now considered a subspecies of *Gorilla gorilla*. Present populations are restricted to densely forested hills on the Nigeria-Cameroon border about 300 km from the nearest population of western lowland gorillas (*G. g. gorilla*). Several very important conservation efforts on behalf of the Cross River gorilla have been launched over the past few years. Molecular studies are now underway at the City University of New York and should confirm these populations as genetically distinct. Field studies in Cameroon have reconfirmed the gorilla's presence in the Mone River Forest Reserve and the Mbulu Hills, which could possibly be linked to those of the Takamanda Forest Reserve, where the Wildlife Conservation Society (WCS) has an ongoing biodiversity conservation program. WCS has established a similar program at Nigeria's Cross River National Park under the direction of Dr. John Oates (City University of New York). Objectives of the Nigerian program include determining the extent of the gorilla's distribution within national park boundaries and assessing potential population links with the Takamanda gorillas, surveying gorillas that reside on community land in the Mbe Mountains, and establishing a permanent research base within the newly-designated Afi Mountain Wildlife Sanctuary.

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NOTES

A NOTE ON THE SOMALI GALAGO *GALAGO GALLARUM* (THOMAS, 1901)

The Somali galago *Galago gallarum* occurs in eastern and northern Kenya, Somalia, and southern Ethiopia. Groves (2001) describes the distribution as "broadly between Tana and Webi Shebeyli Rivers, west to Lake Turkana and rift lakes of Ethiopia, in semiarid woodland country." Very little is known about this species. Studies to date have concentrated on the museum collections. *G. gallarum* is regarded as a species distinct from the northern lesser galago (or Senegal bushbaby) *G. senegalensis*, with which it is marginally sympatric in Kenya (Olson, 1979, 1986; Nash *et al*., 1989; Groves, 2001; Grubb et al., 2003). No field studies have been conducted on this species and field observations come from opportunistic encounters. Here we present notes on a sighting of two Somali galagos during a brief field trip in 1999 to Garissa District, south-eastern Kenya. We also present observations made during a preliminary examination of the collection of galagos at the National Museums of Kenya, Nairobi.

During a night walk (from 22:10–00:15h, 27 January 1999), two Somali galagos were seen near our camp at Gababa (01° 34.40'S; 40° 07.12'E, 180 m asl), situated to the east of the Tana River. This is an area of *Acacia mellifera* dominated bushland. We were guided to this location by a local pastoralist who noted the galagos when he was cutting thorny branches for livestock fencing. He stated that the galagos were concealed deep inside an acacia bush and that there was no evidence of a nest. When we reached this location at 22:30 h, two Somali galagos were seen in a 1.8 m tall *A. mellifera*. Although one of the galagos came to the ground and fled, the other, an adult male (scrotum seen) remained in the acacia. We observed the galago for 45 min at a distance of 3–7 m, using our headlamps, spotlight, and binoculars. We later located the other galago about 50 m away and obtained good views of it for approximately 20 min. The second galago was smaller than the first, suggesting that it was either an adult female or a subadult male.

The following is a description of these two Somali galagos: Muzzle, cheeks and forehead ashy-grey, giving the impression of large grey eye rings around feint, narrow, black eye rings. 'Tear' lines black. Nose stripe light grey. Nose tip and around mouth black. Eyes relatively large, giving bright orange eye shine. Ears black. Top of head and back reddish-brown with a pinkish tinge. Rump more rufous than back. Flanks, outsides of front and rear legs rufous, almost light orange. Tail dark brownish-black over proximal half and near black, bushier, over distal half. Shoulders, forearms, and thighs orange brown. Hands grey on dorsal side. Throat and ventrum nearly white. Except for their size, the only difference between the two galagos was that the tail of the smaller animal was almost entirely black.

Both Somali galagos were very distinct from *G. senegalensis* seen by the authors either near the Tana River or elsewhere in Kenya. One call was recorded which we describe as similar to the single note, brief, 'tjong' call of *G. senegalensis*. In *G. senegalensis* this call is made in the context of 'medium' alarm (Zimmermann, 1990). In our situation the galago was obviously alarmed by the presence of people and the strong torch light shining on it. The recording of this call is deposited at the Nocturnal Primate Research Group Sound Archive, Oxford Brookes University, OX3 0BP, UK.

There is one *G. gallarum* specimen (reg. no. 987) at the National Museums of Kenya. This specimen was collected in 1911 on the Uaso Nyiro River near the Lorian Swamp, north-eastern Kenya. The skin is still in good condition. When placed next to a *G. s. braccatus* taken just south of the Tana River (reg. no. 990), the differences in the pelage are considerable. The *G. gallarum* specimen is overall reddish-brown on the dorsum and the *G. s. braccatus* specimen is grey on the dorsum. A comparison of facial characteristics was prevented by the condition of the *G. gallarum* skin.

