*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 | | | |

**Catherine Sourmail**
21 cache d'Erpion 59144 Gommegnies, France, Tel: 0033327499388, Fax: 0033327499388, Email: sourmailc@yahoo.fr

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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

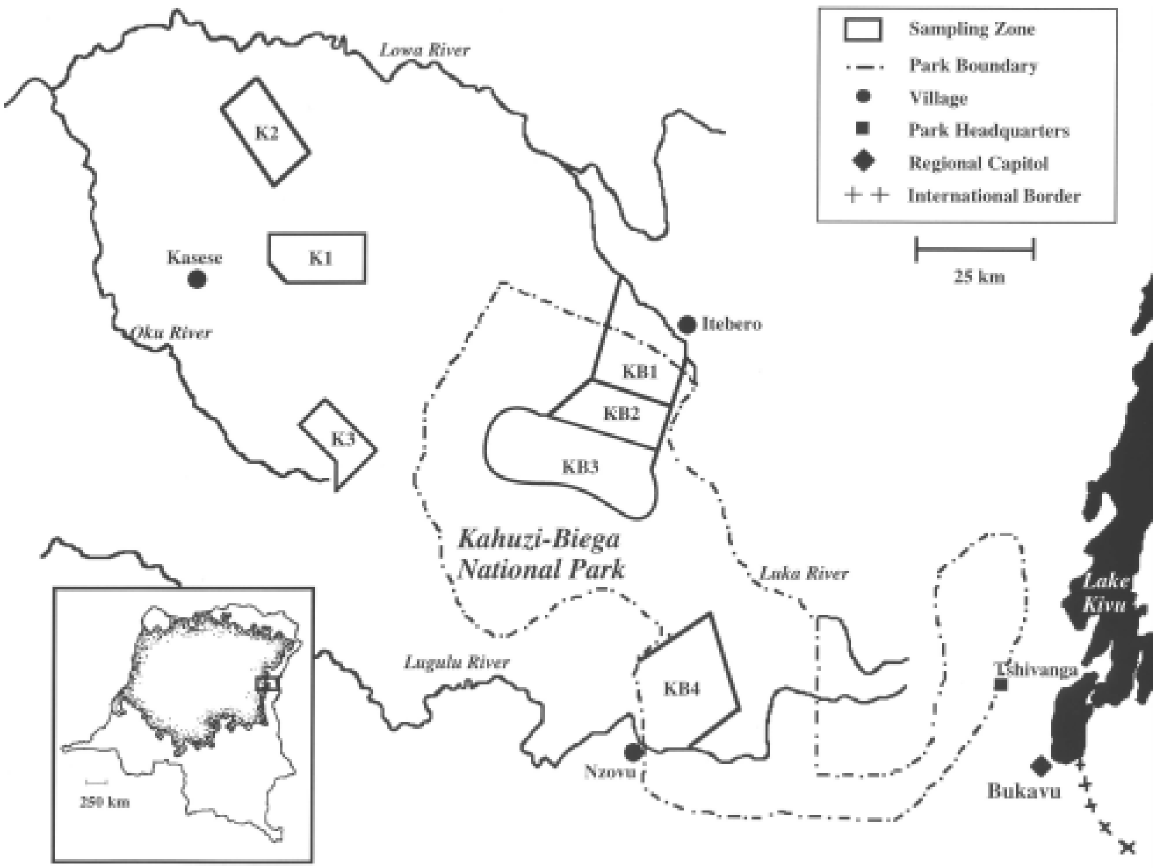


*Figure 1. Sampling zones for distribution, abundance and relative biomass estimates of primates within Kahuzi-Biega National Park lowlands and adjacent forest in eastern DRC (1° 8'–2° 29' S, 26° 51'–28° 51'E; 1994–95).*

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.

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**Jefferson S. Hall**
Africa Program, Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York 10460, USA, Tel.: +718 220 5887; E-mail: jhall@wcs.org

**Lee J.T. White**
Wildlife Conservation Society, Gabon, c/o Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York 10460, USA,; E-mail: lwhite@uuplus.com

**Elizabeth A. Williamson**
Department of Psychology, University of Stirling, Stirling, United Kingdom; E-mail: e.a.williamson@stirling.ac.uk

**Bila-Isia Inogwabini**
Africa Program, Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York 10460, USA; E-mail: bi4@kent.ac.uk

**Ilambu Omari**
Africa Program, Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, New York 10460, USA; E-mail: oilambu@hotmail.com

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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