The vocal repertoire, natural history, and conservation status of *G. gallarum* have yet to be studied. Indeed, this species remains one of Africa's least known primates. Field scientists working within the geographic range of *G. gallarum* are encouraged to look for this galago and to obtain as much information as possible.

Acknowledgements

We thank Simon Bearder, Lesley Ambrose, Debbie Nightingale, Carolyn Ehardt and Yvonne de Jong for their comments on the draft manuscript, and Zoo Atlanta, Conservation International, Kenya Wildlife Service, Hirola Management Committee, National Museums of Kenya, and the IUCN Eastern Africa Regional Office for financial, logistical, and office support.

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GALAGO (GALAGIDAE) BODY MEASUREMENTS AND MUSEUM COLLECTIONS DATA

When our paper (Nash *et al.*, 1989) on galago alpha taxonomy was published, most primatologists were just beginning to appreciate the systematic diversity and taxonomic confusion that existed within the galagos or bushbabies (Olson,1979). Research into galago systematic diversity is a subject of increasing interest because of its significant and immediate conservation consequences (*e.g.,* Bearder *et al.*, 1995; Bearder, 1999; Honess, 1996; Masters, 1998; Anderson, 2000, 2001; Anderson *et al.*, 2000; Masters & Bragg, 2000; Groves, 2001). We hope to facilitate further museum-based research on galago systematics and diversity by providing supplementary data to our 1989 paper.

We provide here in table 1 the sample sizes on which the ranges and means of morphological measurements of each species were calculated and we now add standard deviations. The table does not assign species to genera, for the reasons listed below. We recognize that this does not follow entirely correct taxonomic conventions and so, for clarity, also have provided the common name that is associated with each species recognized in our original descriptions. Table 1 also includes standard deviations and several corrections to the measurements published in our previous paper (Nash *et al.*, 1989).

In addition, we provide a list (table 2) of all the museums and private collections from which Olson collected these data. In total, 5,003 specimens were examined by Olson as part of his original research on galago systematics and taxonomy in the 1970s. Of these, 3,027 specimens provided from one to 29 body and cranial measurements on dentally mature individuals. These 3,027 included specimens of all 11 species originally recognized by Olson. Weight was the measurement least commonly available. Body measurements recorded by Olson were those taken by the collector at the time the specimen was captured and prepared. Olson determined the taxonomic identity of each specimen to subspecies based upon morphological and geographical criteria developed by him as part of his systematic revision of the group. All but a few of the 5,003 specimens were examined directly. Some body measurement data, from a few specimens reported in private correspondence or field notes and not directly examined by Olson, are included in the total sample.

The "Total" column in table 2 lists the number of specimens in each collection that were determined by Olson to be taxonomically identifiable at the species level. This number also gives the reader an approximation of the total size of the samples contained in the museums visited by Olson. Additional specimens exist in the collections of most of these museums but they were not included in this sample because they were either in too poor a condition or lacked sufficient provenience data to be identified. Consequently, they were not included in the sample total of 5,003 specimens. Where no number is listed for a museum, the collection may include galagos, but they could not be directly examined. Table 2 gives the name of each museum at the time the original data were collected in the 1970s. If the name of the museum has changed since that time, the new name is listed in the table footnotes.

Finally, please note the *Erratum* (Nash *et al.*, 1990) that was previously published concerning the original article. In the original paper, the name "Galago" was incorrectly typeset in italics in the title implying that we were adopting it as the formal generic name for the species described in the article. This was a major typographical mistake. In fact, given the widely divergent opinions amongst the authors at the time about the likely number of bushbaby genera (*i.e.*, *Galago, Galagoides*, *Euoticus, Sciurocheirus* and *Otolemur*), the authors could only agree in the original paper to use "Galago" as a common name thus avoiding altogether the contentious issue of generic diversity and affinities of species-groups.

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Table 1. Sample sizes and corrections to the galago body measurements presented in Nash, Bearder and Olson (1989)[1]

Species		*crassicaudatus*				*garnettii*				*alleni*		
Common name		large-eared greater galago				Garnett's greater galago				Allen's galago		
Page[2]		63				64				66		
Measures[3]	N	mean	range	SD	N	mean	range	SD	N	mean	range	SD
Head/body length	360	313	255-400	24.94	368	266	230-338	16.44	53	199	155-240	21.82
Tail length	357	410	300-550	36.98	363	364	308-440	21.63	53	261	205-300	21.07
Ear height	344	62	48-72	4.09	356	45	34-55	2.80	45	37	30-45	3.59
Hindfoot length	340	93	70-108	5.59	359	91	80-103	4.25	47	69	55-77	4.99
Weight	157	1131	567-1814	240.07	269	767	550-1040	95.42	21	314	200-445	75.25
Species		*elegantulus*				*matschiei*				*senegalensis*		
Common name		Needle-clawed galago				Matchie's galago				Senegal galago		
Page[2]		67				68				69		
Measures[3]	N	mean	range	SD	N	mean	range	SD	N	mean	range	SD
Head/body length	72	188	106-270	26.44	6	166	147-184	12.12	508	165	132-210	11.07
Tail length	69	283	194-337	23.00	6	255	240-279	13.11	498	*255*	195-303	16.55
Ear height	56	30	24-40	2.80	7	39	37-42	1.60	483	*40*	21-57	2.88
Hindfoot length	68	57	34-67	7.88	7	68	63-70	2.79	498	*67*	52-78	4.13
Weight	14	293	223-350	45.06	6	210	196-225	12.67	388	206	112-300	32.60
Species		*gallarum*				*moholi*				*zanzibaricus*		
Common name		Somali galago				Mohol galago				Zanzibar galago		
Page[2]		71				73				73-74		
Measures[3]	N	mean	range	SD	N	mean	range	SD	N	mean	range	SD
Head/body length	25	167	130-200	17.97	826	150	88-205	12.76	132	153	120-190	10.64
Tail length	25	252	205-293	18.39	824	228	113-279	15.55	131	220	170-265	14.41
Ear height	27	35	30-40	2.01	807	39	23-50	3.46	129	35	27-46	3.62
Hindfoot length	25	62	57-75	3.90	812	59	37-78	4.05	128	*58*	47-70	3.90
Weight	0	ND	ND	ND	477	158	95-244	22.78	72	145	104-203	21.04
Species		*thomasi*				*demidoff*						
Common name		Thomas' galago				Demidoff's galago						
Page[2]		76				78						
Measures[3]	N	mean	range	SD	N	mean	range	SD				
Head/body length	47	146	123-166	8.83	200	129	73-155	11.97				
Tail length	46	*195*	150-233	14.62	199	179	110-215	14.50				
Ear height	46	*29*	23-33	2.20	180	24	14-35	2.88				
Hindfoot length	46	*52*	39-58	3.11	191	46	35-60	3.65				
Weight	29	99	55-149	18.01	49	70	44-97	13.41				

[1] means in italics for tail length, ear height, and/or foot length under *senegalensis*, *zanzibaricus* and *thomasi* are corrections
[2] page number in original publication
[3] linear measures in mm, weight in g

Table 2. Sources of specimens of galagos for body measurements

Museum Abbreviation	Museum	Place	Total[1]
AIUZ	Anthropologisches Institut der Universitat	Zurich, Switzerland	
AJH	Alexander J. Haddow Collection	London School of Hygiene and Tropical Medicine, London, UK	108
AMNH	American Museum of Natural History	New York, NY, USA	400
ANS	Academy of Natural Sciences	Philadelphia, PA, USA	18
BMNH	British Museum (Natural History)[2]	London, UK	899
CAS	California Academy of Sciences	San Francisco, CA, USA	4
CMNH	Carnegie Museum of Natural History	Pittsburgh, PA, USA	54
ELM	East London Museum	East London, South Africa	
FKJ	F. K. Jouffroy Collection	Paris, France	1
FMNH	Field Museum of Natural History	Chicago, IL, USA	73
IRSNB	Institut Royal des Sciences Naturelles de Belgique	Brussels, Belgium	40
ITS	Ivan T. Sanderson Collection	See Sanderson (1940)	11
KM	Kaffrarian Museum	King Williams Town, South Africa	84
KNM	National Museums of Kenya	Nairobi, Kenya	100
LACM	Museum of Natural History	Los Angeles, CA, USA	34
LM	Livingstone Museum	Livingston, Zambia	
MB	Museu Bocage	Lisbon, Portugal	
MCSNG	Museo Civico di Storia Naturale	Genova, Italy	13
MCSNV	Museo Civico di Storia Naturale	Venezia, Italy	
MCZ	Museum of Comparative Zoology	Boston, MA, USA	105
MD	Museu do Dundo	Luanda, Angola	17
MHN	Musee d'Histoire Naturelle	La Chaux-de-Fonds, Switzerland	22
MHNG	Museum d'Histoire Naturelle	Geneve, Switzerland	32
MNHN	Museum National d'Histoire Naturelle	Paris, France	63
MRAC	Musee Royal de l'Afrique Centrale	Tervuren, Belgium	335
MSU	The Museum, Michigan State University	East Lansing, MI, USA	5
MVZ	Museum of Vertebrate Zoology	Berkeley, CA, USA	33
MW	Museum Wiesbaden	Wiesbaden, Germany	2
MZ	Museo Zoologico de "La Specola"	Firenze, Italy	20
MZC	Musue e Laboratorio Zoologico	Universidade de Coimbra, Portugal	3
NHMAA	Natural History Museum, University ofAddis Ababa	Addis Ababa, Ethiopia	2
NHMBA	Naturhistorisches Museum	Basel, Switzerland	
NHMBE	Naturhistorisches Museum	Bern, Switzerland	13
NHMV	Naturhistorisches Museum	Vienna, Austria	32
NMNH	National Museum of Natural History	Washington D.C., USA	483
NMRB	Natural History Museum[3]	Bulawayo & Harare, Zimbabwe	510
NMV	National Museum Victoria	Victoria, Australia	5
NR	Naturhistoriska Riksmuseet	Stockholm, Sweden	29
OM	Odontological Museum	Royal College of Surgeons of England, London, UK	32
OSUM	The Museum, Oklahoma State University	Norman, OK, USA	
PCM	Powell-Cotton Museum	Birchington, UK	212
RMNH	Rijksmuseum van Natuurlijke Historie	Leiden, Netherlands	27
RSM	Royal Scottish Museum	Edinburgh, UK	18
SMF	Forschungsinstitut Senckenberg	Frankfurt, Germany	11
SMNS	Staatliches Museum fur Naturkunde	Stuttgart, Germany	13
SMT	Staatliches Museum fur Tierkunde	Dresden, Germany	8
SMW	State Museum Windhoek	Windhoek, Namibia	6
TELLO	Jose L.P. Lobao Tello Collection	Lisbon, Portugal	
TM	Transvaal Museum	Pretoria, South Africa	253
UZM	Universitetets Zoologiske Museum	Copenhagen, Denmark	23
WHRL	W. H. R. Lumsden Collection	London School of Hygiene and Tropical Medicine, London, UK	538
ZF	Zoologisches Forschungsinstitut und Museum Alex. Koenig	Bonn, Germany	33
ZI	Zoological Institut, Academy of Science of USSR[4]	Leningrad, USSR	10
ZM	Zoologisches Museum	Berlin. Germany	245
ZMA	Zoologisches Museum	Amsterdam, Netherlands	2
ZMUZ	Zoologisches Museum der UniversitatZurich	Zurich, Switzerland	9
ZSBS	Zoologische Sammlung des Bayerischen Staates	Munich, Germany	13
		TOTAL	5003

[1] see text for explanation of total specimen numbers
[2] now Natural History Museum
[3] now National Museums of Zimbabwe
[4] now Zoological Institut, St. Petersburg, Russia

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SUDDEN DECLINE OF A COMMUNITY OF CHIMPANZEES *PAN TROGLODYTES* IN GOMBE NATIONAL PARK, TANZANIA

Gombe National Park (35 km^2) in western Tanzania is home to three communities of robust chimpanzees *Pan troglodytes schweinfurthii*. The Mitumba (northern) community ranges within the Mitumba, Kavusindi and Busindi Valleys. This community presently consists of 25 known individuals and is being habituated for tourism. The Kasekela (central) community is the main study group in the Park and has been habituated to humans since the early 1960s. Numbering between 40 and 45 individuals, it presently ranges from the Rutanga Valley to Nyasanga. The range today may be at its largest since records began in the early 1960s.

Until the start of 1999, little was known about the Kalande (southern) community, which has remained unhabituated to humans. An habituation project underway during the 1980s estimated the population to be about 80 individuals, making it the largest community in the Park. The range extended as far north as Kahama Valley and as far south as the southern-most part of Nyamagoma Valley.

This study was initiated because all evidence pointed to a dramatic reduction in the size of the Kalande community since the mid-1990s. Reports of sightings and vocalisations of large groups had fallen to zero. Worryingly, the Kasekela community increased its range two valleys south to Nyasanga without meeting any resistance. This suggested that the number of males defending the Kalande community had fallen.

The aims of the project were four-fold: (1) estimate the density and population of chimpanzees remaining in the south; (2) study patterns of associations and distribution among community members; (3) study the vegetation and other aspects of chimpanzee ecology; and (4) identify the underlying causes of the decline.

The study found that our initial suspicions were correct. The numbers of individuals in the Kalande community has fallen sharply. Analysis of data received on nest counts (for October and November 1999), show about 19 chimpanzees remaining. Direct observations indicate that there are 20 to 30 chimpanzees remaining. This is supported by the fact that the present community range is no larger than the present Mitumba community range, which, in its recent past, has supported between 25 and 30 chimpanzees. In addition, both food quality and quantity in the Kalande community's range are much poorer than in either of the other two communities. It is, therefore, unlikely to support more chimpanzees.

Almost all known cases of poaching occurred in the southern area of the Park. During the latter half of 1998, day long surveys produced evidence of poaching or trespassing in this area (*e.g.,* snares, hunters, hunting dogs, local villagers fleeing from inside the Park). A dead male chimpanzee was found without his hands and genitals. Since this project commenced, however, the area has been more thoroughly surveyed by researchers than in previous years. Snares have yet to be discovered in any of the five valleys under study, and the lower frequency with which poaching has been detected implies that research has played a part in reducing poaching, as it does in other parts of the Park. On recent occasions, however, semi-automatic gunfire has been heard at night, implying that poachers may have changed tactics.

Although other factors, such as disease, may have contributed to the decline, I believe that the evidence strongly points to poaching as the main cause. Traditionally, poachers have targeted bushbuck *Tragelaphus scriptus*. This is because Tanzanians have a taboo against eating primates, and the majority of the local population are Muslim and, therefore, do not eat bushpig *Potamochoerus porcus*. Traditions are, however, changing. For example, people in the Southern Highlands of Tanzania eat monkey, which is presently considered a great delicacy (Orenstein, 1998).

The closest town to Gombe is the port town of Kigoma, 15 km south of the Park, with an established trade route between Burundi, D.R. Congo, Tanzania and Zambia. Since 1996 there have been rumours of bushmeat on sale in Kigoma. An animal trade does exist. For example, people (notably Congolese) have regularly approached the expatriate community trying to sell animals, including chimpanzee infants.

An influx of Congolese refugees, who do not share the Tanzanian traditional taboo against eating primates, may have increased the trade in threatened species and bushmeat between Tanzania and D.R. Congo, and within Tanzania itself. During 1998, NGO employees visiting Gombe showed researchers photographs of bushmeat on sale within the Lugufu Camp, near the Lilanshimba Hills, a known chimpanzee habitat. Some of the bushmeat on sale was almost certainly chimpanzee.

Villages on the southern side of the Park have a large Congolese population. Incidents of bushmeat trafficking between these coastal villages and Kigoma are known and the closest source for this trade is the Park. The discovery of the decomposed remains of a female chimpanzee close to the ranger's outpost, two valleys north of the southern border, coincided with two Congolese approaching the expatriate community in Kigoma trying to sell a live infant chimpanzee allegedly held in Mtanga, the village along the southern border of the Park. Over the last few years, due to its close proximity to the wars in Burundi and D.R. Congo, firearms have become readily available in this region.

Poaching for game is only one of the resources under pressure at Gombe. The most common form of poaching is for wood, especially along the Mtanga border and east along the Rift Escarpment. Along the Rift, Burundi refugees cut trees to manufacture charcoal. Within just a few months, remaining stretches outside the Park will have disappeared altogether and it is certain that the pressure on the Park for wood will grow.

Certainly the problems at Gombe are not unique from the problems facing other protected areas. The fact, however, that Gombe is so small and is not surrounded by a buffer zone, makes it extremely vulnerable to outside pressures. Research has been able to show that despite the dramatic fall in numbers of the Kalande community, it is still a cohesive community and, if protected over the coming decades, has the potential to increase to its former numbers. Presently, the Gombe Stream Research Centre and Tanzanian National Parks are working closely to eliminate all poaching activity.

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REPRODUCTION OF THREE AFRICAN CERCOPITHECINES IN CAPTIVITY IN BRAZIL

Introduction

Large differences in the availability and quality of food during the year may play an important role in determining the timing of reproduction in free-ranging primates (Butynski, 1988; Feistner, 1988). In captivity, however, diet quality tends to be uniform throughout the year. As such, diet quality is expected to have less influence on the timing of the reproductive cycle of captive primates than of wild primates. We present data on the monthly distribution of birth records of three cercopithecine species in captivity in Brazil: sacred baboon *Papio hamadryas*, mandrill *Mandrillus sphinx*, and patas monkey *Erythrocebus patas*. Studies in the wild and semi-captivity indicate that *Erythrocebus patas* has a discrete birth season, whereas the other two species may give birth throughout the year (Lancaster & Lee, 1965; Butynski, 1988; Feistner, 1988; González-Martínez, 1988; Nakagawa, 2000a, 2000b). We follow Lancaster & Lee (1965) and Di Bitetti & Janson (2000) in defining seasonal breeders as those for which all birth records are concentrated over a discrete period of the year and there are no births in some months. In addition, a species may be a non-seasonal breeder but show a birth peak when birth records occur throughout the year but are clustered in some months (*sensu* Lancaster & Lee, 1965).

Methods

We sent a questionnaire to Brazilian zoos asking for information on (a) date of birth, (b) species (scientific name), (c) litter size, (d) sex of offspring (male or female), and (e) characteristics of the cage (outdoor or indoor). In this note, we group data from all zoos on the African cercopithecine species for which we received sufficient birth records to test for seasonality. Six zoos located in southeastern or southern Brazil (except for the Parque Zoológico de Goiânia) recorded births of at least one of the species discussed here, during 1960 to 2003, in outdoor cages.

Birth records of each species were grouped by semester (December-May and June-November for *Papio hamadryas*; February-July and August-January for *Mandrillus sphinx* and *Erythrocebus patas*). Semester definition was based on the grouping of the set of adjacent months presenting the greatest concentration of births of each species. Differences in the temporal distribution of births by semester were then examined using the chi-square test.

Results and Discussion

A total of 25 births of *Papio hamadryas* (12 males, 4 females, and 9 unknown), 17 of *Mandrillus sphinx* (3 males, 5 females, and 9 unknown), and 18 of *Erythrocebus patas* (3 males, 5 females, and 10 unknown) were recorded (table 1). Singletons were born in all cases. *Papio hamadryas* was a non-seasonal breeder because it gave birth in all months. However, it showed a birth peak from December to May (72% of birth records; $\mathcal{X}^2=4.84$, d.f.$=1$, $p<0.05$; figure 1a). These findings are in accordance with observations of wild hamadryas baboons by Kummer and Kurt (cited in Lancaster & Lee, 1965).

The births of *Mandrillus sphinx* were also well distributed across the year ($\mathcal{X}^2=1.47$, d.f.$=1$, NS; figure 1b). That no births were recorded for this species in three separate months (February, July, and September) may be an effect of the small sample size. Nevertheless, we consider mandrills non-seasonal breeders. In semi-captivity Feistner (1988) also observed that mandrills were non-seasonal breeders, but detected a concentration of births in a few months (90% of full-term births of surviving infants occurred from January to April).

Erythrocebus patas, on the other hand, is a seasonal breeder whose births were concentrated in 7 consecutive months (July to January; $\mathcal{X}^2=14.22$, d.f.$=1$, $p<0.001$; figure 1c). A birth season lasting 3 to 4 months during the dry season was observed in other studies both within (November to February in Africa, Butynski, 1988; Nakagawa, 2000a) and outside the species' natural range (January to April in Puerto Rico, González-Martínez, 1988). Captive animals in Brazil showed a longer birth season than observed in other populations. All births of this species in Brazil were recorded at the same zoo (Parque Zoológico Municipal Quinzinho de Barros) located in Sorocaba, State of São Paulo. The climate of this region is characterized by a wet season (October to March) when 80% of the annual rainfall occurs (approximately 180 mm mo^{-1}) and a dry season (April to September) in which average monthly rainfall is about 70 mm. In contrast to the aforementioned studies, the majority of births occurred during Sorocaba's wet season (n$=13$, 72%) rather than in the dry season (n$=5$, 28%). We suggest that environmental factors, other than food availability and rainfall, may play an important role in determining the timing of reproduction of *Erythrocebus patas* in captivity in Brazil. Photoperiod may be the environmental factor that triggers the onset of reproduction in this species. Comparing the 4-month

Table 1. Location of zoos sending data on birth records of African cercopithecine species in captivity in Brazil. Sample size for each species is also shown.

Zoo	*Papio hamadryas*	*Mandrillus sphinx*	*Erythrocebus patas*
PZ Sapucaia do Sul/RS (29°48'S, 50°10'W)	3	6	---
JB World-Beto Carrero/SC (26°59'S, 48°38'W)	2	---	---
PZ Municipal Quinzinho de Barros/SP (23°32'S, 46°37'W)	9	5	18
PZ Municipal Bauru/SP (22°18'S, 49°03'W)	6	---	---
Fundação Rio-Zoo/RJ (22°54'S, 43°10'W)	2	6	---
PZ Goiânia/GO (16°40'S, 49°16'W)	3	---	---
Total	25	17	18

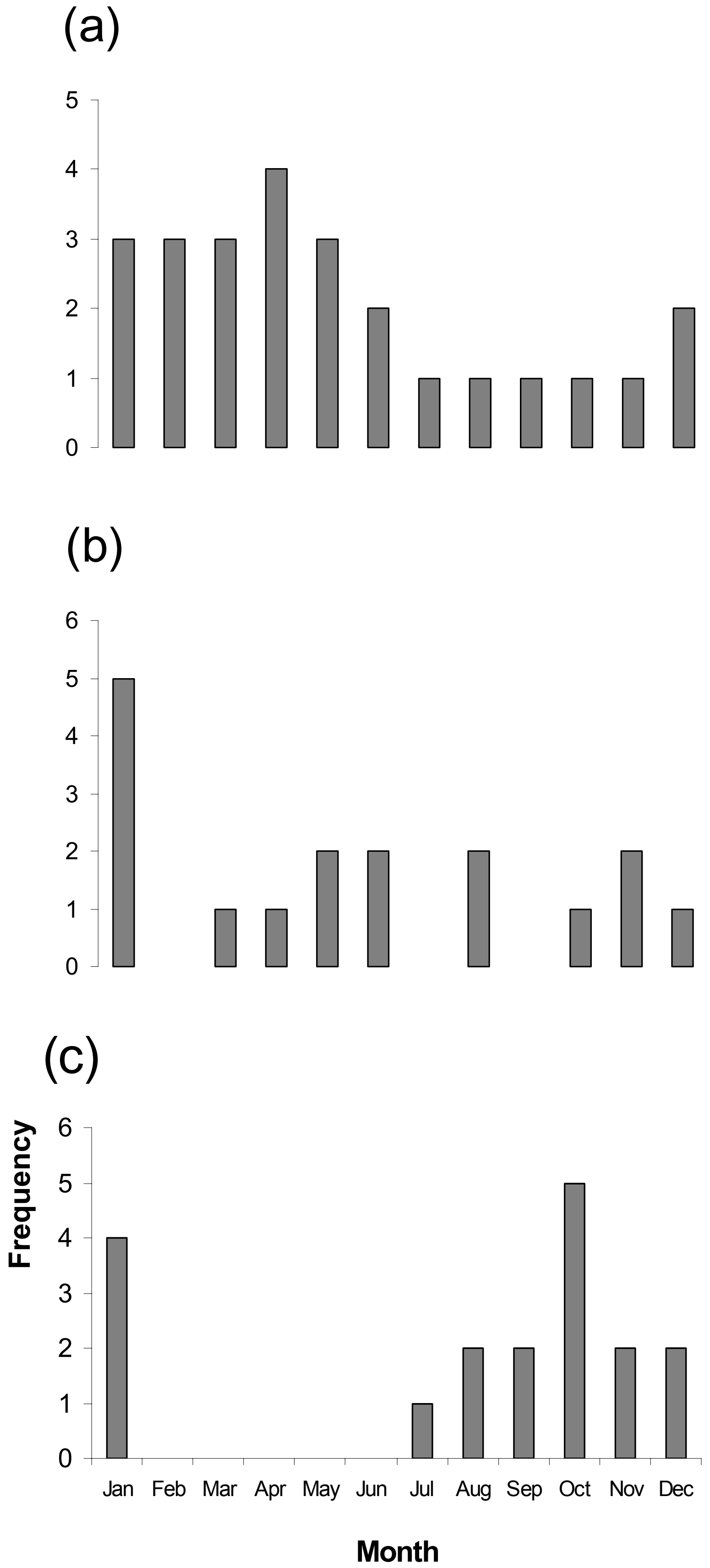

Figure 1. Monthly distribution of births of captive (a) *Papio hamadryas* (N=25), (b) *Mandrillus sphinx* (N=17), and (c) *Erythrocebus patas* (N=18) in Brazil.

periods in which the majority of births were recorded in Brazil (October-January), Africa (November-February), and Puerto Rico (January-April), there is a consistent displacement in birth periods in time that is compatible with changes in photoperiod.

Despite concerns about the validity of captive studies for predicting the occurrence, duration, and temporal distribution of mating and birth seasons of wild guenon populations (Butynski, 1988), our results for birth season for three cercopithecine species matched the timing of field and semi-captive studies. In addition, experimentally controlling for the effect of such factors as food quality and availability, photoperiod, rainfall, and temperature, in captive studies may help identify the proximate mechanisms affecting the timing of reproduction of wild populations. For example, a recent report on the birth seasonality of *Macaca mulatta* in captivity in Brazil (Gomes & Bicca-Marques, 2003) strengthens the hypothesis that photoperiod (Vandenbergh, 1973) influences the timing of onset of reproduction in this species, supporting the value of captive studies in increasing our understanding of the mechanisms triggering reproductive events in wild primate populations.

Acknowledgements

We thank the zoos who kindly shared their primate birth records with us, and the Pontifícia Universidade Católica do Rio Grande do Sul for logistical support.

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- *Vocalizations of Wild Chimpanzees in Gombe National Park* by Hugo Van Lawick, Peter Marler, and Jane Van Lawick-Goodall. 1971.
- *Ecology and Behavior of the Patas Monkeys in Waza National Park, Cameroun* by J. Stephen Gartlan. 1975.
- *Aspects of the Behavior of the Sifaka* (Propithecus verreauxi verreauxi*)* by Thomas T. Struhsaker and Alison Richard. 1973.

ERRATUM

Thompson, Jo A.M. 1999–2000. New Distribution record for the southern talapoin. *African Primates* 4: 68–69.

The naming of species on figure 1 (adapted from Kingdon, 1997) of this article is not correct.

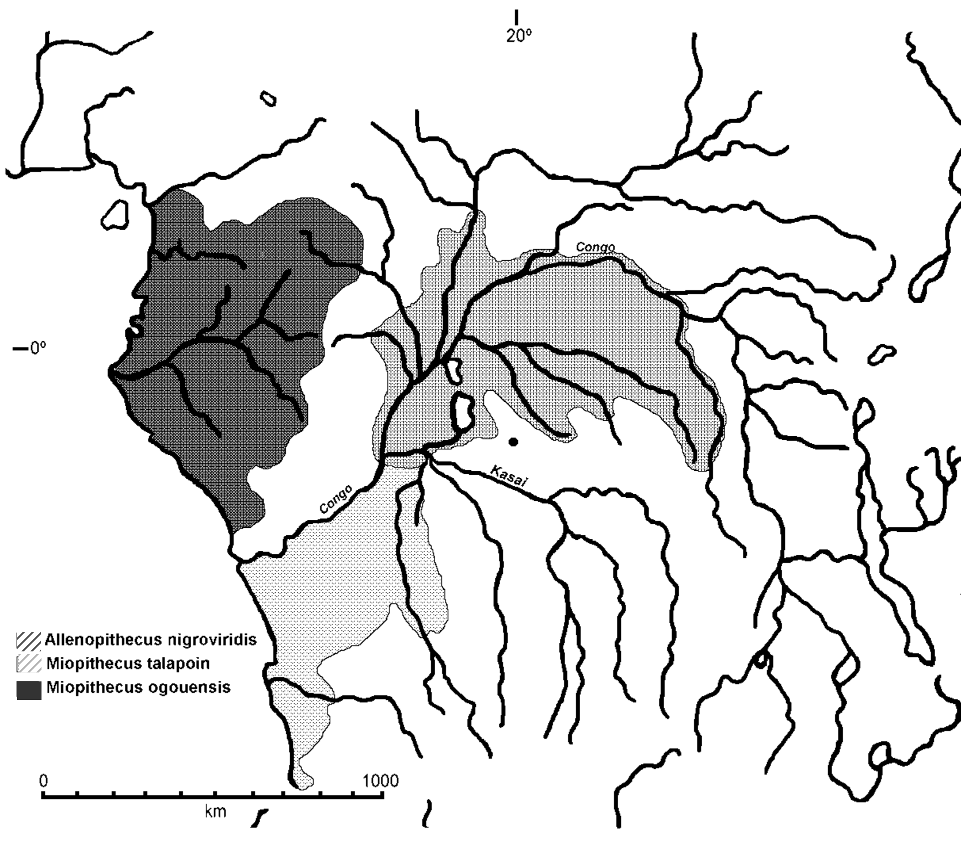
The dark shaded area (top left) is not the distribution of *Allenopithecus*, but that of the northern talapoin *Miopithecus ogouensis*.

The dark grey-shaded area (top right) is that of *Allenopithecus*.

The southern bright grey shaded area (below left) is that of the southern talapoin *Miopithecus talapoin*.

See corrected figure 1 below.

Our apologies for any inconvenience this may have caused and our sincere thanks to Rudolf Haslauer for pointing out this mistake.



Corrected figure 1. Geographic ranges of Allenopithecus nigroviridis, Miopithecus talapoin, *and* M. ogouensis. *Map adapted from Kingdon (1997). Black dot indicates the new site for* M. talapoin.

NOTES FOR CONTRIBUTORS

African Primates publishes information relevant to the conservation of non-human primates and their ecosystems in Africa. Its aim is to facilitate the exchange of information and ideas among primatologists and conservationists working with primates in Africa. It is hoped that this newsletter will enhance the conservation of African primates:

by increasing interest in their survival,

by alerting people to situations where primate species and populations are under threat, and

by providing a forum for useful debate on some of the more pressing, controversial, and sensitive issues that have an impact on the conservation of these primates.

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For authors with word-processing capabilities, please send the **final draft** in electronic form as either an e-mail attachment (preferably in either *.rtf or *.doc format) or on a high density PC compatible diskette to ladepew@africaonline.co.ke or Box 10018, Bamburi PO, Mombasa, Kenya.

Use metric units only.

Tables, figures and photographs are encouraged. All require complete, but concise captions listed on a separate sheet. Most "articles" should be accompanied by a map that shows all the place names mentioned in the text.

Figures, such as maps and sketches, should be drafted in black ink, lettered clearly to allow for reduction, and should be 'camera-ready'. Please follow the style in this issue of *African Primates*.

Black-and-white prints are best but colour photographs can also be used for black-and-white reproductions. All photographs must be sharply focused and of high quality. Each photograph should be labelled with a photographer credit.

'References' should be an alphabetical list of only those publications cited in the text. They should conform to the format used in previous issues of *African Primates*.

Each author should provide name, affiliation, address, telephone number, fax number and E-mail address (if available).

Have at least two senior colleagues review your draft manuscript. You should revise the manuscript accordingly prior to submission.

Please send contributions to: **Thomas M. Butynski**, Senior Editor, *African Primates*, Conservation International, P.O. Box 68200, City Square 00200, Nairobi, Kenya, E-mail: TButynski@aol.com

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Front cover illustration: Needle-clawed galago *Euoticus elegantulus*. Drawing by Steven Nash. See article on pages 40–50.

Logo: De Brazza's monkey *Cercopithecus neglectus*. By Steven Nash.

African Primates is produced in collaboration with **Conservation International**, 1919 M Street NW, Suite 600, Washington, DC 20036, USA, and with the **IUCN Eastern Africa Regional Office**, P.O. Box 68200, Nairobi, Kenya.

AFRICAN ***PRIMATES***

Contents for Volume 6, Numbers 1&2, 2002–2003